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PROJECT PROFILE

USA

The Central Artery / Third Harbor Tunnel Project ('The Big Dig')

Boston, Massachusetts

omega centre

Centre for Mega Projects in Transport and Development

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CONTENTS

E PROJECT FUNDING/FINANCING

Introduction
Cost forecasts
Actual costs
Funding sources

- Capital funding
- Operations revenue

F. OPERATIONS

Traffic volume

G. BIBLIOGRAPHY

List of Figures

List of Tables

A INTRODUCTION

Project name

The Big Dig is the unofficial name of the Central Artery/Tunnel Project (CA/T), which is sometimes referred to as the Central Artery/Third Tunnel Project [MTA, Project Background]. The unofficial name of the project was inspired by the designation used to refer to the Panama Canal, the Big Ditch, which was an expensive project that took decades to complete [Boston Globe].

Type of project

Summary

Located: Boston, Massachusetts, United States of America.

Period: The CA/T project officially began in 1982. Construction started in 1991 and the official end date for the project is 31 December 2007, when the partnership between the program manager Bechtel/Parsons Brinckerhoff and the Massachusetts Turnpike Authority came to an end. [Murphy & Lewis; 2003].

Owner: Massachusetts Turnpike Authority.

Primary Contractors: Betchel/Parson Brinckerhoff.

Description

The Big Dig or the Central Artery/Tunnel Project (CA/T) combined two large projects into one: the depression of Boston's Central Artery (Interstate 93) in Massachusetts, and the construction of a third tunnel under the Boston Harbor to link traffic to the Logan Airport. The total endeavor consisted of building a total of 160 lane-miles of new highway within a 7.5-mile long corridor [Gelinas, 2007]. The 160 lane-miles estimate includes several major interchanges (some underground) as well as other on and off ramps and High Occupancy Vehicles (HOV) lanes (including some in tunnel).[1]

Table 1, below, gives a breakdown of the distribution of lane-miles in relation to actual miles.

Table 1: Lane miles in the Big Dig project

Length of tunnels*	5 miles
Tunnel lane miles	80 miles
Total project length	8 miles
Total lane miles	More than 160 miles

* Big Dig tunnels include cut-and-cover, immersed tubes, jacked tunnel and other special tunneling methods. This table has been modified from a table available from the Washington State Department of Transportation website: http://www.wsdot.wa.gov/Projects/Viaduct/BigDigcomparison.htm

[1] Sutherland, Holly; Massachusetts Turnpike Authority (MTA); personal communication; 15 June 2009. Holly.Sutherland@masspike.com

An important part of the project effectively turned an elevated highway into a 3.5 mile (5.6km) tunnel under the city, all while the traffic continued to flow on the elevated artery. The project also involved building six interchanges and several bridges, including the Leonard P. Zakim Bunker Hill Memorial Bridge over the Charles River. Another significant component of the project was building a third tunnel under the Boston harbor – the Ted Williams Tunnel, which extends Interstate 90 to Logan International Airport.

Moreover, the space vacated by the elevated artery has been allocated for a greenway (named after Rose Kennedy). [Massachusetts Turnpike Authority (1 & 2)]. The project has created over 300 acres of restored open space, including more than 45 parks and major plazas. The project provides the potential to integrate the city of Boston with its waterfront and a major shoreline restoration project has been completed as well as a new pier and docking facility. Overall, over USD 300m in surface restoration has been spent as part of the Big Dig project. [MTA website – Parks and Urban Restoration].

The initial plan also included a rail connection between Boston's two major train terminals but this was eventually dropped from the project. [Murphy & Lewis; 2003].

Figure 1: The Big Dig - before and after completion of the project

(Source : New York Times photographs, published in 2007)

Description of mode type

The Big Dig is mainly a highway/motorway project for on-road vehicles that includes tunnels, highway interchange connectors, and bridges. Ancillary pedestrian facilities are also part of the project; in particular the Rose Kennedy Greenway that extends over 27 acres, mostly over the now depressed central artery. [MTA – Project Background].

Country/location

The Central Artery /Tunnel (CA/T) project, known as the Big Dig, cuts through the heart of Boston, Massachusetts, on the northeast coast of the United States of America.

Current status

The two main components of the project (the underground Central Artery and the Third Harbor Tunnel) as well as a number of bridges and connectors were completed as of December 2007 (see description below, under Principal project characteristics). After construction ended, the old elevated highway was demolished. The area vacated by the old structure has been replaced by open space – The Rose Kennedy Greenway, which officially opened in October 2008. Some parts of the greenway will be open to modest development and in the coming years a few cultural institutions have been selected to build facilities between the parks [MTA – Project background]. The soils excavated to build the tunnels were used to cap a number of local landfills, fill in the Granite Rail Quarry in Quincy (MA), and restore the surface of Spectacle Island, which had been used as a garbage dump, and is now a park and part of the Boston Harbor Islands National Recreation Area. [Boston Harbor Islands Partnership].

A number of other projects were also completed as part of the Big Dig, including the relocation of underground utilities as well as a number of mitigation projects to address noise, rodent control, environmental and air quality concerns. The most expensive project was the building of the Phase II Silver Line tunnel under Fort Point Channel, in coordination with the Big Dig construction. Silver Line buses now use this tunnel and the Ted Williams Tunnel to link South Station and Logan Airport. [for an interactive map of the city, key components of the CA/T project, and the location of the MBT Silver Line stations, including the airport and South Station, go to:
http://www.mbta.com/schedules_and_maps/subway/lines/?route=SILVER#waterfront]

Other components are yet to be completed including pedestrian and biking facilities, and a few transit projects such as: 1) the Green Line streetcar service to the Arboway Line in Jamaica Plain; 2) the Green Line extension, beyond Lechmere Station; and, 3) the link between the Red and Blue subway lines. The extension beyond Lechmere is in progress and the Red and Blue subway line connection is being designed; the status of the Arborway Line is still unclear. Among the projects dropped from the initial plan, is the North-South Rail Link that would have connected North and South Stations (the major passenger train stations in Boston). The Dukakis administration dropped this project because it viewed it as an impediment to acquiring federal funding for the Big Dig project [Euchner, 2002].

Noteworthy, on 23 January 2008, the Bechtel Infrastructure Corporation and Parsons Brinckerhoff reached an agreement to settle claims by the Commonwealth of Massachusetts and the US Attorney for the District of Massachusetts regarding their work as management consultant for the Boston Central Artery/Tunnel project. The companies agreed to implement a number of specific measures to apply lessons learned to their future work, in order to avoid accidents such as the falling of a portion of the I-90 tunnel ceiling, which led to

the tragic death of Milena Del Valle in 2004. Under the terms of the agreement, Bechtel Infrastructure Corporation (BINFRA) is contributing USD 352m toward the settlement and Parsons Brinckerhoff (PB) contributes USD 47,230,500, which includes funds intended for future repairs and non-routine maintenance of the Central Artery/Tunnel. Both BINFRA and PB will take specific actions to enhance their existing training, compliance, and quality assurance programs in order to improve long-term performance and ensure that future work benefits from lessons learned during the Central Artery/Tunnel project. The agreement also provides remedies in the unlikely event of a future major incident for which B/PB is liable [Bechtel, 2008].

B BACKGROUND TO PROJECT

Principal project objectives

The main goals of the Big Dig project may be summarized as relieving highway traffic congestion, reducing bottlenecks in Downtown Boston, and decreasing the accident rate. In terms of the first objective, the elevated Central Artery had been designed to carry up to 75,000 vehicles per day when it opened in 1959. However, the volume of traffic continued to increase, with traffic escalating to 200,000 vehicles per day, and approximately 190,000 of those going over the Charles River crossing in the 1990s. The two tunnels under Boston Harbor between downtown Boston and East Boston/Logan Airport were facing the same problem. This translated into severe congestion, with traffic crawling for more than ten hours each day and the accident rate on the elevated highway was four times the national average for urban Interstates. The accidents were concentrated around exits from the elevated highway onto local streets in downtown Boston, and this was linked to the lack of an 'Inner Belt' highway that was supposed to complete the Central Artery design. Such an Inner Belt was never built because of community opposition to the construction of an additional highway, which would have required displacing thousands of residents and businesses. Through the years, it became clear that without major improvements to the Central Artery and the harbor crossings, the congestion was only going to get worse [Euchner, 2002; Hatch, 1999].

The annual costs from this congestion were considerable, including wasted fuel from idling in stalled traffic and related impairments to air quality, as well as charges for delayed deliveries. All of these were estimated to cost USD 500m per year. In addition, Boston's North End and Waterfront neighborhoods were cut off from the downtown, limiting these areas' ability to participate in the city's economic life. [MTA – Project Background].

Key enabling mechanisms and decision to proceed

<u>Inter-jurisdictional coordination/commitment from key agencies</u>

The concept of burying Central Artery was first conceived at a meeting in spring 1971 between Bill Reynolds, a highway contractor, and Frederick P. Salvucci, an anti-highway activist and transportation advisor to Mayor Kevin White. Salvucci had just helped stop the construction of I-95 through the heart of Boston. They agreed that the idea of another highway through Boston would not progress and Mr. Reynolds proposed the depressed road. It was then formally considered by the Boston Transportation Planning Review (BTPR).

While various communities across Boston supported this idea, the business sector wanted better access to Logan Airport, and was advocating for a third harbor tunnel. The Big Dig and the Turnpike's Boston Extension projects were then financially and legally joined by the legislature as the Metropolitan Highway System. In the early 1980s, Governor Dukakis (then in his second term) and Fred Salvucci (his Secretary of Transportation) came up with the strategy of tying the two projects together – thus gaining a broad base of support for the project. Salvucci then proceeded to work with the Boston Redevelopment Authority (BRA) and the Mayor's office to control the threat to older neighborhoods posed by the Inner Belt and Logan Airport expansion. He developed alliances with neighborhood groups and environmentalists during the early battle against the Inner Belt and gained their initial support for the CA/T project. [Euchner, 2002, Huges, 1998]

Planning for the Big Dig project officially began in 1982, and the environmental impact studies were started in 1983. Because Massachusetts was arguing that the Big Dig was part of the 'yet to be built' portion of the interstate system, which was considered at the time to be nearing completion, Fred Salvucci rushed to meet a 30 September 1983 deadline on the draft EIS for the unbuilt portions of the interstate system in Massachusetts. He also proposed to widen the artery and to build a general-purpose tunnel, promising to build without major traffic disruption using 'slurry wall' construction technology. [Gelinas, 2007].

After extensive lobbying for federal dollars with the aid of an influential Massachusetts congressional delegation, a public works bill appropriating funding for the Big Dig was passed by US Congress early in 1987. However, President Ronald Reagan vetoed this bill on 27 March 1987 because he deemed the project to be too expensive. With the help of US Congressman Tip O'Neill, Congress eventually overrode the president's veto and the project proceeded. Ground was first broken in 1991. Yet arriving at this point meant overcoming several obstacles – not just technical or engineering problems but also political, social, and environmental disputes, as outlined below. [Altshuler & Luberoff, 2003; McNichol & Ryan, 1991].

In July 1988, Fred Salvucci announced his personal selection of Scheme Z as the design for the Charles River crossing, and by August 1988 the first press reports began coming out about the new plan. By 1989, government officials, businessmen, citizens and advocacy groups began to argue that Scheme Z was a terrible design for the new Charles River interchange. The communities involved were in opposition to the proposed design. Some declared it "an aesthetic monstrosity that will scar the landscape for years to come and blight the city for Bostonians as yet unborn" [McManus, 1990]; others called it a "an intrusive, spaghetti-like set of bridges and lanes" [Palmer, 1995]. The proposed design involved six loop ramps, including 18 to 20 lanes of expressway crossing the Charles River in a 300ft wide corridor, complete with a humped up I-93 structure 110ft high. Scheme Z would have required certain traffic to cross the river twice, the 'double cross' in the words of one official's Freudian slip [Kaiser, 1993]. There were significant confrontations over the imposition of a 70-acre viaduct village on the banks of the Charles River, especially in East Cambridge (Boston) but also in Charlestown and around the New Boston Garden and the Traverse Street Ramp [Kaiser, 1993; Gelinas, 2007].

In November 1990, a modified Scheme Z was presented as a great development and quickly incorporated into the Final Supplemental EIS. With state and Federal approvals, the 'amputated' Scheme Z became the official approved plan and Salvucci was able to get Scheme Z officially through the EIS/R process before leaving (he was scheduled to leave office in January 1991). The intense battle over Scheme Z culminated in December 1990, as newspaper articles and community and political lobbying reached a peak, and the Salvucci/Dukakis Administration struggled to take last minute initiatives to rescue the project. Before the end of 1990, the Conservation Law Foundation (CLF) called a surprise press conference to announce an agreement between CLF and Executive Office of Transportation and Construction (EOTC), the Massachusetts Department of Public Works (Mass DPW) and the state Department of Environmental Protection (Mass DEP). The agreement involved a list of transit mitigation measures tied to the project, including expenditures on mass transit and related parking, and restrictions to downtown parking. There was also an implicit understanding that CLF would not attack Scheme Z and in particular, that it would not take legal action against it if the mitigation commitments held. [Huges, 1998; Kaiser, 1993].

During the month of December 1990, public comments to the office of the Massachusetts Environmental Policy Act (MEPA) were so numerous that some have stated that they could be measured by the foot. After much public opposition, mitigation commitments in 1990 and proposals for rail links (North/South) in January 1991, Richard Taylor, Secretary of Transportation for the new Republican administration of Governor Weld, recommended that

a stakeholders group be formed to find an alternative design to 'Scheme Z'. Thus, the Bridge Design Review Committee (BDRC) (see community organizations section, below) was convened. In June 1991, the BRDC actually rejected Scheme Z and in August of the same year it proposed to include a tunnel as part of the Charles River crossing. The committee also played a significant role in reviving the North-South rail link project [Huges, 1998].

Eventually, the FHWA rejected the CLF agreement and this caused the CLF to submit a legal suit challenging the river crossing on various counts, including insufficient mitigation for air quality impairments. By 1992, an agreement was worked out again so that many of the commitments were codified into state policy via a consent judgment, provided that CLF would agree not to sue if the state met certain conditions and deadlines. One of the conditions was that Scheme Z be formally rejected and replaced by what was labeled 'Scheme 8.1.D'. Every new variation of a river crossing design became labeled as a modification of plan 8.1.D, with the designations getting up to five modifications (5 Mod) before the BDRC gave its vote of approval on the EOTC process. In the fall of 1992, after the bridge committee's approval, the Massachusetts Executive Office of Transportation and Construction (EOTC) felt that an official Notice of Project Change could be filed for 'Plan 8.1.D Mod 5'. Information meetings were held in Cambridge, Charlestown and Boston to solicit public comments and concerns. MEPA issued their revised scope shortly thereafter. The formal 'notice of project change' triggered the need for a new Environmental Impact Statement. [Huges, 1998; Kaiser, 1993].

There were other problems with the BDRC's proposed design, which included a tunnel under the Charles River. Some contended that this design would create other environmental problems (when digging under the river) and that it could cause an inordinate number of accidents (given short curves on the ramps). Furthermore, the Federal Highway Administration and the Army Corps of Engineers requested that BDRC's design be compared to non-tunnel alternatives. Soon afterwards, the Joint Venture of Bechtel and PB, together with a few subcontractors, developed an alternative design and the paperwork for the EIS. [Huges, 1998]. Then the new Transportation Secretary, James Kerasiotes announced that his office would decide on the final design. When announcing his decision, Kerasiotes stated that "The under-the-river alternative will take two more years and add USD 300m more dollars." [Palmer, 1993a]. His decision turned out to be an all-bridge configuration that included a ten-lane cable-stayed bridge as well as a four-lane girder bridge. In a Record of Decision dated 9 June 1994, the Federal Highway Administration (FHWA) approved the design selection made by the Massachusetts Department of Highways (MHD) for the Charles River crossings as part of the Central Artery/Tunnel (CA/T) Project. [Howe, 1990; Kaiser, 1993].

Key organizations involved

Federal Highway Administration (FHWA) is an agency within the US Department of Transportation. Its role on the project was to provide general oversight, independently from the management role played by the Commonwealth of Massachusetts. The FHWA played a fiduciary role to ensure that the federal funds allocated to the CA/T project were spent according to the law. In 1997 the FHWA signed a management agreement with the Commonwealth of Massachusetts (CoM), and through it with three State agencies, including the Massachusetts Executive Office of Transportation and Construction (EOTC), the Massachusetts Highway Department (MHD), and the Massachusetts Turnpike Authority (MTA). According to this agreement, the FHA would provide federal funding for the project through EOTC (acting on behalf of MHD), which would oversee its contractual obligations (including auditing functions) with the FHWA and also distribute the federal funds. In addition, MTA agreed to assume management of the CA/T project on behalf of MHD, and

provide supervision of the project. It was also stipulated at that time that the MTA would use an Integrated Project Organization (IPO) "through the engineering and management services of the joint venture of Bechtel Corporation and Parsons Brinkerhoff, Quade, and Douglas, Inc." B/PB agreed to report to, and receive direction and supervision from (CoM) acting through MTA, and in turn the contractors would implement that direction throughout the designated phases of the project. [MTA – Finance, Project Partnership]. In 2000, the FHWA convened a federal task force on the project to review its own process of project oversight as well as costs [USDOT, 2000]. Details are provided under the Funding forecast section, below.

The Boston Transportation Planning Review (BTPR) was a transportation planning program for metropolitan Boston during the early phase of the project. Its charge was to analyze and re-design the entire area-wide transit and highway system in the 1970s. The program had close guidance from the national Transportation Research Board (TRB), a division of the US National Academy of Sciences. Alan Altshuler was the first director of the program and reported directly to the governor while Walter Hansen officiated as the project manager. [BTPR, 1972]. In 1973 the BTPR issued a report confirming the moratorium on building another expressway in the Boston metropolitan area (i.e. the Inner Ring), and recommended: 1) improvements to the planning process; 2) alternatives to solve the traffic problem in Boston, and 3): a multi-modal transportation management program that would integrate transit and highways.

Massachusetts Executive Office of Transportation and Construction (EOTC) plays the role of a state Department of Transportation (DOT). However, given Massachusetts' fragmented transportation decision-making process, it often lacks central authority to promote multimodal planning and/or integration of various alternative mobility options. While on the surface the Executive Office of Transportation and Construction (EOTC) oversees statewide planning, most of the planning staff operate within the MHD, organizationally under the EOTC but often operating as a separate entity. [Massachusetts Business Roundtable, 2003]. Other authorities controlling different transportation areas in Massachusetts include:

- The Massachusetts Turnpike Authority (MTA) was created by a 1952 act of the state legislature to oversee the turnpike system. Because it does not receive state or federal funds, it operates on revenues from tolls, and leasing and/or development of land and air rights revenue, as well as advertising. The MTA was in charge of managing the project, and has authority to collect tolls from the Ted Williams tunnel. [Althshuler, 2003]. A detailed description of the role played by the MTA is provided under 'Planning regime'. As the Big Dig project was being finalized, the MTA commissioned a study about the best potential use for the strip of land that became available on top of the submerged artery. The resulting 'Boston Central Artery Corridor Master Plan' has provided a framework for many of the discussions about the future of this land. [Beyond the Big Dig].

- The Massachusetts Bay Transportation Authority (MBTA), which oversees the operation of bus, commuter rail, subways and ferries in the metropolitan area; and

- Massport, in control of the operation of airports and seaports in the state.

Other organizations

Boston Redevelopment Authority (BRA) was created in 1957 by the Boston City Council and the Massachusetts Legislature. In 1960 the City Planning Board was abolished and its powers were transferred to the BRA. With authority previously held by the Boston Housing Authority its charge was to expand development goals beyond public housing, and it had

power to buy and sell property, acquire property through eminent domain, and grant tax concessions to encourage commercial and residential development. Salvucci relied on the BRA during the early stages of planning for the project. [Boston Redevelopment Authority website].

The Department of Public Works is part of the City of Boston's government. It is responsible for providing "a quality environment for the City of Boston and ensuring that the City's roadways, streets and bridge infrastructure are safe, clean, and attractive." [Kaiser, 1993]

The Massachusetts Department of Environmental Protection (MassDEP) is the state agency responsible for ensuring clean air and water, the safe management of toxics and hazards, the recycling of solid and hazardous wastes, cleanup of hazardous waste sites and spills, and the preservation of wetlands and coastal resources.[2]

The Massachusetts Environmental Policy Act (MEPA) office is an agency of the Commonwealth of Massachusetts, and is part of the Executive Office of Energy and Environmental Affairs (EOEA). Through the MEPA office, its Secretary conducts environmental impact reviews of certain projects requiring state agency action. Agency actions include granting state permits or licenses, providing state financial assistance, or transferring state land.[3]

Contractors

The Joint Venture of Bechtel and Parson Brinckerhoff provided overall management of the design and construction for the Big Dig project, throughout the extent of the project. In 1986 they were awarded an initial one-year transition contract to provide "services required to develop a comprehensive work program for establishing the tasks to be performed by a Management Consultant to manage, coordinate, schedule, direct and review the work being prepared by other design consultants for the Third Harbor Tunnel/Depressed Central Artery Project." It then received a series of limited term contracts that specified and extended its services to the overall management of the design and construction of the project. It was also responsible for preparing Environmental Impact Assessments. [Huges, 2002]. The Joint Venture came to an end in December 2007. [Bechtel, 2008].

Several other contractors were also involved and operated under the supervision of the Joint Venture. Modern Continental received the largest contract in terms of gross value (even larger than the Joint Venture). Other contractors included Jay Cashman, Obuyashi Co., Peter Kiewit Son's Inc., J.F. White, Perini Co. and the Slattery division of Skanska USA. Some of these companies were involved in the mainline tunnel of the project (including waterproofing), utilities relocation and underpinning of the elevated highway. [Commonwealth of Massachusetts, 2004; Wikipedia].

Advocacy and Community Organizations

Several non-governmental organizations were involved in the consultation process for the project, at one point or another. They included the Bridge Design Review Committee, a community including 42 stakeholders organized around the issue of Scheme Z; the Sierra Club, a national environmental organization; various local environmental and transportation groups, including the Charles River Watershed Association, the Committee for Regional Transportation, and Citizens for a Livable Charlestown; ad-hoc organizations such as the Artery Business Committee; the Boston Chamber of Commerce, representing Boston area interests; as well as professional engineers, architects, and urban planners representing

[2] http://www.mass.gov/dep/about/
[3] http://www.mass.gov/envir/mepa/

such organizations as the Conservation Law Foundation and the Boston Society of Landscape Architects.

Artery Business Committee was formed in 1988 to represent business interests in Big Dig planning and construction. From 1998 through 1999 the group worked on ideas for design and programming that as neighbors and abutters they would like to see on Central Artery parcels 12 through 18, and have produced a comprehensive alternate development plan for the central portion of the Greenway, known as the Wharf District. The report is called 'Harbor Gardens: A Concept for Boston's Wharf District'. [Beyond the Big Dig; and ABC-TMA]

The Boston Chamber of Commerce, along with the *Artery Business Committee* with which it eventually merged, had a core group of actors from the business community interested in protecting and growing the downtown core of Boston. The business leadership was active in analyzing key issues and brokering agreements on central disputes.[4]

The Boston Society of Landscape Architects is a chapter of a national volunteer organization for landscape professionals, the *American Society of Landscape Architects (ASLA)*.[5]

The Charles River Watershed Association (CRWA) is one of the country's oldest watershed organizations. It was formed in 1965 in response to public concern about the declining condition of the Charles River, and since its earliest days of advocacy, it has been a key player in major clean-up and protection efforts. CRWA's mission is "to use science, advocacy and the law to protect, preserve and enhance the Charles River and its watershed."[6]

Citizens for a Livable Charlestown was a group of residents and community leaders that coalesced in 1990 in opposition to Scheme Z.[7]

The Committee for Regional Transportation was a coalition opposing the project, which included some environmentalists, public-transit advocates and owners of businesses threatened by the project.[8]

The Conservation Law Foundation is a region-wide environmental advocacy organization founded in 1966. The Foundation partners with communities to conserve natural resources, protect public health and ensure environmental justice, especially in disadvantaged communities, often by leading landmark lawsuits.[9]

The North End Central Artery Advisory Committee, a neighborhood group, has been engaged in reviewing the alternative designs for the North End ramp parcel that is part of the Greenway corridor. It has engaged Sutphin Associates and Weinmayr Associates, both of Cambridge, to review the designs. [Beyond the Big Dig].

The Sierra Club, a non-profit environmental group with independent chapters nation-wide, initially opposed the Big Dig project out of concerns that it would create new 'hot-spots' of pollution in neighborhoods where the six ventilation facilities were located.[10]

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[4] http://www.hks.harvard.edu/rappaport/downloads/bigdig/abc_final_version.pdf
[5] *www.bslaweb.org*
[6] Ibid.
[7] *www.encyclopedia.com/doc/1P2-8201776.html*
[8] *www.encyclopedia.com/doc/1P2-7641860.html*
[9] http://www.clf.org/
[10] http://openjurist.org/2/f3d/462/sierra-club-v-d-larson-sierra-club

Planning regime

With little experience in managing and undertaking a complex project such as the CA/T Project, the Massachusetts Highway Department (MHD) (later the Massachusetts Turnpike Authority (MTA)) issued a contract in 1986 to Bechtel and Parsons Brinckerhoff who formed a Joint Venture to manage the project. This Joint Venture was hired to provide preliminary designs, manage the design consultants and the construction contractors, track the project's cost and schedule, advise the agency on project decisions, and at times act as the MTA's representative. MHD/MTA selected and awarded all of the design and construction contracts. Section-design consultants prepared, and were responsible for, the final designs. The construction contractors were responsible for building the facilities and meeting all of the requirements of their contracts. B/PB was responsible for monitoring the contractors' compliance with the terms and conditions of each of their construction contracts. Eventually, MTA combined some of its employees with B/PB's employees in an integrated project organization. This was intended to make management more efficient, but it apparently hindered MTA's ability to independently oversee Bechtel/Parsons Brinckerhoff. [Beck, 1999; Massachusetts Department of Public Works, 1991; USDOT, 2005].

According to Bechtel's official website MTA changed the management structure in 1999, during the peak of the construction phase. The website states that the agency "converted from a traditional program management model to an integrated project organization, which led to the management shifting to MTA. Although adopted for the stated purpose of streamlining the management structure and trimming costs, it also had the effect of blurring accountability and responsibilities, and discouraging proactive project management." [Bechtel, 2008]. This website also includes a statement that a National Academy of Engineers report stated: "…during the transition to the IPO structure in 1997-1999, the best-qualified person available for a particular managerial position was selected regardless of organizational affiliation (the position of project director, who reports to the chairman of the MTA was reserved for an MTA employee). In effect, B/PB is no longer in the role of a project Management Consultant but supplies highly qualified people to augment the staff of the MTA" [Bechtel, 2008].

The project required monthly reports to be issued (the 'Project Management Monthly' (PMM)) to provide updates on cost, schedule and safety issues. This report included such sections as: an Executive Summary; Milestones Schedule; Budget & Forecast; Progress Schedule; PCA; Future Allowance; Finance; Safety; Insurance; DBE Status; and Work Program Status. Reports were issued immediately after regular monthly meetings of the senior management. Information about these meetings, including their date and location, was made available to the public through a Meetings Calendar [MTA – Finances].

Despite this monthly reporting, a Federal Task Force established by the Federal Highway Administration to review the project found in 2000 that the state of Massachusetts had "breached its trust with the FHWA and others by intentionally withholding knowledge of the Project's potential cost overrun." [USDOT, 2000]. Furthermore, the task force determined that neither the PMM reports nor the Finance Plans were adequate in providing clear and accurate information and that they failed to paint a timely picture of the total cost exposure or cash flow requirements on an ongoing basis. In terms of its oversight role for the project, the task force found that the FHWA had failed to be sufficiently independent from the State and recommended changes in reporting relationships and delegated authority as deemed necessary. [USDOT, 2000].

Moreover, allegations of corruption and poor workmanship became common. In November 2004, a *Boston Globe* columnist wrote: "For years the complaints about the Big Dig focused on outrageous cost overruns and the willingness of politicians of all political persuasions to overlook them. A USD 2.5bn project turned into a USD 14.5bn project. Through it all, one

underlying assumption persisted. Bechtel/Parsons (Brinckerhoff), a premier engineering, construction, and project management venture, would guarantee premier if pricey work. Taxpayers were paying a lot, but in return they were getting an engineering marvel. As it turns out, this world-class engineering venture did not oversee construction of a world-class tunnel... (Now) the public perception regarding Bechtel/Parsons can be reduced to one word: ineptitude." [Tollroads News, 2004]

Some suppliers have been prosecuted for providing substandard materials (e.g. Powers Fasteners Inc. from Brewster, NY for providing poor quality epoxy) and others for fraud (e.g. Modern Continental for making false statements about flaws in a concrete panel in a slurry wall, which caused the leak in a tunnel; as well as for submitting fake receipts for materials and on time spent on the project. Also charged for over-billing is the Adams Management Group Inc., a subcontractor of McCourt Construction Co). [Boston Globe, May 2009]

Finally, the tunnels leaked from the time the project opened – a fact that made many drivers uneasy while driving underneath the Harbor. These problems came to the fore in July of 2006, when a ceiling of one of the I-93 connectors fell down, tragically killing a car passenger and injuring the driver. The affected tunnel was temporarily closed to traffic while investigations were conducted. Statements from Mitt Romney (the Governor at the time) made it clear that repairing the defects will continue to cost taxpayers for years into the future, raising the total bill for the project to over the USD 14.6bn that had been spent at the time of the accident. [Boston Globe, 2006].

Operating and complaint procedures

A number of operating procedures and programs were instituted in order to ensure the safety and health of the public and workers during the life of the project. For example, all contractors were required by contract to hire a full-time safety and health professional to "establish a site-specific safety and health program addressing their scope of work." Managers used a list of "expectations of a safety and health program" as a guideline. In addition, the project used a number of standard procedures governing everything from safety precautions to how accident investigations are handled. [MTA, Project Management].

Special programs

Officials also created special programs to help keep workers safe and reduce risk. These included an electronic tracking program to determine where employees or project visitors were when they visited the tunnel system while under construction. They swiped electronic badges across a reader that allowed Big Dig officials at a central operational office to know who was in each underground area at any given time. Then, when exiting the tunnels, workers would swipe the card again. This procedure was particularly important in case of an emergency. All contractors and sub-contractors were also required to minimize noise for the duration of the project, in particular during construction. Complaint procedures were put in place as well as rules for contractors and subcontractors to address these complaints. [MTA, Project Management].

The Big Dig had an Interim Operations Center (IOC), a 24-hour system to monitor traffic and incidents throughout the project with 16 cameras and a multiple channel radio system. As of the summer of 2002, the IOC had registered 23,483 incidents since June 1994, with an average of 15 complaints during the day, and six to seven actual incidents. The evening shift handled an average of eight to ten complaints daily with one to two actual incidents (up to the summer of 2002). [Holmer, 2002]

Overview of public consultation

In order to get support for the depressed central artery and third tunnel, Salvucci advertized this project as an alternative to more highways in Boston (his initial plan also included more public transit). In doing so, in the early 1970s, he capitalized on the anti-highway sentiments of those who were opposed to the construction of the 'Inner Belt' - a ring road around Boston that was supposed to complement and improve traffic movement through the elevated Central Artery. This additional highway met with strong opposition since it would also displace thousands of families (including 2,000 low income units) [Wofford, 2007].

During this time, then Governor Francis W. Sargent declared a moratorium on new highway construction and sought the advice of various stakeholders on the best transportation alternative. Therefore, he convened both a blue-ribbon committee (chaired by Alan Althshuler, and MIT Professor), as well as a long-term multi-disciplinary study group with approximately 60 participants with diverse points of view (including engineers, lawyers, architects, economists and ecologists, as well as highway department officials and anti-highway activists). This group generated the 'Boston Transportation Planning Review' report, which recommended the underground Central Artery and the Third Tunnel as well as increased connectivity between various transit systems. [Howe, 1991, Wofford, 2007].

The public involvement process was curtailed once the funding for the project was secured and the FHWA declared its opposition to supporting public transit as part of the Big Dig. While there had been public comment periods for the EIS during 1983-1985, there were no public meetings on the plans for the Charles River crossings. In fact, the public was quite unaware of the several alternative designs being considered (so many that there was one for each letter of the alphabet) or the intense internal debate at many levels of state and City government over the final selection of Scheme Z by Salvucci's team. Boston officials opposed Scheme Z for almost a year before reluctantly accepting the plan in exchange for a wide range of 'mitigation measures'. [Kaiser, 1993].

In November 1988, various conservation officials were invited to an event where the model of Scheme Z was presented; environmental groups were also invited. The general response was quite negative, in particular given the maze of ramps of Scheme Z. Some participants ridiculed the design quite overtly, comparing it to a Monty Python creation. Beside community representatives, various key parties showed displeasure with the design, in particular Rebecca Barnes from the US EPA. Apparently the Joint Venture was not too supportive of this design either. [McManus, 1990].

The opposition grew stronger after Peter Howe, a *Boston Globe* reporter, wrote a series of articles in December 1990 on the design of Scheme Z. Various communities organized resistance to the plan, including in East Cambridge, Charlestown, and around the New Boston Garden and the Traverse Street Ramp. Richard Goldberg, the owner of a parking-lot who was protesting the loss of some of his land next to Logan Airport to the project and was also known for organizing protests, provided substantial legal and public relations support for several dissenting groups, including the Committee for Regional Transportation. [Howe, 1990 & 1991, Kaiser, 1993].

In 1990, the city councils of both Boston and Cambridge voted to declare their opposition to the proposed Scheme Z, but not to the entire project. While the editorial pages of the *Globe* continued to support Salvucci's proposal, a heterogeneous coalition had formed to express their agreement with Salvucci's call for state and federal approval of the project's EIS. This coalition included the powerful Boston Building Trades Council, the Boston Society of Architects, the construction industries of Massachusetts, and real estate developers. The Conservation Law Foundation also expressed their agreement, provided that promises about public transit projects would materialize. [Howe, 1990 & 1991, Kaiser, 1993].

Since Dukakis was leaving office on 2 January 1991, there was a sense of urgency in moving the project along and preventing the opposition from derailing it. The new administration of Gov. Weld, and Richard Taylor as his Secretary of Transportation, calmed various interest groups by establishing a Bridge Design Review Committee. This committee, including 42 stakeholders, has been deemed an example of participatory design and conflict resolution. John Wofford, a lawyer who had served as the staff coordinator for the transportation study formed by Gov. Sargent in 1969, facilitated the consultation process. He used open and participatory techniques to develop a consensus about potential solutions. This committee included representatives from five organizations bringing suits against various aspects of CA/T, including Scheme Z. Members also represented national environmental organizations, such as the Sierra Club; local environmental and transportation groups, such as the Charles River Watershed Association, the Committee for Regional Transportation, and Citizens for a Livable Charlestown; ad-hoc organizations addressing CA/T, such as the Artery Business Committee; and long-standing organizations representing Boston area interests, such as the Boston Chamber of Commerce; as well as professional engineers, architects, and urban planners representing such organizations as the Conservation Law Foundation and the Boston Society of Landscape Architects. The Joint Venture made available its multidisciplinary staff, plus five independent consultants including bridge, tunneling, air quality, commuter rail, and traffic experts. [Howe, 1991; Huges, 1998; Kaiser, 1993].

In its report of August 1991, the BDRC proposed a new conceptual design – a river tunnel so as to reduce the number of bridges from three to one; the bridge lanes from 16 to 13; and the number of looped-ramp structures on the Cambridge side, from six to a maximum of four. Various alternative proposals were put forth and considered by the committee. However, problems arose with this design, vis-à-vis the EIS, and the FHWA and the US Army Corps of Engineers found fault with the tunnel proposal. In November 1993, James T. Kerasiotes, the new Massachusetts Secretary of Transportation (who had promised to decide among the competing proposals), announced his selection of a non-tunnel, all-bridge design that specified two bridges side by side, one with ten lanes (the cable-stay bridge design) and another with four. In response to this decision, a number of organizations that favored some variation on the BDRC's tunnel design gave formal notice that they intended to sue in order to block the Secretary's selection, which ignored the massive citizen participation over previous years. Despite this criticism, the design progressed and gained the necessary legal approval to start construction. [Altshuler, 2003; Huges, 1998; Kaiser, 1993].

Outreach - Beyond the Big Dig

The use and potential development of the stretch of land created by the depression of the Central Artery was the subject of intense debate, as it was perceived to be the most important development decision to face Boston in a generation. The Turnpike Authority commissioned a detailed study of the property that would become available above the Central Artery, as well as its potential uses. The resulting 'Boston Central Artery Corridor Master Plan' provided a framework for many of the discussions about the future of that land. [Beyond the Big Dig Forum]

Many voices have been involved in the debate over the use of what is now called the 'Greenway'. Various constituencies expressed their interests in the future of this land, including whether the new parcels should be neighborhood-oriented or welcoming to visitors, fun attractions or serious civic symbols, crowded or calm places, allow for the development of new buildings or be left entirely open. A few things were clear from the beginning:

- Streets and sidewalks would be the largest component of the Big Dig cover;

- The final design would comprise about seven acres of land within the 27 acres being restored above the Central Artery, with the balance already dedicated to other purposes;

- Buildings would cover ten parcels, restoring blocks and covering highway ramps;

- The Massachusetts Horticultural Society was chosen to build a major exhibit and educational center on three parcels at the edge of the Financial District;

- Environmental and public planning had designated the remaining parcels as open space.

[Lewis, 2001; Beyond the Big Dig Forum]

Community resistance

While the idea of depressing the elevated Central Artery, which had been seen by most residents as an eyesore in the heart of Boston, was initially broadly supported, various communities opposed specific design elements of the project as they were developed. These included initial community resistance with respect to where the Ted Williams tunnel would surface as it approached Logan Airport as well as opposition to Scheme Z – one of the preliminary designs for the Charles River crossings.

The description of community opposition has been provided above (under the 'Public consultation' section). This section outlines the concerns of communities in the early 2000s, related to access to the Boston Harbor and the shore side as well as hazardous vehicles that, unable to go through the depressed highway, would be roaming local streets. The community felt that the main obstacle keeping them landlocked was not the Artery, any more than the overpass at North Station kept people from crossing to cultural sites and traditional pubs. The central barrier on the walk-to-the-sea route was the six-lane highway. The fear was that the roadway would linger, and – worse yet – that the number of trucks filled with hazardous waste would increase on streets above ground because of the prohibition of vehicles carrying chemicals and other dangerous materials entering the new submerged central artery. Thus, the fear of the community was that the Big Dig project would not strengthen the path to the sea, by failing to include safe routes for walkers connecting downtown with the harbor and a promenade for people. [Hotz Kay, 2002]

Environmental statements and outcomes related to the project

<u>Summary</u>

The environmental review process began in 1982. Recommendations from such reviews range from mitigation measures related to the construction period, to permanent environmental improvements. The goal was to meet requirements under both the National Environmental Policy Act (NEPA) and the Massachusetts Environmental Policy Act (MEPA).

The first Final Environmental Impact Statement/Report (FEIS/R) was approved in 1985. In 1990 a supplemental FSEIS/R was also approved for the South Boston Haul/Bypass Road.

The project-wide Final Supplemental Environmental Impact Statement/Report (FSEIS/R) received a certificate from the state Executive Office of Environmental Affairs (EOEA) in January 1991 and its formal approval from the Federal Highway Administration (FHWA),

known as the Record of Decision, in May 1991. After receiving the Record of Decision the project was given the green light to begin advertising construction contracts. This 5000-page, 12-volume FSEIS/R was extensively reviewed by agencies and the public, who commented on the document both in writing and at public hearings. Later in 1994 a supplemental FSEIS/R specifically for the Charles River Crossing was approved.[11] [MTA – Environmental section; Engineering.com]

In order to authorize and maintain construction, thousands of other federal, state and local environmental permits, licenses and approvals were required, as well as ongoing environmental reviews of project changes and permit modifications by the agencies.

Details

As stated in the 'Public consultation' section above, Salvucci produced the 'Boston Transportation Planning Review' report. This report recommended against either the construction of the Inner Belt or the extension of major highways into the urban area. As alternatives, it proposed and summarized the pros and cons of a complex set of projects that would place a third tunnel under Boston Harbor, set the elevated central artery underground, and extend several Boston transit lines. The construction industry, which favored highway construction, opposed this alternative plan. [MIT, 2002]

An Environmental Impact Assessment (EIS) was prepared for the project because funding was being secured from the federal government. This was consistent with the mandate of the National Environmental Protection Act (NEPA) of 1969, which required that an EIS be prepared for all federally funded transportation projects. The goal of this requirement was to obtain detailed information about how the proposed project would affect the environment, both positively and negatively. The review included a description of the impacts on air and water resources, as well as habitats and parklands. The initial report, titled 'Central Artery Depression Preliminary Feasibility Study: Review Draft', was prepared in 1974 and a further report in 1975. [Huges, 1998].

Once the Massachusetts delegation to the US Congress (led by Tipp O'Neill) had argued effectively that Congress should include a portion of CA/T as part of the interstate cost estimate in 1976, the Federal Highway Administration (FHWA) decided to reject the project on other grounds – by refusing to accept the EIS prepared for the artery part of the project. The FHWA argued that: 1) the transportation benefits were limited in comparison to the then estimated costs of USD 1.3bn; 2) the project was going to take some parkland (which actually was mostly a parking lot owned by a state park agency); 3) serious operational and safety problems were likely to emerge; and, 4) ninety-seven businesses would be displaced and/or relocated. In 1985 the state of Massachusetts presented its formal response to the FHWA's objections, and its response included an analysis that showed that the artery depression would have a better ratio of benefits to costs than other major interstate projects supported by the FHWA, including New York Westway and Los Angeles Century Freeway. Eventually, the head of the FHWA, Ray Barnhart, accepted the EIS, much to the dismay of the then USDOT Secretary Elizabeth Dole. The negotiations over funding continued (including congressional override of a presidential veto). Eventually a compromise was reached – the FHWA agreed to support congressional legislation authorizing Federal Interstate Completion funding for the harbor tunnel and the north and south portions of the artery; and Massachusetts would have to find other federal and non-federal sources of funding for the central portion. [Althshuler, 2003; Huges, 1998].

[11] All these documents and their draft and summary documents are available for review and copying at the Transportation Library at 10 Park Plaza in Boston.

In 1983, and using an early conceptual design, the Department of Public Works submitted the EIS, which was approved by the Massachusetts Secretary of Environmental Affairs and the US Environment Protection Agency in 1985. In 1986, the Massachusetts Department of Public Works issued a transition contract to Bechtel and Parsons Brinckerhoff (PB) who formed a joint venture to manage the project. Notably, PB specialized in environmental impact statements and in solving problems associated with air and water quality, noise and vibration abatement, ecology and land use. (In addition, Bechtel was able to assist clients in obtaining project funding). Thus, a more detailed design responding to qualifications in the approval required the preparation of a supplemental EIS. Joint Venture engineers, environmental specialists, editorial assistants and employees of the Boston architectural firm of Wallace, Floyd Associates Inc., invested months of work to develop such EIS. In 1990 the Massachusetts DPW issued a draft of a CA/T Final Supplemental Environmental Impact Statement/Report (FSEIS/R). [Engineering.com; Huges, 1998].

As the project design was being finalized in 1990 it hit a roadblock – the design for the Charles River crossings, or Scheme Z, as presented by Salvucci. Furthermore, this part of the project had required a supplemental Environmental Impact Review (EIR). In 1986, the state Environmental Affairs Secretary John DeVillars had called for the formation of a Bridge Design Review Committee to improve the design of the river crossing but Salvucci did not heed his advice. [Kaiser, 1993]

In accord with the law, the Joint Venture widely circulated the draft version of the FSEIS/R, placing copies in libraries, providing for a public hearing and defining a public comment period. One hundred seventy-five persons, including spokespersons from government agencies, such as the US Environmental Protection Agency and from public interest groups (e.g. the Sierra Club) spoke out and 99 persons provided written commentary at a public hearing held in June 1990. The period for public comment on the published transcript of the hearing was extended until 22 September 1990, eliciting 273 letters. [Buzbee, 2005; Kaiser, 1993].

In December 1990 a *Boston Globe* article exposed EOTC's interference in rewriting the DeVillars' statement on the Draft EIR. EOTC was also accused of revising the original text of the EIR, quite liberally. After his 2 December 1990 article, Peter Howe published other articles exposing critical elements of the Scheme Z controversy. Unanimous condemnation of Scheme Z came from the City Councils of Boston and Cambridge, as well as the Aldermen of Somerville. Meeting after local meeting, news story after editorial, MEPA comment after legal filing, all produced negative comments on Scheme Z. [Howe, 1990, 91].

By the time of the general public controversy in December 1990, Fred Salvucci had already fast-tracked a document containing Scheme Z, which had to be acted upon by the Federal Highway Administration in the form of a Final Record of Decision (ROD) on the EIS. This ROD recognized the officially selected plan of the Commonwealth, Scheme Z, and in May 1991, the ROD was issued, providing official acceptance of Scheme Z as the state's preferred alternative. Moreover, the FHWA chose not to accept or include a transit mitigation agreement as part of the package because it considered that transit commitments did not fall under its jurisdiction. [Huges, 1998].

Key stakeholders (including the Weld Administration, the business community, and most residents in the area) agreed that Scheme Z would not move forward, and a Bridge Design Review Committee was formed in January 1991, to find alternatives to Scheme Z. The BDRC's selection of a tunnel proposal triggered the need for another EIS. As stated above in the public consultation section, in the end the administration of Governor Weld overrode their tunnel proposal and selected instead the cable-stayed bridge design. A new EIS was developed by the Joint Venture and was accepted in 1994. [Kaiser, 1993; Huges, 1998].

One of the concerns that required state and federal approval involved the excavation of up to 16mn square yards of soil. This project received approval from state environmental agencies in 1991, after satisfying concerns that the excavation process would not release toxins and that millions of rats would not be set free to roam the streets of Boston in search of new housing, thus threatening hundreds of homes. By the time the federal environmental clearances were delivered in 1994, the process had taken seven years, during which time inflation greatly increased the project's original cost estimates [Palmer, 1994].

Land acquisition

Typical of the 1950s, the design and construction of the elevated 'Central Artery' (completed in 1959) was driven by technical and economic values. This project entailed the demolition of buildings on 36 city blocks, for which most people did not receive proper compensation. Given this poor planning precedent, and in an effort to prevent such a situation from happening again, Salvucci promised to build the CA/T project without violation of any neighbourhood or community or the loss of any residential buildings. Depressing the Central Artery under the elevated one would indeed prevent razing through neighbourhoods or disrupting the social fabric of communities. Thus, the project was seen as increasing parkland – the green belt that would be constructed on top of the central artery once the depression was completed. Nevertheless, the EIS cited that a parking lot owned by the state park agency would be taken over during the project, and that 97 business would be displaced. Moreover, the siting of the exit from the tunnel to Logan Airport could become controversial. Salvucci manoeuvred the design so that the third tunnel would not take any buildings or land in East Boston. Eventually Salvucci gained the agreement of the Massachusetts Port Authority so that the tunnel would surface on the airport land, on a Park & Ride site belonging to Richard Goldberg (who would later oppose Scheme Z). [Altshuler, 2003; MTA website; Kaiser, 1993]. Nevertheless there were a number of land acquisitions, as described below.

Right-of-Way settlements and judgments: USD 572m (as described in the MTA's website – Financial section):

The Massachusetts Highway Department (MassHighway) was in charge of managing the land acquisition requirements for the project. For the most part, land and rights in land, or easements, were acquired by eminent domain, "pursuant to MassHighway's authorizing legislation set forth in Mass. Gen. L. c. 81, and in accordance with the eminent domain procedures set forth in Mass. Gen. L. c. 79." Most of the private land and property acquired was classified as commercial real estate.

The land acquisition process went as follows (as described in the MTA's website – Financial section):

- First, all land and easements to be acquired on either a permanent or temporary basis had to be shown on Right of Way Plans prepared for each design contract section;

- Once the land and easements were identified, for all but the smallest parcels, appraisers selected from MassHighway's approved list of real estate appraisers conducted two independent appraisals;

- Following completion of these independent appraisal reports, a review appraiser who was either a MassHighway employee or selected from MassHighway's approved list

would review the reports, correct any errors, and prepare a final report making a recommendation about the fair market value of the land or easement;

- Given the appraiser's recommendation, all proposed acquisitions in excess of USD 175,000 were also subject to receipt of approval from the Real Estate Review Board, and then by the MassHighway Board of Commissioners;

- The landowner was then contacted by MassHighway (within 30 days of the approval of an Order of Taking by the Board of Commissioners), and informed of the amount established as the fair market value for the property to be taken. The landowner could choose to accept the settlement payment in full or as a (partial) payment 'pro-tanto'. If accepting the latter option, the landowner could petition to a Massachusetts court an additional assessment of damages via a jury trial (within three years of the 'date of taking');

- MassHighway was required to pay interest (at the statutory rate) on any additional award that would be established either by negotiated settlement or jury verdict.

As of the last publicly available information, in 2001 several 'land takings' had been settled or were being processed, as follows:

- Eight cases were either settled out of court or by a jury verdict. The settlement amount for all these cases amounted to USD 25,013,331. This represented an USD 8,083,401 reduction to the base (June 2000) cost estimate;

- Five cases had been filed and were in the process of being settled for an estimated USD 2,800,000, which was a USD 4,300,000 reduction to the base (June 2000) cost estimate;

- Nine known cases were also expected to be filed in 2001. Based on historic trends the market value of these properties had been estimated at USD 9,555,000, which is a USD 4,895,000 reduction to the base (June 2000) cost estimate;

- As of 2001, it was expected that Orders of Taking would be issued on four additional relocations and 72 acquisitions (29 different parties) for an estimated value of USD 15,104,400, or a USD 5,895,600 reduction to the base cost estimate.

Economic impact of the project

In 2006, the Massachusetts Turnpike Authority released a two-volume report on the economic impact of the Central Artery/Third Harbor Tunnel Project. This study found that the Big Dig's associated benefits included:

- Improvements to the Metropolitan Highway System providing approximately USD 168m annually in time and cost-savings for travelers;

- Additional housing, office, retail and hotel development, expected to attract over USD 7bn in private investment and over 43,000 new jobs in the area. These estimates were based on known projects developed up to 2005 (in construction or proposed);

- Approximately 62% improvement in traffic flow, which exceeded project expectations.

[MTA – Economics Development Research Group, 2006]

Summary of major findings of economic study [As stated in the MTA – Economics Development Research Group report, 2006]

The development of the Central Artery/Third Harbor Tunnel Project is seen as contributing to new development in some areas where the elevated highway structure formerly stood. In addition, the MTA has also created locations for new development on air rights above the Turnpike. Together, these projects have created opportunities to help knit together neighborhoods formerly split by highway corridors. Based on known projects developed, in construction or proposed, additional housing, office, retail and hotel development is projected to attract over USD 7bn in private investment, providing a location for over 43,000 jobs. This includes projects along and adjacent to the I-93 corridor, as well as specific projects identified in the South Boston Seaport District.

The pattern of new development in the Back Bay originally derived from the Turnpike extension project is being repeated in South Boston and along the Rose Fitzgerald Kennedy Greenway as a result of the Central Artery/Third Harbor Tunnel Project. At the end of construction, the estimated property tax revenues realized at the South Boston Seaport will be equivalent to 9%–11% of Boston's 2005 tax base[4]. Wages paid to construction workers will yield an estimated USD 5m–6m per year in state income tax and sales tax revenue, if a 20-year development timeframe is assumed.

In 1983 Copley Place was built over the air rights of the Turnpike's Boston extension and today commands the third highest Class A office rents in the country. In 2004, Copley Place took in USD 800 per square foot in annual sales compared to a national retail average of USD 356. The Rose Fitzgerald Kennedy Greenway itself comprises as much property as the entire Turnpike created in the Back Bay. Just considering projects developed, under construction or in planning stages, the completion of the Central Artery/Third Harbor Tunnel Project is expected to result in:

- USD 7bn in private investment;
- 7,700 new housing units;
- 1,000 affordable housing units;
- ten million square feet of office and retail space;
- 2,600 hotel rooms;
- 43,000 jobs.

Long-term, in the South Boston Seaport District alone, the Central Artery/Third Harbor Tunnel Project is expected to stimulate:

- 16–21m square feet of commercial and residential development;
- USD 100–120m in annual property tax revenues (Volume II, page 21).

The Massachusetts Turnpike Authority owns and operates the Metropolitan Highway System and the improvements associated with the project are estimated to provide approximately USD 167m annually in time and cost savings for travelers. This includes USD 24m of savings in vehicle operating cost plus a value of USD 143m of time savings. Slightly over half of that time savings value (USD 73m) is for work-related trips, and can be viewed as a reduction in the costs of doing business in Boston. For instance:

- Average travel times from the I-90/I-93 interchange to Logan Airport during peak periods have decreased between 42% and 74%, depending on direction and time of day;

- Average afternoon peak hour northbound travel time on I-93 through downtown has dropped from 19.5 minutes to 2.8 minutes;

- The opening of the I-90 connector to Logan International Airport has added 800,000 residents to the 1.7 million who can access the airport within a 40-minute drive of their home.

[MTA, 2006]

C PRINCIPAL PROJECT CHARACTERISTICS

Technical specification

The Central Artery/Tunnel Project and reconstruction of I-93 through downtown Boston has involved varied construction techniques and engineering achievements in terms of tunneling and bridge building in a dense urban environment, making this a very complex project to manage and operate. The project replaces an elevated six-lane highway, with a submerged highway and an extended expressway (Interstate 90) connecting directly with Logan International Airport and bypassing downtown Boston. A significant requirement, which made the design for the CA/T even more complex, was that the construction project could not disrupt business and commercial activities on Boston's central business district or stop traffic on the elevated highway while it was being replaced [MTA, 2006; GML Consulting Limited, 2004].

The Central Artery/Tunnel Project included the largest use of slurry walls anywhere in North America (a slurry wall is a concrete wall that runs from the surface of the ground down to bedrock, defining the area to be excavated and eventually acting as the actual wall of the new Central Artery). This was the single most important construction technique on the project, which allowed the city to remain open for business and for traffic to continue moving during more than a decade of construction [MTA, Engineering Marvels].

The technical specification called for the building of a tunnel under the Boston Harbor and an eight-to-ten-lane underground expressway, which included three major highway tunnels, to replace the six-lane elevated highway as well as two bridges to provide 14 lanes crossing the Charles River. Before heavy construction began, utilities had to be relocated and mitigation measures put in place. Then the slurry wall construction began in the mid-1990s, which required underpinning of the existing elevated Central Artery before excavation. [MTA, Bridges & Tunnels]. In addition, and also before the excavation project could start, the project required use of the latest applications for preventing damage to Boston's vital subsurface infrastructure as well as mitigation plans. Therefore, an underground utility relocation program was put into place to move 29 miles of gas, electric, telephone, sewer, water, and other utility lines maintained by 31 separate companies. At the end, about 5,000 miles of fiber optic cable and 200,000 miles of copper telephone cable were installed. [MTA, Facts and Figures].

Because half of the project involved tunnels, this construction project excavated about 13 million cubic yards of earth material and four million cubic yards of concrete, which were hauled by over half a million truckload trips. During the core of the construction period, hundreds of pieces of heavy equipment were used 24 hours a day, including large excavators, front-end loaders, bulldozers, cranes, cement trucks, and both ten-wheel and 18-wheel dump trucks [Catalyst, 2009].

Once I-93 North opened under the footprint of the elevated Central Artery, Big Dig crews began demolishing the aging elevated highway. This work was finished in 2004, after southbound traffic was also shifted underground and the Artery became devoid of vehicles for the first time in half a century. [MTA, Engineering Marvels, Bridges and Tunnels].

Principal transport modes

The main transport mode is private passenger and commercial vehicles traveling across and around Boston. Some pedestrian accommodations are being completed towards the end of the project. As of 2008, the critical bicycle and pedestrian bridges promised as part of the Big Dig project were significantly delayed and at risk of being eliminated or reduced

significantly in scope. The Cross-Roads Initiative has yet to incorporate best practice for bicycle accommodation into its streetscape designs. Parking for bicycles is virtually non-existent. [Rosenblum, 2007]

Parent project

The CA/T project – the interstate highway route 90 extension and its connecting roadways and tunnels – is part of the Federal Highway System and links to the Massachusetts Turnpike system. This 7.5 mile highway corridor (which includes 160 lane-miles) has been viewed as bringing to a close the construction of the massive interstate highway network begun during the administration of President Dwight Eisenhower [Seely, 1987].

Principal project characteristics

Overview

Along with improving mobility in downtown Boston, the project reconnected neighborhoods severed by the old elevated highway and improved the quality of life in the city beyond the limited confines of the new expressway. The project has created more than 45 parks and large public plazas and restored significant stretches of the Boston Harbor walk. Clay and dirt from the Big Dig's excavation have been used to fill and cap landfills throughout New England as well as for major shoreline restoration in the Charles River Basin, Fort Point Channel, Rumney Marsh and Spectacle Island. Visitors to the 100-acre Spectacle Island now enjoy the new park and pathways developed, as well as its new visitor center and docking facilities, which were turned over to the City of Boston and the Department of Conservation and Recreation in 2006 [MTA Project & Parks.]

Schedule (information from the MTA's website)

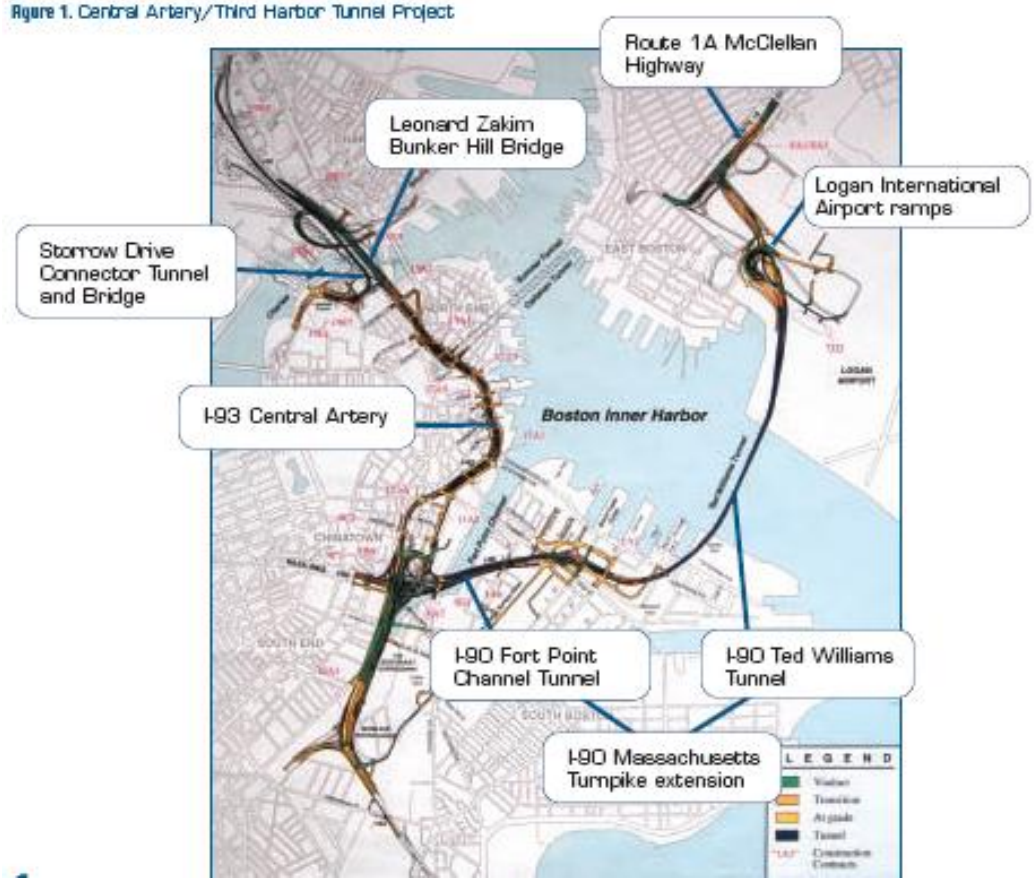
Construction on the CA/T project started in late 1991. Substantial completion was reached by January 2006 and the project was considered finished by December 2007. A detailed project schedule is as follows:

- The Ted Williams Tunnel opened in December 1995;
- The Leverett Circle Connector Bridge was completed in October 1999;
- Construction of the I-90 Connector to the Ted Williams Tunnel and Boston's Logan Airport finalized in January 2003;
- The opening of the underground I-93 North took place in March 2003, the initial opening of the underground I-93 Southbound in December 2003, and the full opening of the underground I-93 Southbound tunnel on 5 March 2005;
- The surface roadways were completed during the summer of 2007;
- Other remaining work was completed by December 2007, except for one park and certain other project elements, which were expected to be completed in 2010.

Description of route

The harbor tunnel portion of the CA/T project facilitates the movement of traffic to Boston's Logan airport, while the underground central artery improves the movement of interstate traffic through the Boston region. The map below provides a picture of the routes available to vehicles. [MTA website]

Figure 2: Main and intermediate travel nodes



[Source: Information from the MTA website]

Main and intermediate transport nodes

Most of the main transportation infrastructure nodes associated with the project are described in detail below.

The Ted Williams Tunnel (TWT) was named after the legendary Boston Red Sox baseball player. It extends beneath the Boston Harbor and it was the first milestone of the Central Artery/Tunnel Project to be completed. The 0.75-mile underwater part of the 1.6-mile tunnel was built using a dozen steel tube sections, each longer than a football field. They were sunk into a trench on the Boston Harbor floor and connected together.

The tunnel opened on schedule on 15 December 1995 but only to local commercial traffic (with the exception of hazardous cargo). In January 2003, the Connector to the Mass Turnpike (I-90) extension was finalized, thus connecting this third harbor tunnel to the highway system and doubling Boston's cross-harbor tunnel capacity from four to eight lanes. Ted Williams Tunnel is connected to I-90 Massachusetts Turnpike and opened to all traffic, when the connections to the Mass Turnpike (I-90) and Route 1A were completed in mid-January 2003. http://www.massturnpike.com/bigdig/background/twt.html

The Charles River Bridges

The Charles River crossing includes two parallel bridges – a four-lane Leverett Circle Connector Bridge and the Zakim Bunker Hill Bridge. Together, these bridges more than double the cross-river capacity to 14 lanes. They are described below.

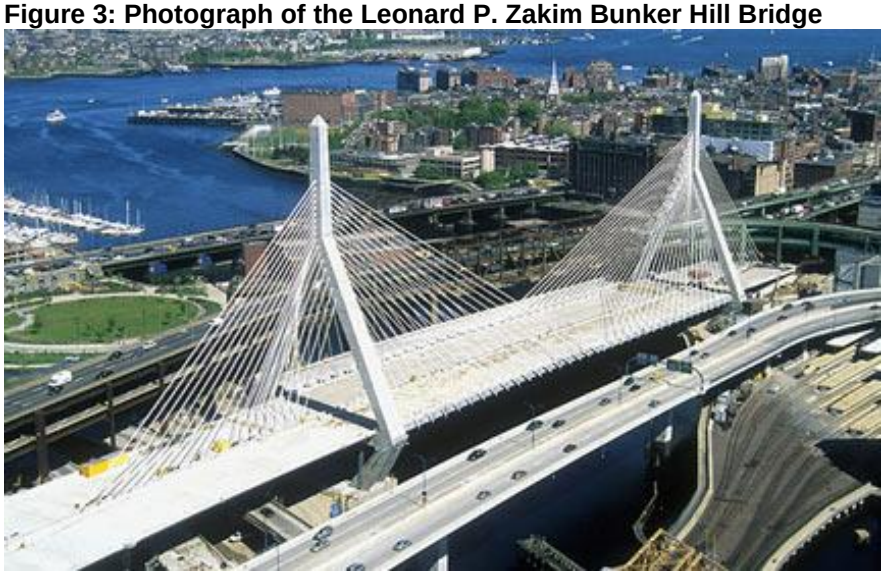
- The Leonard P. Zakim Bunker Hill Bridge

This bridge has been named after the civil rights activist, Lenny Zakim, and the Bunker Hill Monument in nearby Charleston. The design company involved in this project was HNTB, and it was actually designed by Swiss bridge engineer Christian Menn, who shaped the two forked inverted-Y towers to reflect the Charleston monument's obelisk. Recognized as a new landmark gateway to downtown Boston, it is the widest cable-stayed bridge in the world, and the first in the United States with an asymmetrical, hybrid design. The distinctive bridge is supported by two forked towers connected to the span by cables and girders. It was the first bridge in the country to employ this method. [Bridge Pros; MTA, Bridges and Tunnels].

Its ten lanes replaced the deteriorating six-lane double deck bridge (demolished in the spring of 2004) and connect to the underground Central Artery near the Fleet Center at Causeway Street. Eight lanes pass through the legs of the twin towers and two cantilevered on the east side. The cantilever portion, which accommodates northbound traffic from the Sumner Tunnel and the North End, provides the bridge's unique, asymmetrical design. The bridge uses both steel and concrete in its frame, which extends 1,432ft in length. The main span consists of a steel box girder and steel floor beams, while the back spans contain post-tensioned concrete. The back spans on the landside of the towers (measuring 267ft on the downtown side, and 420ft on the Charlestown side) are supported by single planes of cables. The one-plane cable design used on the south back span allowed traffic flow to continue on the existing I-93 connection to Leverett Circle during construction. [MTA, Charles River Bridges; MTA Engineering Marvels].

The Zakim bridge was opened to traffic in three stages – the four lanes of I-93 Northbound were opened first (in March 2003); then, the four lanes of I-93 Southbound were opened in December 2003, and the remaining two lanes were opened to traffic in 2005. The cost of the cable-stayed bridge upon its completion was USD 100m. [Bridge Pros; MTA, Charles River Bridges].

Figure 3: Photograph of the Leonard P. Zakim Bunker Hill Bridge



[Source: MTA website]

This bridge, and its companion bridge (see below), were built within a busy transportation corridor that already houses the Massachusetts Bay Transit Authority's (MBTA) Commuter Rail and Orange Line. In order to avoid impacts on the Orange Line and its ventilation building, the legs of the bridge's concrete towers are truncated in at a 55-degree angle and straddle the MBTA tracks as they surface from the Orange Line tunnel in Charlestown. [MTA Charles River Bridges].

- The Leverett Circle Connector Bridge:

This bridge was completed in October 1999 at a cost of USD 22.27m. It is an 830ft long bridge, with four lanes that parallel the cable-stayed bridge, and connects the Leverett Circle area on the northwestern edge of downtown Boston with points north of the Charles River. The Leverett Circle Connector Bridge opened to traffic eight days ahead of schedule in October 1999. [MTA Charles River Bridges; and MTA Bridges and Tunnels].

Figure 4: Photograph of the Leverett Circle Connector Bridge

Specifications of the Leverett Circle Connector Bridge:

- Main span length – 380ft; back span length - 225ft; bridge width - 76 ft;
- Superstructure: single steel box girder 18ft deep at the piers, nine feet deep at center span;
- Concrete bridge deck;
- Substructure: two water piers, two land bents, cast-in-place, supported on drilled shafts.

[MTA Charles River Bridges].

The I-90 Extension

The Massachusetts Turnpike (I-90) Extension opened to traffic on 18 January 2003. The construction of the I-90 Extension involved some of the most complicated and challenging engineering on the Central Artery/Tunnel Project. It required tunnel jacking, the construction of a casting basin for immersed tube tunneling and cut-and-cover tunnel construction. [MTA Bridges & Tunnels]

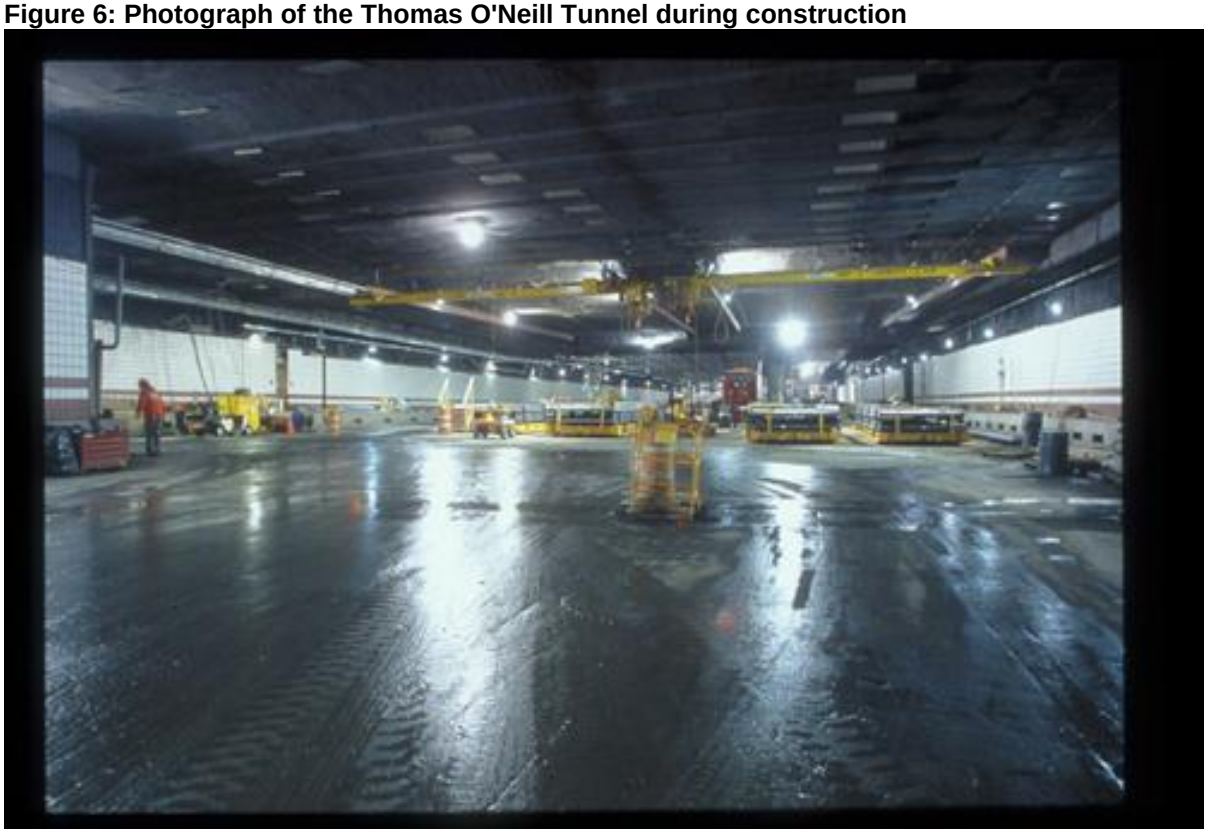
Once this extension was completed, the I-90 offers an uninterrupted connection from Seattle, Washington on the west coast of the United States to Logan International Airport (East Boston) on the east coast. At the same time, MassPike now extends 138 miles from the New York border to Route 1A in East Boston. Thus, for the first time drivers from south and west of Boston have direct access to Logan Airport and Massachusetts' North Shore via I-90 eastbound. This direct, 3.5-mile, route to the airport saves drivers as much as 45 minutes off the previous route, which involved leaving the MassPike, merging onto the old Central Artery northbound and then exiting in the North End to take the Callahan Tunnel to Logan. The new I-90 interchange in South Boston also provides direct access to the center of a vital new development area for the Boston seaport, including the Massachusetts Convention Center. [MTA, Bridges and Tunnels]

Figure 5: Photograph of the I-90 Extension

The Thomas P. O'Neill, Jr. Tunnel (I-93 tunnels)

This extends 1.5 miles underground from Kneeland Street to Causeway Street, which connects to the Leonard P. Zakim Bunker Hill Bridge. This section of the project opened in stages during 2003. [MTA, Bridges and Tunnels]

Figure 6: Photograph of the Thomas O'Neill Tunnel during construction



Project Management

Overview

Design and construction of the project was supervised by the Joint Venture of Bechtel Corporation and Parsons Brinckerhoff.[12] Due to the size and complexity of the project, the design and construction was broken up into dozens of smaller subprojects with well-defined interfaces between contractors. Major heavy-construction contractors were involved on the project, including Jay Cashman, Modern Continental, Obayashi Corporation, Perini Corporation, Peter Kiewit Sons' Incorporated, J.F. White and the Slattery division of Skanska USA (of these, Modern Continental was awarded the greatest gross value of contracts, joint ventures included) [MTA]. In addition, C&C Consultants LLC were responsible for providing civil engineering work on a section of the project (Design Section 1A). Their services included the horizontal and vertical alignment portions, as well as grading, drainage, utility and pump station design, and coordination with the agencies involved. A significant technical problem dealt with was the placement of a high fill over existing utility lines to provide a temporary ramp connection between Congress Street and Summer Street. Because of the fill, C&C had concerns about the added earth pressure on some of the existing utility lines. They called for a structural pad spanning the affected area to carry the added loads. OSHA and utility company regulations regarding maximum depth of manholes had to be carefully checked at a number of locations. [C&C Consultants, website]

[12] Bechtel is based in San Francisco and is one of the world's premier engineering, construction, and project management companies (www.bechtel.com). Founded in 1885 and headquartered in New York City, PB is a leader in the development and operation of infrastructure to meet the needs of communities around the world. The firm provides strategic consulting, planning, engineering, and program and construction management services to both public and private sector clients (www.pbworld.com).

Pre-construction phase

After the Boston Transportation Planning Review recommended against the Inner Belt highway concept, it conducted a brief feasibility study in 1972 for a project to replace the Central Artery with a tunnel. In 1975, engineers at the Department of Public Works (DPW) were tasked with developing a plan for the highway depression, and in 1976 a special Central Artery office was set up at DPW (including Frank Sholock, Dave Wilson, Ed Fitzgerald, Bill Oliver and Jim Allen) to prepare corridor studies for the project, covering three distinct areas. The north area covered the City Square and Charleston; the Central area was in Boston's downtown, and the south needed to connect with a tunnel to the airport. [Kaiser, 1993]

Design studies continued through the decade, in part because Dukakis lost the 1978 gubernatorial election and was replaced by Edward King, who was opposed to replacing the Central Artery with a tunnel. The project was revived during Dukakis' second term. Starting in 1988, the design for the Charles River crossing became a source of major problems and over 27 other plans were developed. Salvucci overrode the internal objections of the agencies involved and chose a variant of the plan known as 'Scheme Z'. This plan was considered to be reasonably cost-effective, but had the drawback of requiring highway ramps stacked up as high as 100ft (30m) immediately adjacent to the Charles River. As described under the 'Public consultation' section, several community groups, advocacy organizations and the city of Cambridge objected to this design. The latter sued to revoke the project's environmental certificate and forced another redesign of the river crossing.

The design to resolve this new challenge was proposed by the Swiss bridge engineer Christian Menn, who suggested a modern, cable-stayed bridge with asymmetrical design using steel and concrete. His plan was accepted in November 1993 and construction began on the Leonard P. Zakim Bunker Hill Memorial Bridge [Sigmund, 2007].

Figure 7: Leonard P. Zakim Bridge

Construction phase

The specific construction components on the project are described above under 'Project overview'. In this section, emphasis is given to the main engineering solutions developed to address major construction challenges encountered during the construction of the Central Artery and the various tunnels and connectors.

The reconstruction of the Central Artery project was a complex endeavor requiring novel engineering solutions to hold up an elevated highway while tunneling directly beneath it.

The builders faced multiple challenges, including difficult soil conditions, relocation of underground utilities, constrained working spaces, preventing damage to glass and steel office towers and fragile old brick buildings, and keeping Boston open for business throughout 14 years of construction. In addition, a number of mitigation measures had to be put in place. [MTA, Engineering]

Figure 8: Photograph of the Central Artery construction project

Use of slurry walls and underpinning of the elevated highway during construction

The contractor's initial plan had been to make a watertight subterranean roadway by building a set of parallel massive vertical slurry walls that would extend from street level down to the bedrock and then digging out the dirt between them. They would then build a concrete tunnel box between these parallel walls and use a membrane to seal the box tight. However, when they looked closely into the actual conditions of the site, the engineers found that the space available was too narrow to accommodate the inner tunnel box and keep the eight lanes specified in the design. Therefore B/PB proposed a novel approach that had never been tried in the United States to build a tunnel – slurry wall construction [Engineering.com; Lewis, 2004; MTA, Engineering Marvels].

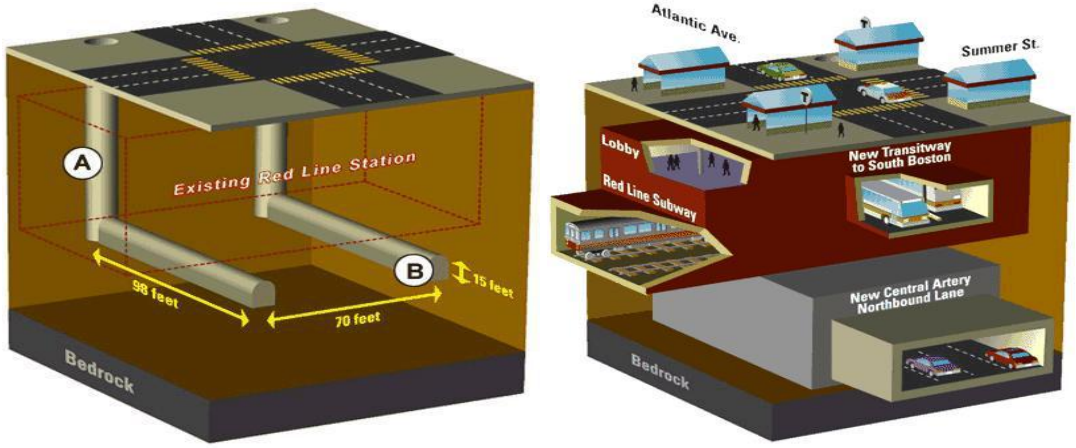
Therefore in the mid-1990s, before excavation could begin, slurry walls were built to buttress the elevated structure. A slurry wall is a concrete wall running from the surface of the ground down to bedrock. It defined the area to be excavated for the underground highway and eventually formed the actual walls of the new Central Artery. 'Slurry' is a clay-water mixture that is pumped into the excavation for the wall to keep the sides intact until concrete is poured. After the tunneled highway opened under the footprint of the elevated Central Artery, Big Dig crews began to demolish the aging elevated highway. That work was finished in 2004, after southbound traffic was also shifted underground. [MTA Engineering Marvels].

Because the old elevated highway was six lanes wide and the new one was projected to be from eight to ten lanes wide, every footing supporting the columns holding up the elevated roadway sat directly in the path of the new highway tunnel. It was then necessary to remove each of these footings while keeping the structural integrity of the existing roadway still in service. Therefore, all the load of the structure had to be shifted onto new supports resting on the walls of the new tunnel. This process of transferring the weight from one structure to another is called 'underpinning'. [Lewis, 1993]

The same process was used to meet another challenge – digging the tunnel underneath the subway lanes. Below Dewey Square, four northbound lanes of the underground highway needed to cross under the Red Line subway tunnel, as well as another tunnel for the Silverline, an electric bus line that was underway at that time (originally called Transitway). Building slurry walls as in the rest of the central artery was not an option if the subway

structures and services were to be preserved. The main problem was that slurry walls require digging concrete panels into the bedrock but the subway infrastructure was blocking the way down. The engineering solution was to build a gigantic reinforced concrete table or box resting on bedrock under the Red Line's tunnel to support the subway while providing a secure place for the highway. Thus, this process of underpinning was more complicated than building the rest of the central artery. The pictures below provide a schematic representation of the 'before' and 'after' engineering project. [Engineering.com; MTA Engineering Marvels].

Figure 9: The 'before' and 'after' engineering project



[Source: Illustrations available at Engineering.com]

Another challenging problem – the highway tunnel crossing Boston's Fort Point Channel - was addressed by building a 'casting basin'. This involved the use of tunnel sections lowered into a trench, similar to the technique used to build the Ted Williams Tunnel under the harbor. Furthermore, traffic between both tunnels connects via an I-90 extension, which needed to cross underneath nine active railroad tracks, including Amtrak. [Engineering.com; MTA, Engineering Marvels].

Major construction flaws

While certain errors were probably expected in a project of this complexity, some major design or construction flaws have been found in the project since 2004.

The first major problem occurred in September 2004, when water burst through a wall of the northbound side of the Thomas P. O'Neill Tunnel, indicating that there were leak problems in the tunnel. The wall breach was linked to pockets of sand or gravel left under the three-foot concrete walls. The highway was temporarily closed, and traffic disrupted, while construction managers looked for and repaired such defects. During this process towards the end of 2004, more than a thousand leaks were found in the O'Neill tunnel. [Estes & Murphy, 2007].

When it became clear that the extent of the problem was large, Governor Mitt Romney asked (without success) that Mathew Amorello resign from his post as MTA chairman [Toll Road News, 2004]. In November 2004, the Massachusetts state auditor Joseph DeNucci published a report stating that knowledge of serious leakage issues went back to 1997. The audit office had secured papers from the Federal Highway Administration (FHWA), including a report of a Waterproofing Task Force Team comprised of officers of Bechtel/PB, the Massachusetts Highway Department (predecessor to the Turnpike as state manager) and

the FHWA. The report found that an evaluation conducted in 1997 had reported that the waterproofing work was very poor. An article in Toll Road News (2004) summarizes the problem and related development afterwards as follows:

- The leak problems are attributed to the contractors allowing clay and debris to fall into concrete work, thus forming pathways for water;
- Faulty surface preparation for sealants and membranes;
- Poor application practice; the workers applying the waterproofing were poorly trained and did not know or follow the manufacturer's instructions;
- All three major waterproofing methods were failing: Bentonite, Polyurethane and sheet HDPE (high density poly ethylene);
- While the contractor, Modern Continental, has been identified as the responsible party for this problem, the lack of appropriate supervision and poor quality control of the waterproofing work indicates that the Joint Venture shares the responsibility. [Toll Road News, 2004]

The tunnel's design planned for no such leaks, but as much as 1.9m gallons of water were being pumped out each month, according to information disclosed in March 2007. The Turnpike Authority, which manages the Big Dig, has acknowledged that hundreds of leaks remain and that plugged leaks are regularly reopening. Finding and plugging leaks is expected to continue indefinitely. [Estes & Murphy, 2007].

Major accident

Another large defect in construction was tragically found in July 2006, when 26 tons of concrete fell down in the Interstate 90 connector tunnel, killing a passenger and injuring the driver in a car traveling to Logan Airport. This fatal construction flaw was linked to the failure of the epoxy adhesive and the insufficient number of bolts used to attach the concrete ceiling to the roof of the tunnel. "The evidence suggests that the epoxy-and-bolt system used to fasten the concrete slabs overhead is so commonly used that its failure seems unique to the Big Dig. 'That technique is used extensively,' says Jerome Connor, a structural engineering professor at the Massachusetts Institute of Technology (MIT) in Cambridge. Epoxy is a high-strength adhesive that often requires mixing on-site before installation. "It's the fact that they only used a limited number of bolts - there was a very low margin of safety," says Dr. Connor, who was not personally involved in the investigation" [Bradley, 2006].

Figure 10: Workers walk from a Big Dig tunnel in Boston on 11 July 2006. Cement ceiling panels fell from the open area visible in the center of the photo

(Source: Associated Press /The Boston Globe, George Rizer)i

Figure 11: Firefighters inspect a section of ceiling in the Interstate 90 eastbound connector tunnel through Boston that collapsed onto the roadway

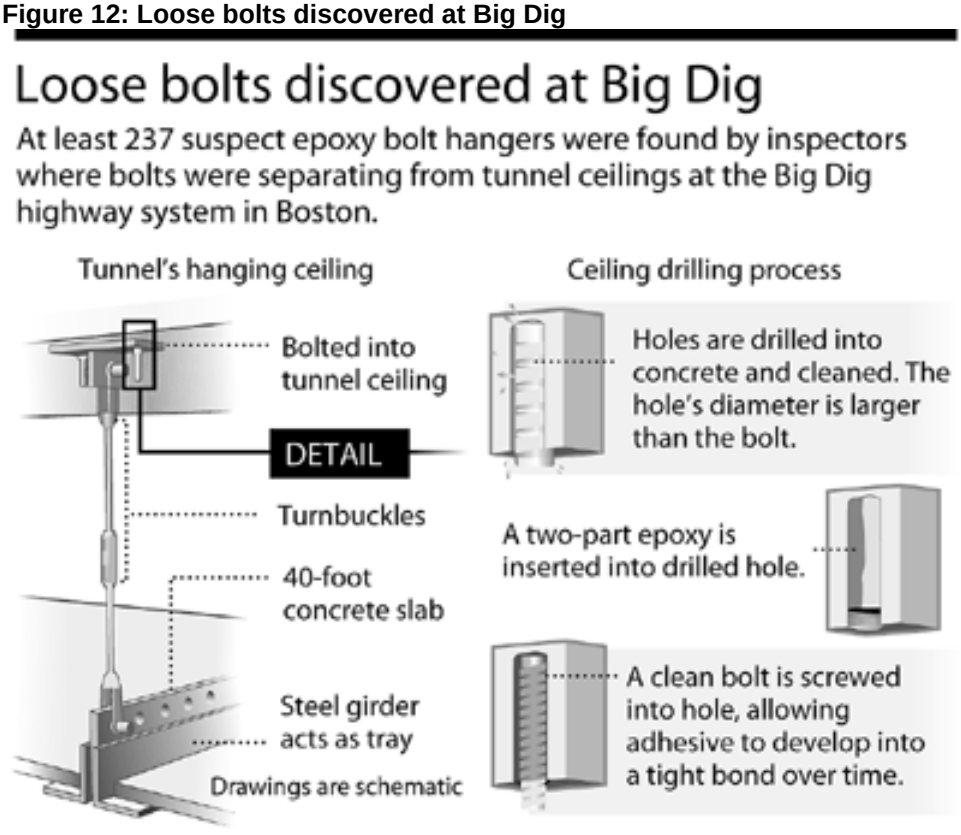
(Source: Associated Press / Newser, Photograph from July 10, 2006. http://www.newser.com/article/d9895nj00/promises-promises-three-years-after-big-dig-collapse-no-action-on-tunnel-inspection-plan.html)

An accident report by the National Tunnel Safety Board (NTSB) in July 2007 found fault not only with the contractors but also with the transportation agency in charge of the project. While the contractors used the wrong type of adhesive and applied too few bolts to secure the concrete slabs to the tunnel's ceiling, the Massachusetts Turnpike Authority failed to implement a tunnel inspection program [Miga, 2009]. After the accident, the MTA claimed that it had inspected the affected section of the ceiling in 2003 but there are no records to confirm that anyone crawled into the five-foot space above the suspended ceiling to check the condition of the adhesive, or the number of bolts. Subsequently, the agency failed again to inspect the tunnel as required by its obligation to bondholders [Allen & Murphy, 2006].

It seems that the one problem with the faulty construction was the State of Massachusetts' lack of adequate supervision of private contractors. David Luberoff, Executive Director of the Rappaport Institute for Greater Boston has asked whether this "was the right management structure for a large project." Bechtel/Parsons Brinckerhoff, the joint venture leading the Big Dig, was involved in both the design and construction efforts - an arrangement that some observers say may have complicated the project's oversight [Bradley, 2006]. Moreover, an article in *Toll Roads News* reports that: "the Bechtel/Parsons Brinckerhoff joint venture put out thousands of incomplete and erroneous engineering drawings generating constant mid-course corrections during construction and thousands of cost-escalating change orders. They conspired with state officials to cover up both financial and engineering problems, failed to properly supervise contractors, and throughout billed the state for their own mistakes. Their total take from the project is put at USD 2bn for a project initially estimated to cost in total USD 2.5bn." [Toll Roads News, 2004]

Figure 12 offers a schematic interpretation of the technique commonly used on this type of projects.

Figure 12: Loose bolts discovered at Big Dig



(Source: Rome's News Tribune, 15 July 2006 edition)

D PROJECT TIMELINE

Table 2 includes details about the project's timeline for key events associated with the project. Table 3 provides a summary of the project schedule, as described by the 'MTA's Project Schedule and Timeline' webpage, while Table 4 shows the timeline of associated developments.

Project Timeline

The Big Dig is the unofficial name of the Central Artery/Tunnel Project (CA/T), a megaproject that rerouted the Central Artery (Interstate 93), the chief highway through the heart of Boston, into a 3.5 mile (5.6km) tunnel under the city. The project also included the construction of the Ted Williams Tunnel (extending Interstate 90 to Logan International Airport), the Leonard P. Zakim Bunker Hill Memorial Bridge over the Charles River, and the Rose Kennedy Greenway in the space vacated by the previous I-93 elevated roadway. Initially, the plan was also to include a rail connection between Boston's two major train terminals. The project concluded on 31 December 2007, when the partnership between program manager Bechtel/Parsons Brinckerhoff and the Massachusetts Turnpike Authority ended.

Table 2: Timeline: the Boston Downtown Corridor (Central Artery) and the Tunnel Project (CA/T)

Year	Month	Type of Decision / Action	Description / Comments	References/ Stakeholders
1930		A city planning board noted that Boston's "street system should be adapted to the requirements of the motor age" and proposed an elevated expressway – the Central Artery.	The Central Artery's first planners acknowledged that "the erection of … elevated structures ... in downtown Boston" would hurt some residents' quality of life. But a "vehicular subway" - the first mention of the idea that, half a century later, would become the Big Dig - "would interfere with sewers and with … rapid transit subways."	Nicole Gelinas, reporter, City Journal article: "Lessons of Boston's Big Dig." Dan McNichol, its former deputy director of public affairs, in his book The Big Dig http://www.discovery.org/a/3440
1954		Last stretch of the Boston Artery project buried in a tunnel. (Boston understood the Artery's impact so quickly that in 1954 it changed tack and buried a last stretch in a tunnel).	The Artery vivisected Boston; it barred pedestrians from the water and overwhelmed low-rise streets, a historic outdoor fruit and vegetable market, and even the historic Faneuil Hall with traffic, noise, and shadow. It erased swaths of the working-class Italian North End, displacing 573 businesses - mostly small shops and trading firms - and hundreds of families. Owners of some buildings that escaped the bulldozers bricked over windows that faced the Artery.	Nicole Gelinas, reporter, City Journal: "Lessons of Boston's Big Dig."
1959		Elevated Central Artery is opened for traffic.		
1972-1985		Concept of burying Central Artery is created and revived throughout this	Fred Salvucci, Dukakis's Transportation Secretary, reignited proposal for the Big	• Fred Salvucci, Dukakis's Transportation Secretary

		period. Planning for the Big Dig as a project officially began in 1982, with environmental impact studies starting in 1983. The Final EIS report is completed in 1985. In 1985 the price tag for the project was estimated at USD 2.6bn (or ~6bn in inflation adjusted 2006 dollars), but it didn't include mitigation or real costs for staying on schedule.	Dig project in 1983. His proposal emphasized five themes: 1) he called on the business community to support the artery "depression" in exchange for support for the tunnel to East Boston. 2) he rushed to meet the 30 September 2009 deadline EIS for unbuilt portions of the interstate system in MA. 3) he proposed to widen the artery and build a general purpose tunnel; 4) he promised to build without major traffic disruption using 'slurry wall' construction technology; and 5) he emphasized that the existing artery was nearing the end of its useful life.	Reference: Gelinas; and, Alan Altshuler and David Luberoff 'Megaprojects…'
1986-1990		Many visions and plans put forward for the corridor. Bechtel/Parsons Brinckerhoff begins work as management consultant.		
1987		US Congress approves funding and scope of project, through a public works bill appropriating funding for the Big Dig. Building acquisition and business relocation process begins (no private homes taken). Construction starts in Charlestown.	Massachusetts Democrat Tip O'Neill, the House's majority leader and soon to be its Speaker, in 1976 inserted 'placeholder' funds for the Big Dig into a congressional blueprint of costs to complete the Interstate Highway System. In 1987 Reagan vetoed a highway bill that contained the Big Dig's first significant federal funding, but Tip O'Neill and Ted Kennedy garnered enough supporters, including 13 Republicans, for an override.	
1988		Final design process under way. Exploratory archaeology digs begin.		
1989		Scheme Z for the Charles River crossings is rejected by the public. Preliminary/final design and supplemental environmental review continue, because		

		a new design process starts for the Charles River crossings.		
1990		State Secretary of Environmental Affairs approves downtown construction. Congress allocates USD 755m to project.	Approval conditional on acceptable open space and development balance being created over the Big Dig.	
1991		Federal Highway Administration issues Record of Decision, the construction go-ahead. Final Supplemental Environmental Impact Statement/Report (FSEIS/R) approved. Construction contracts begin to be advertised and awarded. Construction begins on Ted Williams Tunnel and South Boston Haul Road. Ground was first broken in 1991 and construction of the Downtown Corridor starts in 1991. The project was managed by the Massachusetts Turnpike Authority, with the Big Dig and the Turnpike's Boston Extension from the 1960s being financially and legally joined by the legislature as the Metropolitan Highway System. Price tag raised to USD 8bn and then in 1994, to USD 14bn. Bechtel and Parsons officials compiled convincing evidence that the Big Dig would cost nearly USD 14bn in completion-year dollars and took their findings to the state, but the state decided	Starting in 1991 and over 14 years, Massachusetts, its consultants and its contractors designed and built seven and a half miles of highway - 161 miles of separate lanes - more than half of them in tunnels. They built six interchanges and 200 bridges - all without major interruptions to businesses and other activities. Contractors were allowed to start work on pieces of the project before designs for other key parts were complete. This approach - part of the project's philosophy of getting things done now and asking questions later - meant expensive changes to contracts. By the early 1990s, as the state added new work, and as its consultants and contractors looked underground to see what was actually there, the Big Dig's price tag had ballooned to nearly USD 8bn. As early as 1991, the state's inspector general warned of the "increasingly apparent vulnerabilities ... of	Wikipedia • Keith Sibley, Bechtel and Parsons's longtime Big Dig director. • Former State Inspector General Bob Cerasoli

		to keep this information from the public. Mitigation measures are included as part of the construction plan.	[Massachusetts's] long-term dependence on a consultant" whose contract had an "open-ended structure" and "inadequate monitoring." Mitigation made downtown businesses happy, promising not to shut down any of the Central Artery's six lanes during construction, and promising further that companies wouldn't lack electricity or telephones for even a few hours. Mitigation eventually accounted for about one-third of the Big Dig's cost - from the thousands of dollars needed to outfit North End apartments with air conditioning, soundproof windows, and firm mattresses as residents settled in for a decade of construction to the more than USD 1bn needed to rework a planned bridge that business leaders, residents, and the nearby city of Cambridge considered ugly.	
1992		More than USD 1bn in design and construction contracts under way. Dredging and blasting for the Ted Williams Tunnel ongoing. Downtown utility relocation to clear path for Central Artery tunnel construction begins. Archaeologists find 17th and 18th century artifacts at a North End dig.		
1993		South Boston Haul Road opens. All 12 tube sections for Ted Williams Tunnel are placed and connected on harbor floor.		
1994		Charles River Crossing revised design		

		and related FSEIS/R approved. New set of loop ramps open in Charlestown.		
1995-1998		The 'Consensus Plan' is adopted by city and state to locate streets and sidewalks, defining final parcel boundaries for the Greenway that will be built after the elevated CA structure comes down. Ted Williams Tunnel opens in 1995 but use is limited to commercial traffic and high-occupancy vehicles. Downtown slurry work under way for I-93 tunnels in 1996. Overall utility work 80% completed in 1997. The federal government imposed a permanent funding cap on the project. (YEAR?) Gov. Weld transferred Big Dig's assets to the MA Turnpike Authority (YEAR?)	Governor Weld needed a ready source of money for the project, without hiking taxes or cutting spending elsewhere. So he transferred the Big Dig's assets to the Massachusetts Turnpike Authority, an unaccountable public entity akin to New York's Metropolitan Transportation Authority, in return for some of the authority's future toll revenue, which would back Big Dig bonds.	
1998		MA state government further blurred the distinction between public and private sectors by folding Bechtel and Parsons employees and its own workers into one 'integrated project organization' in 1998. Construction begins on the Charles River Crossing.		
1999		Process begins to select developers for parcels targeted for buildings Overall construction 50% complete.		

		New Broadway Bridge opens. Leverett Circle Connector Bridge opens.		
2000-2001		Master plan for final parcels is assembled by Turnpike Authority, with program ideas, design guidelines and principles. Nearly 5,000 workers employed on the Big Dig		
2001	April	A 'request for qualifications' sent out by Turnpike Authority chairman Matthew Amorello to solicit designers for the North End parcels. Overall construction 70% complete.		• Turnpike Authority chairman Matthew Amorello
2001	Early May	Unilateral decision by Turnpike Authority Chairman, Amorello, to begin the process for accepting designs for the key Wharf District parcel of the Artery, rather than waiting until a new governing body could be created.	These and the previous month's decision by Amorello rankled Acting Governor Jane Swift, Mayor Thomas Menino, and House Speaker Thomas M. Finneran. They were negotiating the creation of a public-private trust to take over the project instead of the Turnpike Authority.	• Acting Governor Jane Swift • Mayor Thomas M. Menino • House Speaker Thomas M. Finneran
2001	31 May	A national panel of experts in governance, landscape architecture and design called on the Legislature to create a public-private trust by year's end (2001) to design, build and operate the Rose Kennedy Greenway, the 30-acre ribbon park to sit above the Central Artery tunnels in downtown Boston.	The proposal was one of nine ideas debated during a panel discussion titled 'Beyond the Big Dig', a four-month exploration of the future of the Surface Artery, sponsored by the Globe, WCVB-TV, and the Massachusetts Institute of Technology. The event took place as debate on the Greenway has begun in earnest, nearly 12 years after the Big Dig commenced. The land, which runs more than a mile from the Charles River to Chinatown, is owned by the Turnpike Authority, but several lawmakers and observers have lately	The panel included: • Jill Ker Conway, chairwoman of Lend Lease Corp.; • Hubie Jones, co-director of Boston's City-to-City program and special assistant to the chancellor for urban policy, UMass-Boston. • M. David Lee, partner with Sull and Lee Architects; • Laurie Olin, partner at Olin Partnership; and • Elizabeth Barlow Rogers, author of "Landscape Design" • MA Senate President Thomas F.

			called for a new body to take control. Eight other recommendations were made by the panel, including: 1) that a 'Common Ground Task Force' of neighbors, businesses and cultural leaders be formed to produce and manage major public events on the Greenway; 2) that the 'Garden Under Glass' greenhouse proposal be adopted "as a critical anchor" to the Artery park, but that the Massachusetts Horticultural Society, the presumptive creator of the structure, present a master plan and funding no later than 1 January 2004 or risk losing its place on the Greenway; 3) that at least one additional 'major public attraction' be located on the Greenway; 4) that the two parcels containing highway ramps be covered with 'imaginative structures'; 5) that at least 2,000 units of new housing, a quarter of which would be affordable, be built on the perimeter of the park. 6) that the city of Boston create at least 1m square feet of 'cultural and commercial activities' along the park's edge, and 7) that streets crossing the Greenway "become elegant tree-lined promenades." A spokeswoman for Senate President Thomas F. Birmingham, Alison Franklin, said Birmingham "supports the trust that unites public and private support to attract the talent, resources, and vision we need." Richard Dimino, president of the Artery Business Committee, said the panel's recommendation should strengthen the push for the creation of a trust: "Their	Birmingham • Richard Dimino, president of the Artery Business Committee; former city transportation commissioner and current President of the business group A Better City. • Raphael Lewis, Globe Staff • Senate President Thomas F. Birmingham

			objective views and expertise have concluded what we at the ABC, and many others, believe is an essential element of getting this thing right.''	
2002	 14 April 11 May 30 May	New concepts advanced by the city and state to create a management entity for the Downtown Corridor. Leonard P. Zakim Bunker Hill Bridge completed. Creative Community Conversations: On 14 April, some 230 people took part in the first of two public forums about the future of the Central Artery land. A second workshop was held on 11 May at Boston English High School. 30 May meeting at Faneuil Hall to present the ideas to a joint state and city committee responsible for choosing a developer for the corridor, parts of which will be ready for development in less than three years.	This effort included a major exploration undertaken by *The Boston Globe* and Massachusetts Institute of Technology (MIT), in association with WCVB-TV Channel 5, of the open space options for the new land being created by the depression of the Central Artery. Participants were placed into small groups and asked “to dream about what the parks could be.” In an effort to collect ideas about what should be built on the mile-long stretch of land that will open once the Central Artery is torn down, the Boston Foundation and the Boston Society of Architects yesterday asked more than 200 city residents, workers, and those concerned about Boston's future to draw up a wish list.	Co-sponsors: • The Boston Foundation and Boston Society of Architects • WCVB-TV5 • Boston Society of Landscape Architects Others: • Mark Maloney, Boston Redevelopment Authority • Peter DeMarco, *Globe* Correspondent See other list under: http://www.boston.com/beyond_bigdig/conversations/benefactors.htm
2002-2003	September 2002 15 January 2003	*Key legislator questions need to create trust for Big Dig land* *Design teams selected*	With opposition growing to the creation of a public trust to control the Surface Artery land left behind by the Big Dig, a key legislator yesterday said a new organization may not be needed. Senator Robert A. Havern III, an Arlington Democrat who is co-chairman of the Legislature's Transportation Committee, said the matter of who should own and control 30 acres from Causeway to Kneeland streets may be too complicated to resolve now.	• Senator Robert A. Havern III, Arlington Democrat and co-chairman of the Legislature's Transportation Committee

	February 2003	*Last Surface Artery design team picked*	Teams selected to design final parcels. The three teams chosen to design eight of the eleven key park parcels were opened to ideas and proposals from other designers, neighbors and interested parties near and far. More than a decade after planning began to restore the Surface Artery corridor and return it to the use of Boston residents and visitors, the designer selection process is complete. Public Library forums in February 2003 on the design of the Rose Kennedy Greenway showed that the project was capturing Boston's imagination.	
2003-2004	17 January 2003 March 2003 and December 2003	The last parcels are designed I-90 Connector from South Boston to Rt. 1A in East Boston opens in January. I-93 Northbound opens in March. I-93 Southbound opens in December.	The opening ceremony was held for the I-90 Connector Tunnel, extending the Massachusetts Turnpike (Interstate 90) east into the Ted Williams Tunnel, and onwards to Logan Airport. Moving the elevated Interstate 93 underground was completed in two stages: northbound lanes opened in March 2003 and southbound lanes (in a temporary configuration) on 20 December 2003.	
2004	15 September	The open parcels are completed. Dismantling of the elevated Central Artery (I-93). A major leak in the Interstate 93 north tunnel forced the closure of the tunnel	Construction of the buildings on other parcels continued.	http://masspike.com/bigdig/updates/timeline.html

	December	while repairs were conducted in September 2004. A tunnel underneath Leverett Circle connecting eastbound Storrow Drive to I-93 North and the Tobin Bridge opened 19 December 2004, providing access to I-93 North and Tobin Bridge.	The main parts of the project are finished by the end of 2005.	
2005	25 March	Full opening of I-93 South, including the left lane of the Zakim Bridge, and all of the refurbished Dewey Square Tunnel. Opening of the completely renovated Dewey Square Tunnel, including new exit and entrance ramps. Opening of the two cantilevered lanes on Leonard P. Zakim Bunker Hill Bridge. Opening of permanent ramps and roadways at I-90/I-93 Interchange and in other areas.		
2006	13 January March 10 July	The final ramp downtown (exit 20B from I-93 south to Albany Street) opened in January 2006. Thus reaching substantial completion of the Central Artery/Tunnel Project. Spectacle Island Park opens to the public. The State of Massachusetts threatens to sue contractors, demanding that contractors refund taxpayers USD 108m for shoddy work. Falling concrete panels in a Big Dig	Designers engineered a lightweight ceiling for the tunnel but MA, annoyed by cost overruns and cleanliness problems on a similar ceiling, and at the suggestion of federal highway officials, decided to fit the new tunnel with a cheaper ceiling, which turned out to be heavier. The ceiling's designer, a company called Gannett Fleming, called for contractors to install the ceiling with an unusually large built-in margin for extra weight. Shortly after contractors installed the ceiling - using anchors held by a high-strength epoxy, as Gannett specified - workers noticed that it was coming loose. Consultants and contractors decided to take it apart and	Reference: International Herald Tribune. "State weighs suing 'Big Dig' contractors". 2006-03-20. http://www.iht.com/articles/2006/03/19/news/notes.php.

		tunnel that had been open for three years killed Milena del Valle, a 38-year-old car passenger.	reinstall it. Two years later, after a contractor told Bechtel that "several anchors appear to be pulling away from the concrete," Bechtel directed it to "set new anchors and retest". After the resetting and retesting, the tunnel opened to traffic, with fatal consequences.	
2007	December	Restoration of Boston city streets. Continued construction of the Rose Kennedy Greenway and other parks. Construction on development parcels will continue after the Central Artery/Tunnel Project is finished.	The Big Dig, Massachusetts's three-decade long quest to bury and expand the Central Artery, Boston's major interstate highway, and carve out a new underwater tunnel to Logan Airport was completed in late 2007. The most expensive public works project in the history of the United States came to an end. The project, estimated at USD 2.6bn ended up costing more than six times that, almost USD 15bn (USD 14.8bn).	http://masspike.com/bigdig/updates/timeline.html
2008	23 January 24 January July	Bechtel/Parsons Brinckerhoff agreed to pay USD 407m in restitution for its poor oversight of subcontractors (some of whom committed outright fraud), as well as primary responsibility in the death of a motorist. Several smaller companies agreed to pay a combined sum of approximately USD 51m. About USD 100m of the landmark USD 458m Big Dig settlement will be quickly drained to fix a long list of defects, many previously undisclosed, from cracked sidewalks and crosswalks to failing fireproofing, faulty wiring and deteriorated joints between sections of roadways. Project estimated to cost USD 22bn.	However, despite admitting to poor oversight and negligence as part of the settlement, the firm is not barred from bidding for future government contracts. A 17 July 2008 article in *The Boston Globe* stated, "In all, the project will cost an additional USD 7bn in interest, bringing the total to a staggering USD 22bn, according to a Globe review of hundreds of pages of state documents. It will not be paid off until 2038."	Reference: Boston Globe, *"Big Dig settlement will take quick hit USD 100m is needed for immediate fixes."* Article by Andrea Estes, Globe Staff / 24 January 2008

(Source: Rudin Center for Transportation Policy and Management 2009. The Boston Downtown Corridor (Central Artery) and the Tunnel Project (CA/T) Timeline)

Table 3: Central Artery/Tunnel Project Milestones
(as presented in MTA's Project Schedule and Timeline)

1982:	Work begins on Final Environmental Impact Statement/Report (FEIS/R)
1985:	Final Environmental Impact Statement/Report (FEIS/R) filed and approved early the next year.
1986:	Bechtel/Parsons Brinckerhoff begins work as management consultant.
1987:	Congress approves funding and scope of Project. Building acquisition and business relocation process begins (no private homes taken).
1988:	Final design process under way. Exploratory archaeology digs begin.
1989:	Preliminary/final design and environmental review continue.
1990:	Congress allocates USD 755m to project.
1991:	Federal Highway Administration issues Record of Decision, the construction go-ahead. Final Supplemental Environmental Impact Statement/Report (FSEIS/R) approved. Construction contracts begin to be advertised and awarded. Construction begins on Ted Williams Tunnel and South Boston Haul Road.
1992:	More than USD 1bn in design and construction contracts under way. Dredging and blasting for the Ted Williams Tunnel ongoing. Downtown utility relocation to clear path for Central Artery tunnel construction begins. Archaeologists find 17th and 18th century artifacts at a North End dig.
1993:	South Boston Haul Road opens. All 12 tube sections for Ted Williams Tunnel are placed and connected on harbor floor.
1994:	Charles River Crossing revised design and related FSEIS/R approved. New set of loop ramps open in Charlestown.
1995:	Ted Williams Tunnel opens to commercial traffic.
1996:	Downtown slurry work under way for I-93 tunnels.
1997:	Overall utility work 8% complete.
1998:	Enter peak construction years. Construction begins on the Charles River Crossing.
1999:	Overall construction 50% complete. New Broadway Bridge opens. Leverett Circle Connector Bridge opens.
2000:	Nearly 5,000 workers employed on the Big Dig
2001:	Overall construction 70% complete.
2002:	Leonard P. Zakim Bunker Hill Bridge completed.
2003:	I-90 Connector from South Boston to Rt. 1A in East Boston opens in January. I-93 Northbound opens in March. I-93 Southbound opens in December.
2004:	Dismantling of the elevated Central Artery (I-93). Opening of the tunnel from Storrow Drive to Leverett Circle Connector, which provides access to I-93 North and Tobin Bridge.
2005:	Full opening of I-93 South. Opening of completely renovated Dewey Square Tunnel, including new exit and entrance ramps. Opening of the two cantilevered lanes on Leonard P. Zakim Bunker Hill Bridge. Opening of permanent ramps and roadways at I-90/I-93 Interchange and in other areas.
2006:	Reached substantial completion of the Central Artery/Tunnel Project in January. Spectacle Island Park opens to public, after restoration with soils from tunnels excavation project.
2007:	Restoration of Boston city streets.

	Continued construction of the Rose Kennedy Greenway and other parks. Construction on development parcels will continue after the CA/T Project is finished.
2008:	The Rose Kennedy Greenway opens to the public

(Check: http://www.boston.com/news/specials/big_dig_problems/)

Timeline of associated developments

(as presented under MTA Economics section)

Table 4: Timeline of associated developments

1957:	Massachusetts Turnpike opens from New York State border to Route 128 in Newton. Prudential Insurance Company and Turnpike Authority reach deal to allow development on air rights above Turnpike extension.
1960:	Prudential Insurance Company announces that the Turnpike extension is critical to the success of their development.
1962:	Groundbreaking for Turnpike extension from Newton to Boston.
1963:	USD 200m Prudential Center Tower opens with mix of office, residential and retail uses. 1,182,000sq.ft. Municipal Auditorium (later the Hynes Convention Center) opens. 450,000sq.ft.
1964:	Sheraton Boston opens. 1,250 rooms.
1965:	Turnpike extension opens from Newton to Boston.
1967:	Boylston Apartment Tower, Fairfield Apartment Tower, and Gloucester Apartment Tower open as part of the Prudential Center. 781 units.
1969:	John Hancock parking garage built over Turnpike.
1972:	101 Huntington Avenue, part of the Prudential Center, opens. 550,000sq.ft.
1975:	John Hancock Tower opens. 1.6m sq.ft.
1982:	Boston Marine Industrial Park Opens. Planning begins for Central Artery/ Third Harbor Tunnel Project.
1983:	USD 500m Copley Place mixed use project opens. 3.4m sq.ft.
1985:	Ingalls Building at 855 Boylston St. opens across from Prudential. 46,404sq.ft.
1986:	New Back Bay Station opens with Amtrak and Orange Line service. 500 Boylston opens. 715,000sq.ft. World Trade Center Meeting and Conference Center opens (rehab of 1914 Commonwealth Pier Building). 850,000sq.ft. of meeting/exhibition/conference space.
1988:	Tent City housing development opens at Dartmouth and Columbus across from Copley Place. 203 low-income units and 66 market rate units, all rental units. Heritage on the Garden retail and residential complex opens at Boylston and Arlington Streets. 87 condominiums, 118,000sq.ft. of office space and 40,000sq.ft. of retail space.
1991:	Construction begins for Central Artery/Third Harbor Tunnel Project.
1993:	Phase I of Prudential Redevelopment opens, with a 70-store retail arcade. When complete, this increases Prudential Center to 7m sq.ft. (All uses).
1995:	Ted Williams Tunnel opens to commercial traffic.
1998:	John Joseph Moakley United States Courthouse opens on Fan Pier. *(In 2001, the Courthouse was officially dedicated to honor Congressman Moakley.)* Seaport Hotel opens. 427 rooms.
2000:	World Trade Center East office building opens. 490,000sq.ft. of Class A office space and 12,000sq.ft. of retail space.
2001:	111 Huntington Avenue, Phase II of the Prudential redevelopment opens. 840,000sq.ft. of Class A office space and 70,000sq.ft. of retail.

2002:	The Belvedere at Prudential opens. 65 condominiums. Boston Convention and Exhibition Center (BCEC) opens. 1.7m sq.ft. including 600,000 sq.ft. of exhibition space. 131 Dartmouth opens. 369,000sq.ft. of office space. Ted Williams Tunnel is connected to I-90 Massachusetts Turnpike and opened to all traffic.
2003:	I-93 Central Artery opens initial underground northbound and southbound lanes. World Trade Center West office building opens. 517,000sq.ft. of Class A office space and 34,000sq.ft. of retail space.
2004:	Developers selected for 12 acre 'Core Parcel' Waterside Place. 1.2m sq.ft., including 600,000sq.ft. retail space, 276 condominiums, and a 457 room hotel. ManuLife Headquarters opens. 420,000sq.ft. of office space. Westin Hotel under construction. 790 rooms.
2005:	I-93 Central Artery opens full use of all northbound & southbound lanes. Silver Line Transit buses start service in South Boston Seaport District and connecting to the Logan Airport through the Third Tunnel. Greenway Place at 199 State Street opens. 12 condominiums with view of Rose Fitzgerald Kennedy Greenway space. Boston Harbor Residences on Northern Avenue under construction. 465 residential units in two phases. Channel Center Phase I opens. Phase II to include retail, office, and housing. 76 housing units. 21 acre Fan Pier site sold. New mixed use development plan under review. 3m sq.ft. of built space proposed.
2006:	Inter-Continental Boston and the Residences at the Inter-Continental to open. Project built around Artery Vent Building. 424 hotel rooms and 130 condominiums. Construction of the Allston Turn-Around serving the Copley/Prudential, South Boston Seaport District and Logan International Airport Exits.
2007:	Construction of the Rose Fitzgerald Kennedy Greenway, including 30 acres of parks and open space is nearing completion.
2008:	The Rose Fitzgerald Kennedy Greenway opens to the public. Residences at Mandarin Oriental open, including 50 condominium units.

<u>Planned or in development</u>

- Columbus Center groundbreaking. 500 condominiums, 199 hotel rooms. 1.3m sq.ft. First air rights development since Copley Square (approved);
- Pier 4 site. 200 housing units, 225 hotel rooms, 385 Class A office space, and 35,000sq.ft. of retail;
- Russia Wharf adaptive reuse and new development. 50 loft housing units, 300 hotel rooms, 500,000sq.ft. of Class A office space, 22,000sq.ft. of retail;
- 776 Boylston East building (part of Prudential Center) (approved);
- 888 Boylston Street (part of Prudential Center) (proposed);
- Millennium Tower condominiums over the Turnpike (proposed);
- The Clarendon. 350 rental and homeownership housing units (approved).

E PROJECT FUNDING/FINANCING

Introduction and project costs

The Big Dig turned out to be the most expensive highway project in the United States. Initial cost estimates in 1985 had put the price tag at USD 2.8bn (in 1982 dollars, USD 6.0bn adjusted for inflation as of 2006) [CNN, 2006; Inflation Calculator]. Yet, as of 2006, over USD 14.6bn (USD 8.08bn in 1982 dollars) had been spent in Federal and State tax dollars [Johnson, 2006]. However, as a 17 July 2008 article in the *Boston Globe* stated, "In all, the project will cost an additional USD 7bn in interest, bringing the total to a staggering USD 22bn, according to a *Globe* review of hundreds of pages of state documents. It will not be paid off until 2038" [Murphy, 2008]. User fees are not charged on the Central Artery but there are tolls on the Ted Williams Tunnel and other sections of the Massachusetts Turnpike [Howe, 2006].

In July 2007, the Massachusetts Attorney General, Martha Coakley, demanded that contractors refund taxpayers USD 108m as part of "restitution for damages". Other State and Federal officials were asking that contractors pay up to a billion dollars for shoddy work [*The Herald Tribune*, 2006]. In January 2008, Bechtel/Parsons Brinckerhoff agreed to pay USD 407m in restitution for its poor oversight of subcontractors (some of whom committed outright fraud), as well as primary responsibility in the death of a motorist. However, despite admitting mismanagement, the firm is not barred from bidding for future government contracts. Several smaller companies agreed to pay a combined sum of approximately USD 51m , bringing the contractors' settlement to a total of USD 458m. [Estes, 2008].

Cost forecasts

The Massachusetts Turnpike Authority has compiled forecasts for the CA/T since 2000. Below is a summary of the year 2000 forecasts (which has been used as a base year in many calculations). This is followed by the latest available forecast of 2007. This information is available at MTA, Finances.

<u>Early funding forecast</u>

A financial forecast completed in October 2000 presented the integrated cost, schedule and funding forecast for the project. The Finance Plan was compiled from information dated June 2000, including a comprehensive cost and schedule evaluation known as Cost/Schedule Update Revision 7 (CSU7) (providing estimates for all remaining work) and it also included a budgeted contingency. Such finance plans were developed in accordance with Federal Highway Administration (FHWA) guidelines of 23 May 2000. The MTA and the FHWA agreed that the 16 June 2000 Finance Plan Update would be used as the base cost and schedule estimate to which all future Finance Plans were to be compared (as described by MTA Finances, under http://www.masspike.com/pdf/finances/fin_10-01-00.pdf). The overall results of CSU7 may be summarized as:

- Project costs in the year 2000 estimate had increased by USD 560m to a total project cost estimate of USD 14,075m. The largest component of this increase was related to a USD 203m increase in the cost of construction and the addition of a project contingency budget of USD 258m;

- Project schedule milestones were revised to include four month extensions to the Initial I-90 Opening, I-93 Northbound Opening, and Initial I-93 Southbound Opening.

The Project Completion date remained unchanged (December 2004); [actually it finished three years later];

- In the year 2000 it was anticipated that over the following two years as the peak construction period continued, the average cash flow for the entire project would be approximately USD 130m per month. The final two and a half years, mid-2002 to 2004, were expected to incur expenditures of approximately USD 50-75m per month;

- Funding for the project was increased through improvements to existing revenue streams and with proceeds from the sale of Turnpike Authority real estate to address the need identified in the year 2000 cost estimate;

- In accordance with commitments made by the Commonwealth of Massachusetts with FHWA, the federal funding for the project was capped at USD 8.549bn and was not expected to increase to accommodate cost increases;

- The Commonwealth and the Turnpike Authority identified firm funding sources for a total funding amount of USD 14.075bn. The increased funding was expected to be realized from the following:

    - Transportation Infrastructure Fund Increases: The Massachusetts Treasurer's Office would issue General and/or Special Obligation Bonds as specified in the Additional Funding Act and Technical Corrections Bill (Chapters 87 and 125 of the Acts of 2000), and would invest Fund balances according to the plan described in Appendix H to provide USD 375m in revenues above those programmed in the base (June 2000) Finance Plan;

    - Allston Landing Real Estate Sale and Interest Earnings: The Turnpike Authority sold the Allston Landing site for USD 151.7m, and deposited these funds in an account for use by the project. These funds were projected to provide an additional USD 33m (total interest earnings projected to be approximately USD 40m) to support project expenditures, for a total of USD 185m in additional funds.

The Project Financing Forecast of August 2007 indicated that the Big Dig project would cost USD 14.798bn, and that this was consistent with the Finance Plan submitted in May 2007, as summarized by the table below, which provides the breakdown of how the funds were allocated.

Table 5: Budget, cost, commitment and forecast - total costs as of 31 August 2007

$ Millions

	2007 Finance Plan Budget	Potential Forecast	Commitments To Date	Commitments To-Go	Authorized Invoices To Date	Anticipated Invoices To-Go
Construction						
Construction Packages (incl. I90 Ceiling Contracts)	9,580	9,581	9,474	107	9,431	151
Geotech Contracts	30	30	30	0	30	0
Downtown Surface Restoration/Parks	42	42	42	0	34	8
	9,651					
Force Accounts	588	588	587	1	569	19
Section Design Contracts	1,062	1,065	1,075	(9)	1,054	12
Right of Way Settlements	590	590	589	2	589	2
Project Management	2,259	2,260	2,238	23	2,234	26
Insurance Expenses	624	624	593	31	593	31
Contingency	25	18	0	18	0	18
TOTAL PROJECT	14,798	14,798	14,627	172	14,533	265

(Source: http://www.masspike.com/pdf/finances/pmm_aug07.pdf)

Actual costs

As of December 2007, when the main components of the project were considered completed, the official figure for the total costs was USD 14.798bn. However, and as stated above in the overview of this funding section, unofficial projections about the total costs by *The Boston Globe* bring the total price tag to USD 22bn [Murphy, 2008]. Although the total scope of the debt was not previously calculated or publicly disclosed by the state's political leaders, *The Boston Globe* was able to confirm its own calculations in interviews with the state's financial analysts. As of 2008, it become apparent that, contrary to popular belief that the project was heavily subsidized by the federal government, actually 73% of construction costs would be paid by citizens of the State of Massachusetts, in particular drivers and taxpayers. To meet that obligation, the state's annual payments will be nearly as much over the next several years, USD 600m or more, as in the busiest construction period [Murphy, 2008].

The principal reasons for the cost overruns on the project have been summarized as inflation, schedule delays and added scope, including mitigation. One problem is that the original cost estimates were given in current-year dollars instead of being adjusted for inflation. Moreover, the original estimates of project cost did not take into account costs incurred for project changes, mitigation or environmental requirements, or appropriate allowances for risk and escalation. Furthermore, there were management changes over the years and some have stated that this was the reason for a lack of consistent leadership and for the project being completed above budget and years behind schedule [WSDOT].

The following is a history of the project scope and cost since its inception in the 1980s (as presented in the MTA, Finances section (http://www.masspike.com/pdf/finances/costschedule_0507.pdf). This summary shows how financial forecasts were changing over the time of the project.

<u>August 1985</u>

Original Environmental Impact Statement; very conceptual design, without Massachusetts Avenue Interchange, minimal work past Logan Airport in East Boston and north of the Charles River.

Cost**:** USD 2.564bn (in 1982 dollars).

1987 Interstate Cost Estimate (ICE)

Added USD 46m for South Boston Haul Road, Right of Way acquisitions, and other miscellaneous increases. Additional USD 611m increase for escalation from 1982 to 1985 dollars.

Cost: USD 3.175bn (in 1985 dollars)

1989 ICE

Added USD 799m for High Occupancy Vehicle lane, Right of Way acquisitions, I-90 tunnel covers, Route 1A Interchange in East Boston and changes in AASHTO standards. Additional USD 462m in escalation from 1985 to 1987 dollars.

Cost: USD 4.436bn (in 1987 dollars)

1991 ICE

Added USD 299m for Dewey Square Tunnel, East Boston Tunnel Covers, landscaping, railroad relocation, and material disposal program. Additional USD 458m due to escalation from 1987 dollars to 1989 dollars.

Cost: USD 5.193bn (1989 dollars)

1991 Adjusted Project Forecast (APF)

Added USD 255m for West Virginia Fire Tunnel Test, project utilities, change in steel and underpinning designs, and miscellaneous other items. Additional USD 332m due to escalation from 1989 dollars to 1991 dollars.

Cost: USD 5.780bn (in 1991 dollars)

1992 APF

Added USD 354m for project-wide insurance, Right of Way acquisitions, and miscellaneous other items. Additional USD 309m for escalation from 1991 to 1992 dollars.

Cost: USD 6.443bn (in 1992 dollars)

1992 APF (w/New Charles River Crossing)

Added USD 983m for Area North of Causeway, which included USD 324m in escalation from 1992 for scope elements related to the new Charles River Crossing. Additional USD 210m for program management and insurance and USD 104m for escalation from 1992 to 1993 dollars.

Cost: USD 7.740bn (in 1993 dollars)

March 1995 Cost and Schedule Update (CSU) #6

Added USD 258m for detailed assumptions of all Project cost centers. Excluded to-go inflation, scope to be funded by others, and pre-ICE costs.

Cost: USD 7.998bn (in 1994 dollars)

1995/6 Finance Plan

Primary difference from previous USD 7.998bn was including USD 1.153bn inflation for remainder of the project, USD 255m pre-ICE costs, USD 984m 'exclusions'/third party contributions.

Cost: USD 10.4bn (dollars in year costs incurred, including inflation, plus insurance credit)

1996 Finance Plan Update

Cost: USD 10.4bn (dollars in year costs incurred, including inflation, plus insurance credit).

1997 Finance Plan Update

Added USD 400m due to bid results, noise mitigation, dust mitigation, traffic mitigation, and deletion of future air rights credit.

Cost: USD 10.8bn (dollars in year costs incurred, including inflation, plus insurance credit) USD 11.6bn (funding needs without assuming any insurance credit)

1998 Finance Plan Update

Cost: USD 10.8bn (dollars in year costs incurred, including inflation, plus insurance credit) USD 11.7bn (funding needs without assuming any insurance credit)

1999 Finance Plan Update

Cost: USD 10.8bn (dollars in year costs incurred, including inflation, plus insurance credit) USD 11.7bn (funding needs without insurance credit)

March 2000 Finance Plan Update

Changes from prior estimate:

- Design Development USD 321m
- Construction Changes USD 302m
- Maintain Construction Schedule USD 292m
- Force Account Work USD 90m
- Design during Construction USD 60m
- Right of Way (ROW) USD 72m
- Project Management through 2004 USD 260m

Cost: USD 12.2bn (dollars in year costs incurred, including inflation, plus insurance credit) USD 13.1bn (funding needs without insurance credit)

June 2000 Finance Plan Update: (Base Cost Estimate)

Changes from prior estimate:

- Awarded Contracts USD 140m
- Design during Construction USD 28m
- Unawarded Contracts USD 203m
- Rights Of Way USD 16m
- Force Account Work USD 17m

- Project Management USD 39m

Cost: USD 13.5bn (dollars in year costs incurred, insurance credit withdrawn)

October 2000, CSU7

Changes from prior estimate:

- Awarded Construction USD 132m
- Force Account Work USD 28m
- Unawarded Construction USD 71m
- Design during Construction USD 270m
- Rights Of Way USD (23)m
- Project Management USD 73m
- Insurance USD (3)m
- Contingency USD 258m

Cost: USD 14.075bn (dollars in year costs incurred)

October 2001, CSU8

Changes from prior estimate:

- Awarded Construction USD 118m
- Force Account Work USD 12m
- Unawarded Construction USD 32m
- Design during Construction USD 35m
- Rights Of Way USD 4m
- Project Management USD 15m
- Insurance USD (50)m
- Contingency USD 236m

Cost: USD 14.475mm (dollars in year costs incurred)

April 2002, Approved 2002 Finance Plan

Changes from prior estimate:

- Rights Of Way USD 12m
- Insurance USD 150m
- Contingency USD (12)m

Cost: USD 14.625m (dollars in year costs incurred)

October 2002, CSU9

Changes from prior estimate:

- Awarded Construction USD 172m
- Force Account Work USD (5)m
- Unawarded Construction USD (99)m
- Design during Construction USD 11m
- Rights Of Way USD 5m

- Project Management USD 100m
- Insurance USD (37)m
- Contingency USD (147)m

Cost: USD 14.625m (dollars in year costs incurred)

October 2003, CSU10

Changes from prior estimate:

- Construction USD 75m
- Force Account Work USD (1)m
- Rights Of Way USD 14m
- Design USD 8m
- Insurance USD (20)m
- Project Management USD 63m
- Contingency USD (139)m

Cost: USD 14.625m (dollars in year costs incurred)

October 2004, CSU11

Changes from prior estimate:

- Construction USD 77m
- Force Account Work USD (1)m
- Rights Of Way USD (15)m
- Design USD 3m
- Insurance USD (21)m
- Project Management USD 12m
- Contingency USD (55)m

Cost: USD 14.625m (dollars in year costs incurred)

May 2007, Updated Cost Estimate

Changes from prior estimate:

- Construction USD 115m
- Force Account Work USD (12)m
- Rights Of Way USD (2)m
- Design USD 10m
- Insurance USD 19m
- Project Management USD 107m
- I-90 Ceiling Repair USD 54m
- Contingency USD (117)m

The table below provides a picture of how the cost overruns accrued.

Table 6: Cost overruns (information from the MTA - finances section)

Included below are only those items that have increased the cost of the project by at least USD 10m **Type of change**	**CSU 11**	**Updated cost estimate 02/28/07**	**Net increase since CSU 11**	**Explanation**
Construction – C08A1 – East Boston	USD 222	USD 235	USD 13	Asbestos Contaminated Soil
Construction – C09A4	USD 468	USD 483	USD 15	Global Settlement
Construction – C15A3	USD 163	USD 173	USD 10	Global Settlement
Construction – Projectwide	USD 236	USD 269	USD 33	Fireproofing repairs, Microsilica Overlay repairs, South Bay Mall lane rebalancing, Police Details
Construction – C20B1, C22A1, C22A2	USD 86 USD 69 USD 154	USD 119 USD 78 USD 161	USD 50	IPCS, Police Details, Extended Overheads
Downtown Parks – C32A1, B1, C1, D032A, 32B, 32C	USD 31	USD 42	USD 11	Initial Estimate @CSU11 was based on a rough USD per sq. ft. basis. Revised estimate is based on subsequent design development and bid results.
Construction – I90 Accident Remediation	USD 0	USD 54	USD 54	10 July 2006 Accident
Design	USD 1,052	USD 1,063	USD 11	Construction phase services.
Project Management	USD 2,152	USD 2,259	USD 107	Extended Staffing requirements due to Schedule extensions; added IPCS support; and legal costs.
Insurance	USD 605	USD 624	USD 19	Actuarial assessments of open claims and program extension.
Total Cost Increases (over USD 10m)	USD 5,238	USD 5,560	USD 322	

Funding sources

Capital funding

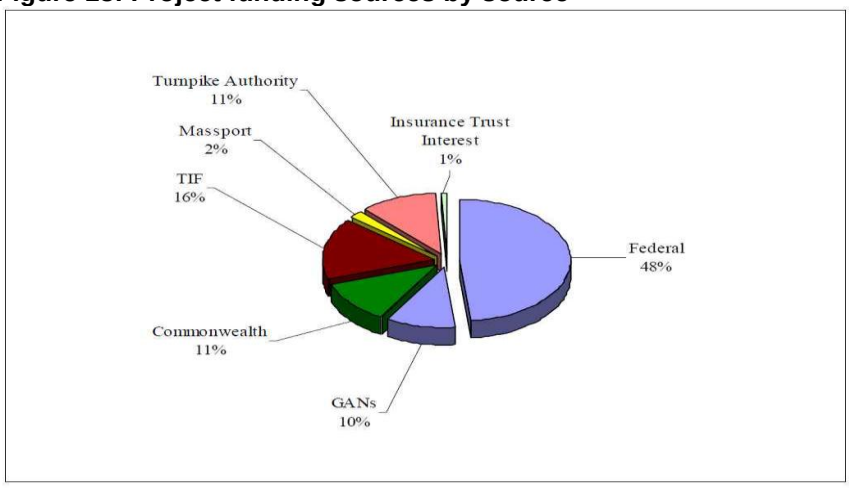
As of the year 2000, federal aid represented approximately 50% of revenues but that percentage fell to 48% by 2005, in part because federal funding contributions were capped at USD 8.549bn (federal aid highway obligation authority ('OA'), notwithstanding the Commonwealth's use of advance construction ('AC') authority). The remaining 50% of the revenues are from state and other sources including general obligation bonds, license and Registry fee bonds, federal Grand Anticipation Notes (GANs), the Turnpike Authority, and Massport. It was expected that when the project received full federal reimbursement through the GANs program, the federal contribution to the project would increases to 61% while the state's portion decreases to 39%. The additional revenue necessary to pay for the USD 560m cost increase above the base year (June 2000 Finance Plan estimate) was expected to come from the state's Transportation Infrastructure Fund and the sale of real estate assets by the Turnpike Authority. As it turned out the State also issued bonds.

According to the MTA [MTA – Finances], the project was being funded by the following sources:

- Federal Reimbursements (USD 7.049bn);
- Federal Grant Anticipation Notes – GANS (USD 1.500bn);
- Commonwealth of Massachusetts (USD 1.633bn);
- State Transportation Infrastructure Funds – TIF (USD 2.410bn);
- Massachusetts Port Authority Funds – MPA (USD 302m);
- Massachusetts Turnpike Authority Funds – MPA (USD 1.591bn);
- Insurance Trust Interest (USD 140m).

The chart below shows the overall sources of funding for the project, by source, as of 2005.

Figure 13: Project funding sources by source

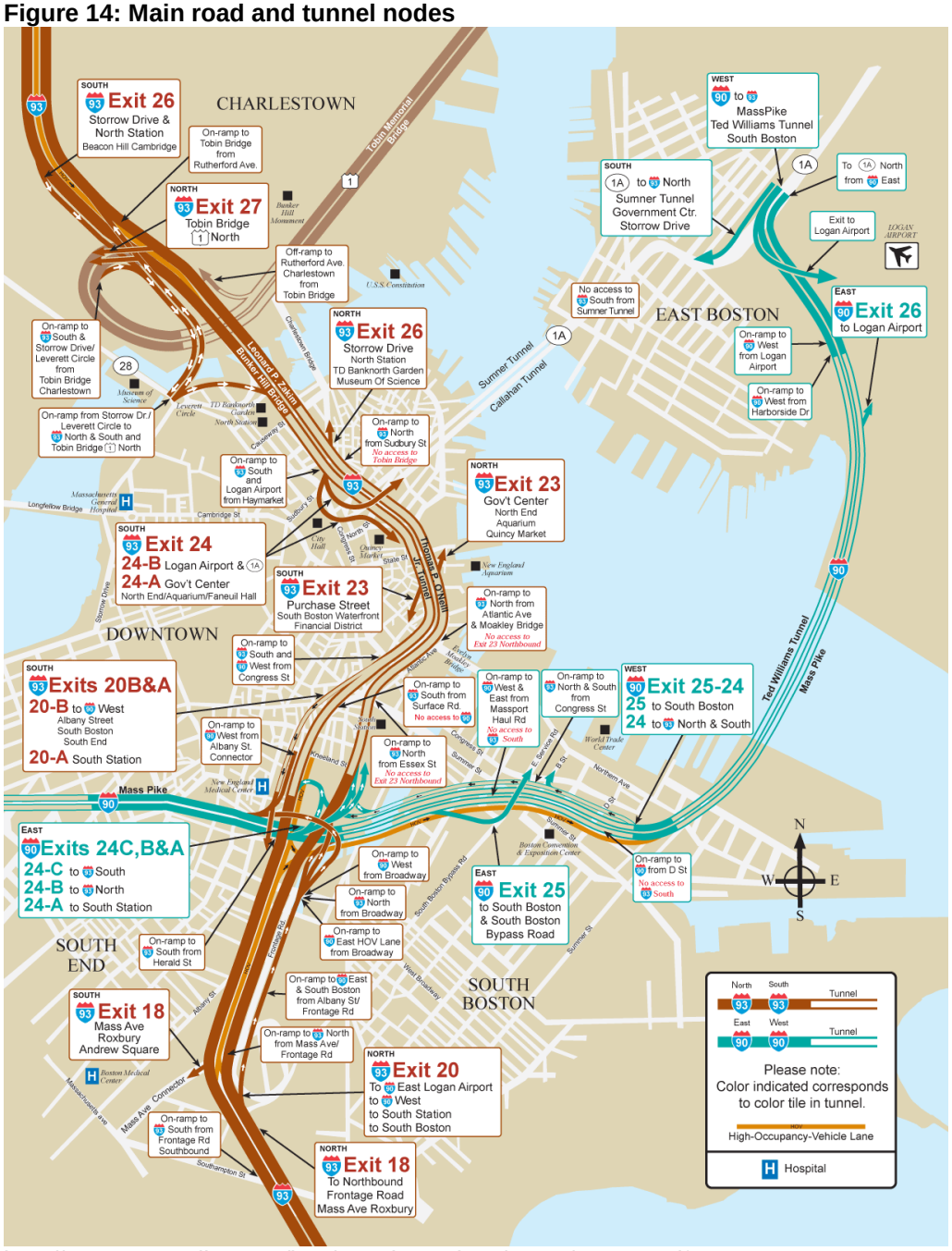


Source: Massachusetts Turnpike Authority – "Big Dig" Finances;
http://www.masspike.com/bigdig/updates/finances.html#pmm

Operations revenue

The submerged Central Artery is part of Interstate 93. Although it is not a toll road, the section running under Boston is owned and operated by the Massachusetts Turnpike Authority. Tolls are charged on the Ted Williams Tunnel and other parts of the Turnpike. Original plans called for MassHighway to operate the submerged artery as it does the rest of the Interstate system. But ownership of the artery was transferred to the Turnpike Authority in 1997 to justify the use of toll hikes to help pay for the Big Dig. While the Turnpike owns and operates the Central Artery, Commonwealth taxpayers nonetheless pay the artery's operating costs to the tune of about USD 35m per year. [Adams, 2004]. Figure 14 depicts the main road and tunnel nodes of the CA/T project. The Interstate (I-93) Central Artery is not currently subject to tolls. Tolls currently exist on the Massachusetts Turnpike I-90 and the Ted Williams Tunnel (marked in green).

Figure 14: Main road and tunnel nodes



http://www.masspike.com/img/travel_services/maps/I93map.gif

Other sources of revenue for the Big Dig project include federal reimbursements (e.g. for the GAN program, as shown above under funding sources), as well as restitution funds from contractors [MTA - Finances]. Given the limited sources of revenue, towards the end of 2008, the state of Massachusetts was facing increasing costs from the USD 2.2bn debt on the project, and this stirred a debate over options to pay for this debt – mostly a discussion about either tolls or taxes [Collier, 2009].

In November 2008, the Turnpike Authority voted to double the USD 3.50 toll at the Sumner and Ted Williams tunnels under Boston Harbor and introduce a 75 cent increase at both the Route 128 exit in Weston and Boston's Allston-Cambridge tollbooths. An earlier toll hike that went into effect early in 2008 had raised tolls by 50 cents and 25 cents, respectively. If approved, the new round of toll hikes for 2009 would make the Boston extension of the I-90 the 14th most expensive toll road in cost per mile when ranked with 77 other federal toll roads, and would raise an estimated USD 80-98m. Mac Daniel, a spokesman for the Turnpike Authority, estimated that this amount "would be enough to cover principal and interest payments on Big Dig debt due at the beginning of 2009, and provide extra funds for Pike maintenance projects that have been delayed" [Collier, 2008]. As of early June 2009, a final vote was still needed to approve the proposed toll increases.

Not surprisingly, the expected toll hike has been met with a strong reaction from the public, in particular those relying on the tunnels to connect with the rest of the city. Given this opposition, an early 2009 confirmation vote has been moved to July 2009. Moreover, in May 2009, a group of motorists organized as a trust approved by the Middlesex Probate Court filed a class-action lawsuit claiming tolls collected on the Massachusetts Turnpike are an illegal tax [Universal Hub, 2009].

It has been estimated that even if the new toll hikes are approved, the revenues may not be sufficient. While the Turnpike Authority is on schedule to pay on Big Dig bonds until 2039, significant increases in payments are due in 2014, 2020 and 2026 [Brit, 2009].

F OPERATIONS

Traffic volume

The goal of the Big Dig project was to relieve the chronic congestion affecting Boston towards the end of the 20th century, by replacing the six-lane elevated Central Artery (Interstate 93). Built in 1953, this roadway was designed to accommodate 75,000 vehicles a day, but through the years the traffic volume escalated to approximately 190,000 vehicles a day. As a result, traffic in central Boston was crawling at a slow pace for over ten hours each day. The new central artery is an eight to ten lane underground expressway, which leads into a 14 lane, dual bridge crossing at Fort-Point on the Charles River. It has been built to accommodate 245,000 vehicles, the projected daily use by 2010 [GML Consulting Limited, 2004].

The project has resulted in better traffic conditions. The original 1990 environmental projection was that the Big Dig would improve traffic flow by 40% by 2010. Today, the project exceeds that with a 62% improvement in traffic flow, and travel times have decreased significantly – by as much as 85% on some of the roadways, as estimated by the Massachusetts Turnpike Authority. This was accomplished while overall traffic volume grew by 23.5% since 1995 [MTA – Economics Impacts Report, 2006]. In 2005, Salvucci, then a professor at the Massachusetts Institute of Technology, stated that parts of the new highway already carried as much traffic as it was projected to carry in 2010. [Discovery Institute].

The Economic Impacts report of the MTA on the associated benefits of the Big Dig project (2006) has summarized what the project means for commuters. This summary is presented below:

- Before the project was built the average traffic speed on I-93 Northbound was 10 mph: today it is 43mph, dropping the average peak travel time from 19 minutes to 2.8 minutes;

- Speed for all harbor tunnels increased from 13mph to 36mph, cutting travel times from 42% and 74%;

- Storrow Drive Eastbound to I-93 North improved from 4mph to 21mph, dropping afternoon peak hour travel times from 16 minutes to 3.1 minutes;

- The improved highway, bridge and tunnel network provides USD 168m annually in time and cost savings for travelers;

- Getting to Logan International Airport is now easier for an additional 800,000 Massachusetts residents who, with the full opening of the I-90 connector to the Ted Williams Tunnel, now live within 40 minutes of the airport. Today, 2.5 million residents live within 40 minutes of Logan International Airport.

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