# UNEARTHING THE BIG DIG

***History can only be understood looking backward, but it must be lived moving forward.***

*(paraphrased after Søren Kierkegaard)*

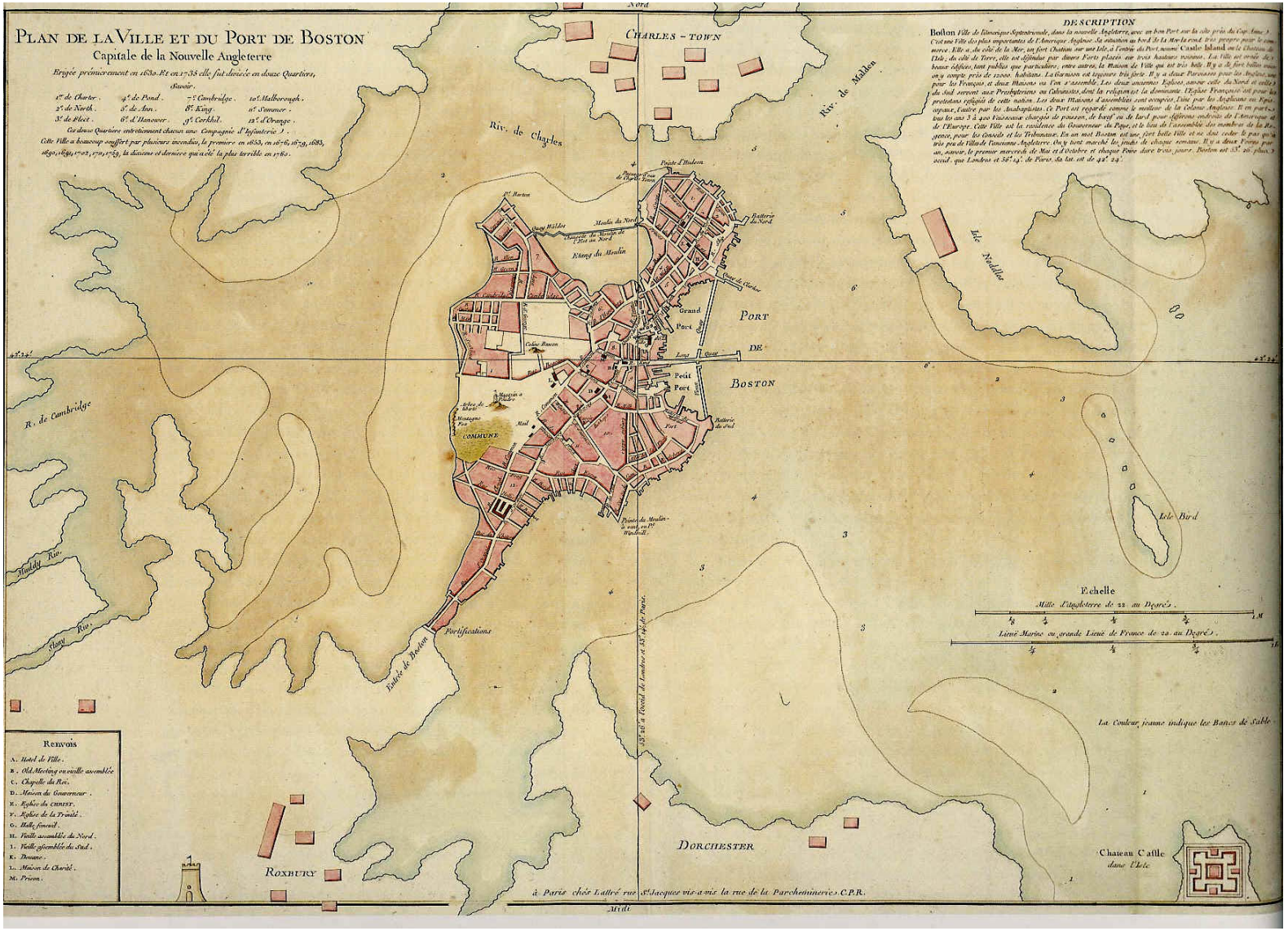
**Frederick P. Salvucci**

**Civil & Environmental Engineering, MIT**

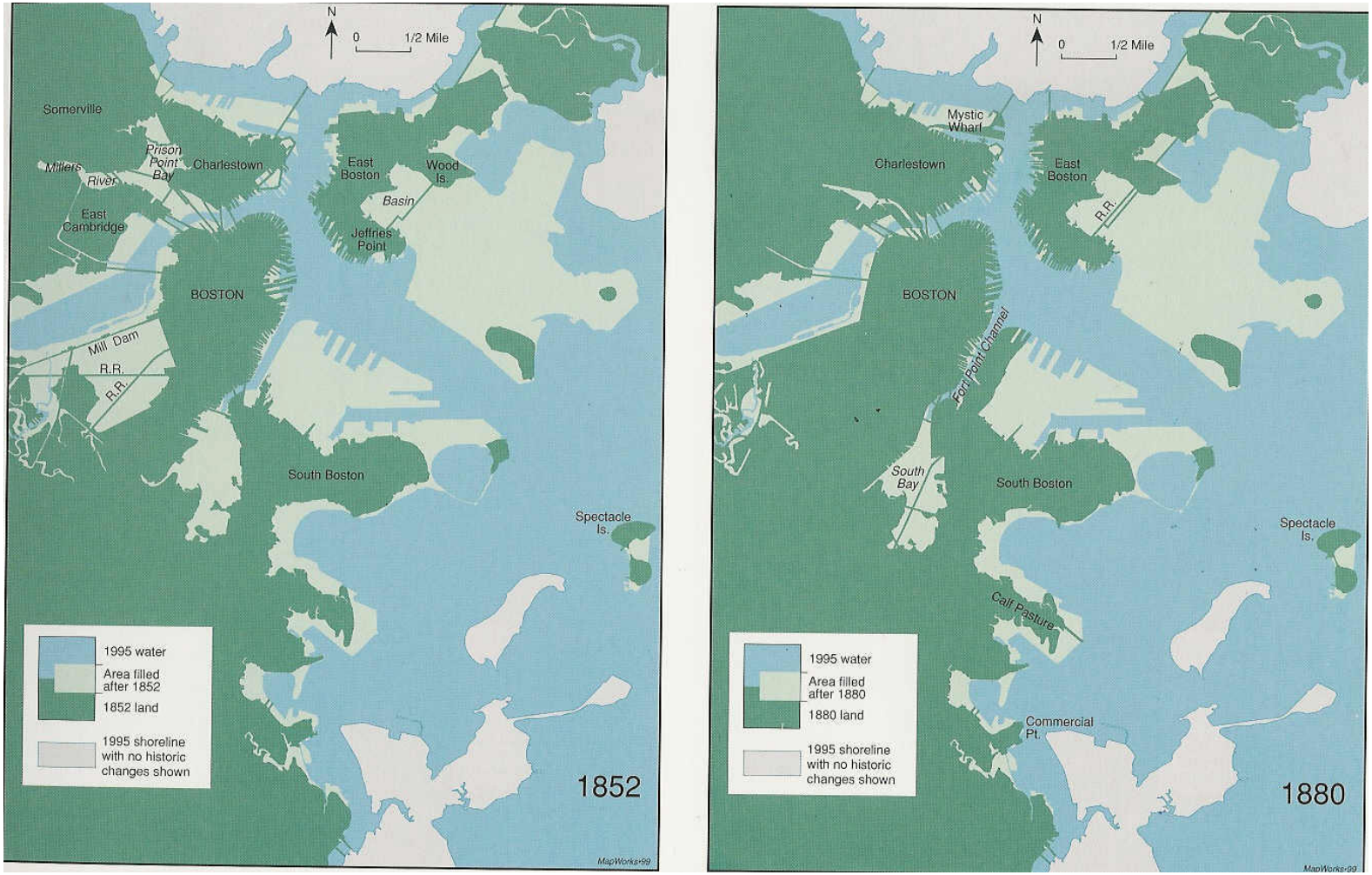
**Donostia - June 11, 2008**

Massachusetts Institute of Technology

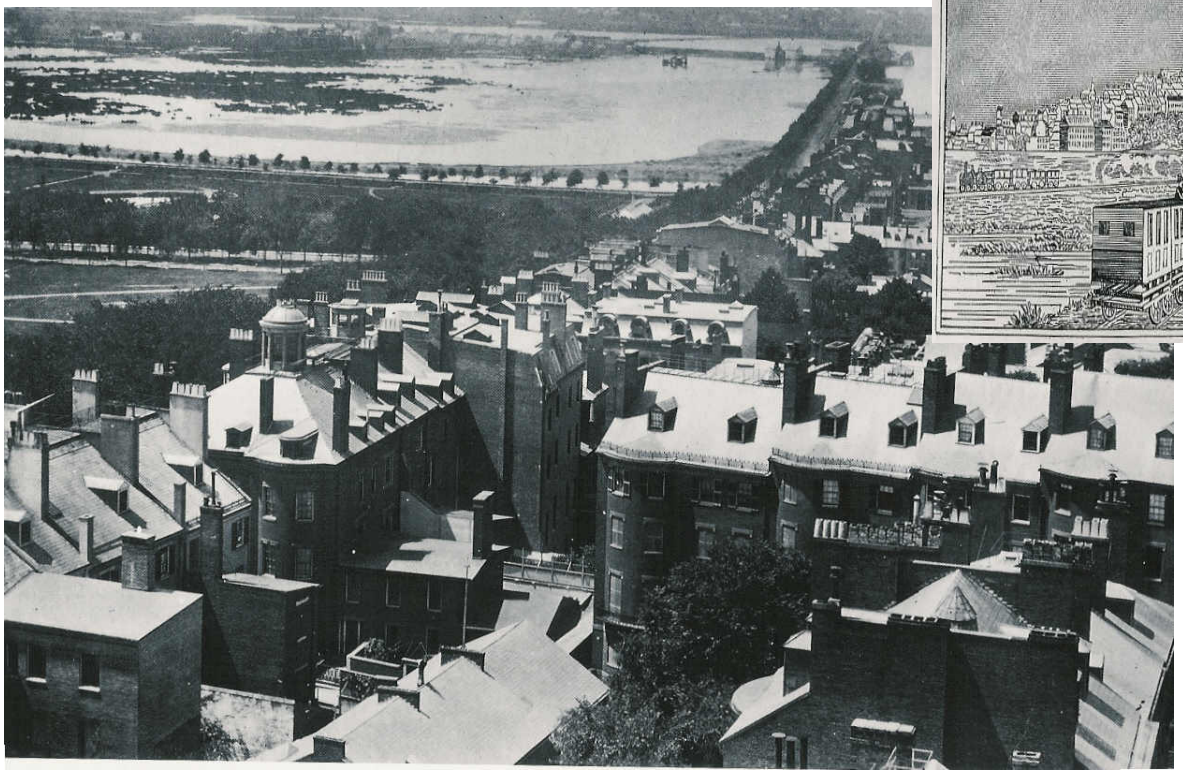
# BOSTON "PRE-HISTORY"

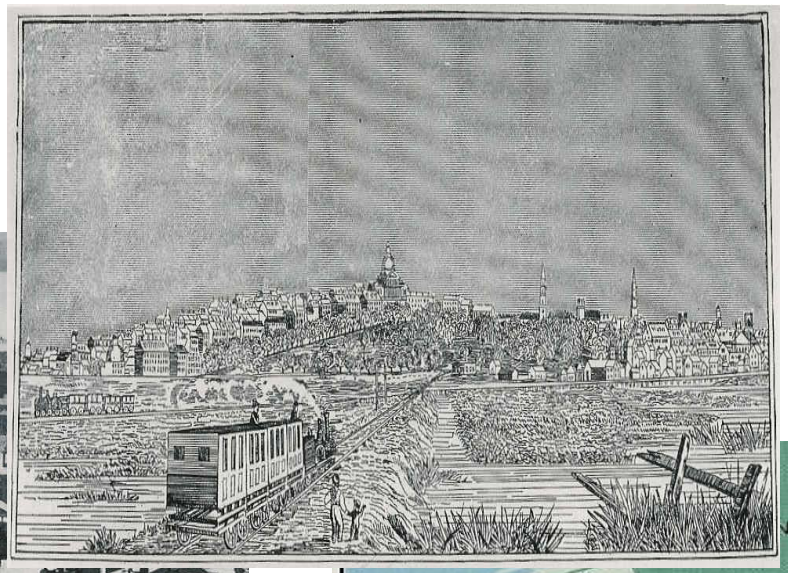


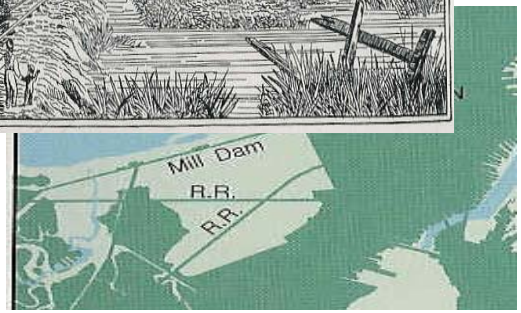
# BOSTON "PRE-HISTORY"
# 1776 --> War of 1812 --> 1830s



# BOSTON "PRE-HISTORY": 1830s - 1870



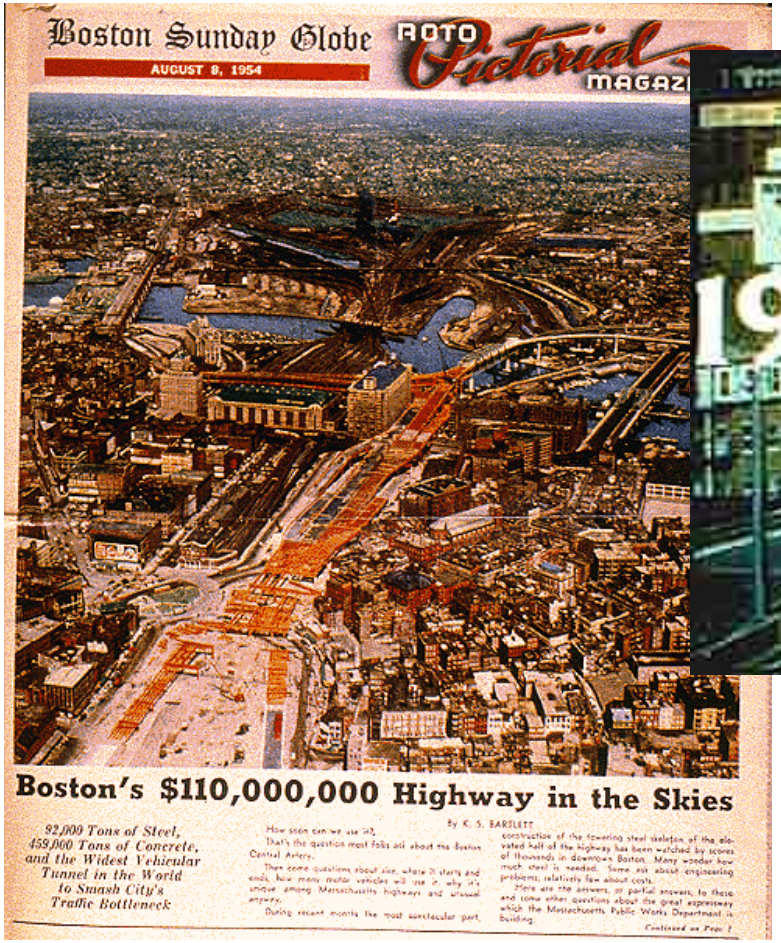




# BOSTON 1923

# GRAND CENTRAL ARTERY …


# GRAND CENTRAL ARTERY…


Boston Sunday Globe ROTO Pictorial MAGAZ

AUGUST 8, 1954

Boston's $110,000,000 Highway in the Skies

92,000 Tons of Steel, 459,000 Tons of Concrete, and the Widest Vehicular Tunnel in the World to Smash City's Traffic Bottleneck

By K. S. BARTLETT

How soon can we use it?

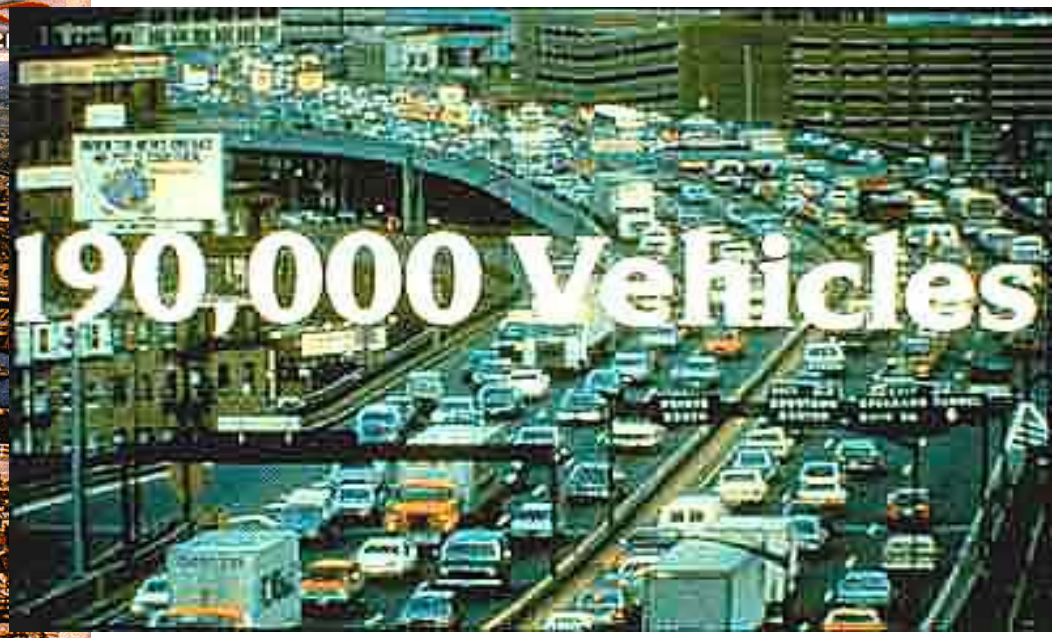
That's the question most folks ask about the Boston Central Artery.

Then come questions about size, where it starts and ends, how many motor vehicles will use it, why it's unique among Massachusetts highways and unusual anywhere.

During recent months the most spectacular part of construction of the towering steel skeleton of the elevated half of the highway has been watched by scores of thousands in downtown Boston. Many wonder how much steel is needed. Some ask about engineering problems, relatively few about costs.

Here are the answers, or partial answers, to these and some other questions about the great expressway which the Massachusetts Public Works Department is building.

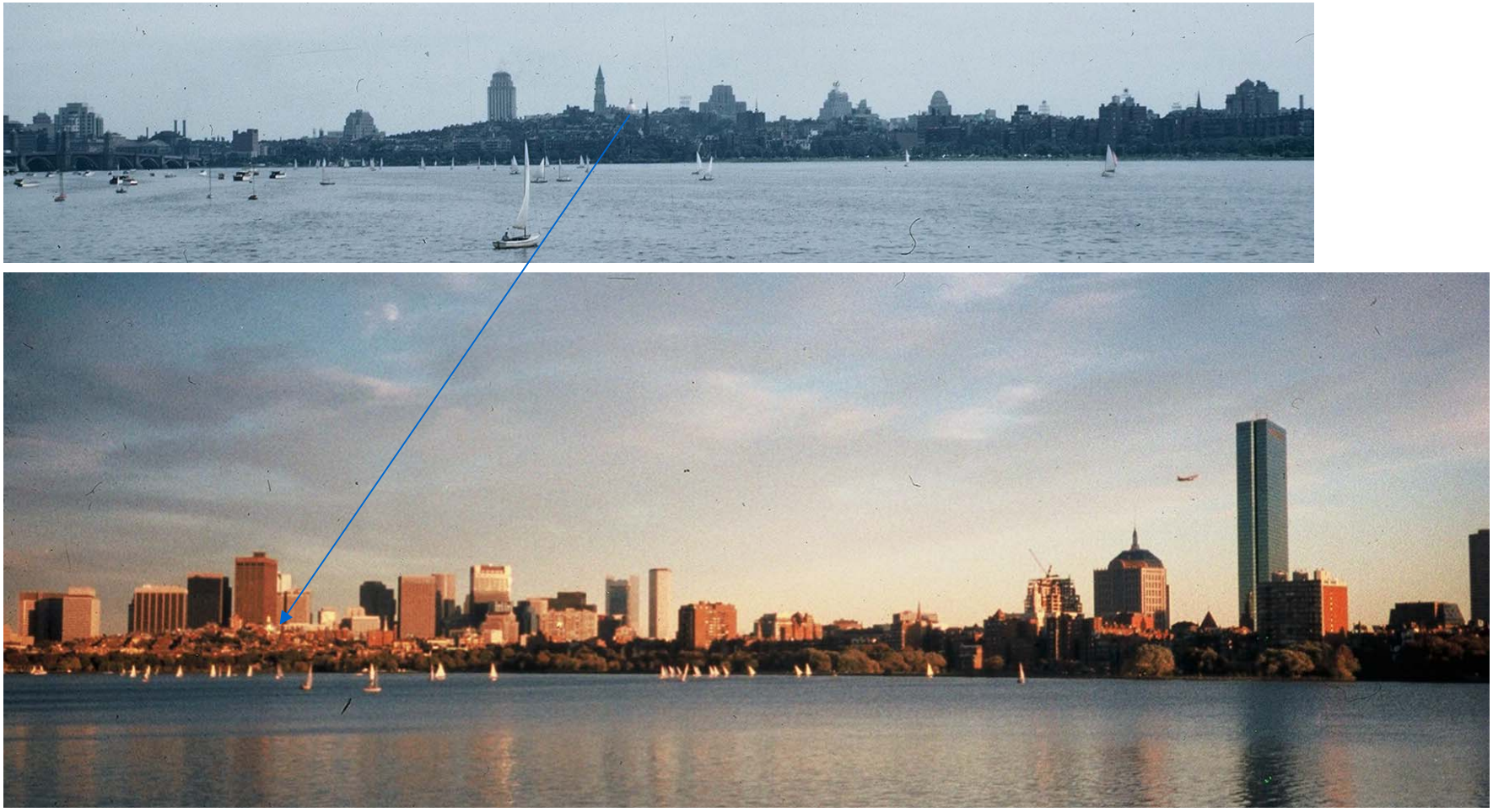
Continued on Page 7



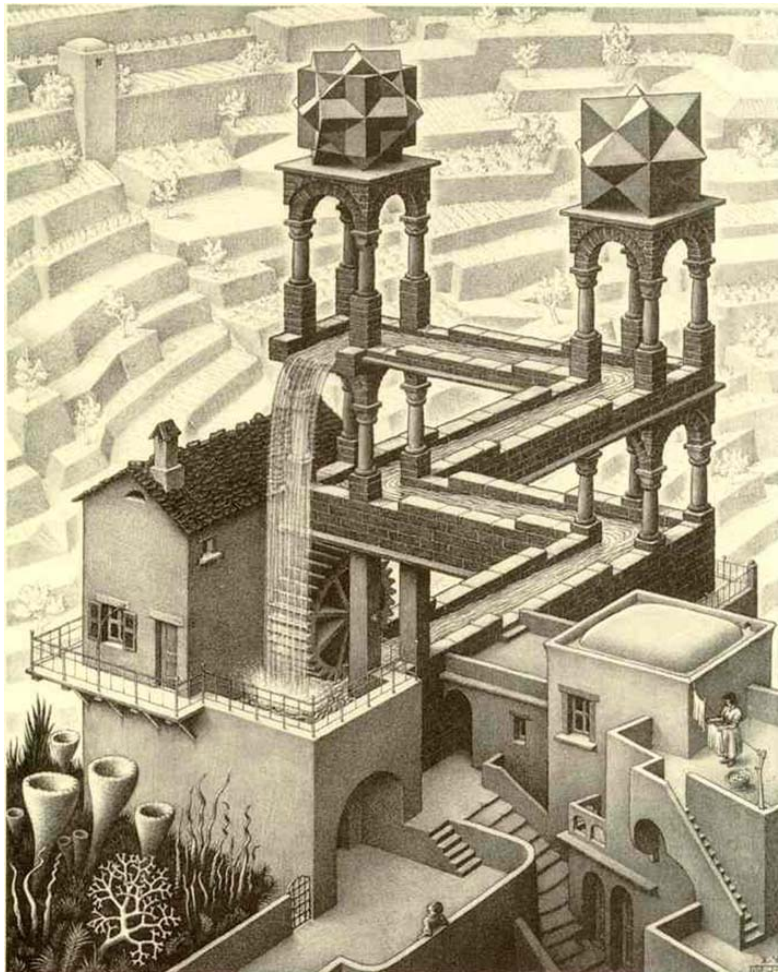
# BIG DIG

# BIG DIG


# BOSTON SKYLINE: 1958 - 1995



# ESCHER PRINT 1



# THE CENTRAL ARTERY/TUNNEL (CA/T) IS LIKE AN ESCHER PRINT

1. The biggest highway project in the U.S. grew out of the anti-highway movement
2. CA/T is about improved quality of mobility for core, or about increasing quantity of low-quality auto access.
3. The CA/T won't work unless continued improvements are made in mass transit
4. CA/T is about environmental improvement by replacing elevated highway primarily with open space.
5. CA/T is about major urban growth in the South Boston seaport district.

# ... ESCHER PRINT (cont'd)

6. The CA/T is about construction jobs
7. The CA/T is about city building and "smart" economic growth
8. Conditions of political support are often ambiguous and imprecise
9. Dominant culture of project, as well as political leadership, can change over the life of the project
10. The CA/T is an example of Massachusetts gaining at the expense of the rest of the US
11. The CA/T is an example of partisan politics depriving Massachusetts of fair treatment under the Interstate Highway Program (1956) and the National Environmental Policy Act

# ... ESCHER PRINT (cont'd)

12. The CA/T is the first interstate highway developed in substantial compliance with the National Environmental Policy Act
13. The cost of the CA/T is higher because of compliance with the National Environmental Policy Act
14. The cost of the CA/T is lower because of compliance with environmental law, meeting its responsibility to reduce environmental costs
15. The cost of the CA/T is higher because of Federal Interstate Highway standards and highway culture
16. The cost of the CA/T is higher because of an excessive practice of "mitigation"

# ... ESCHER PRINT (cont'd)

17. The total cost of the CA/T is lower because mitigation means the project met its responsibility to avoid shifting disruption costs onto abuttors and the city and regional economy
18. The CA/T could be built only with a public/private partnership
19. The CA/T costs increased because of an excessive view of "privatization"
20. The necessity, visibility, and potential disruptiveness of the project generated the political will to accept responsibility for full costs

# ESCHER PRINT

1. **A major civic initiative for the improvement of the environment of the City of Boston**

**or**

**An agglomeration of “business” opportunities for:**

- **developers**
- **contractors**
- **consultants**
- **Massport**
- **Masspike**

# ESCHER PRINT

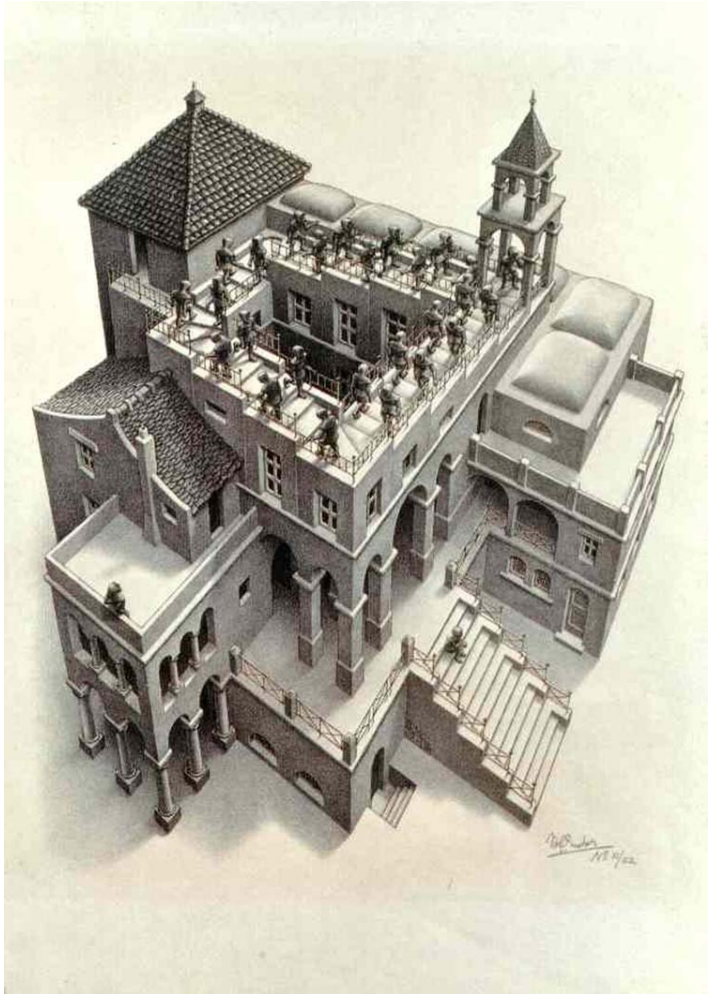
2. **Civic enterprise consensus**
   **-- or 51/49 “spoils” politics; $(.9)^6 < .5$**

3. **Full cost and benefit sharing -- or burden shifting**

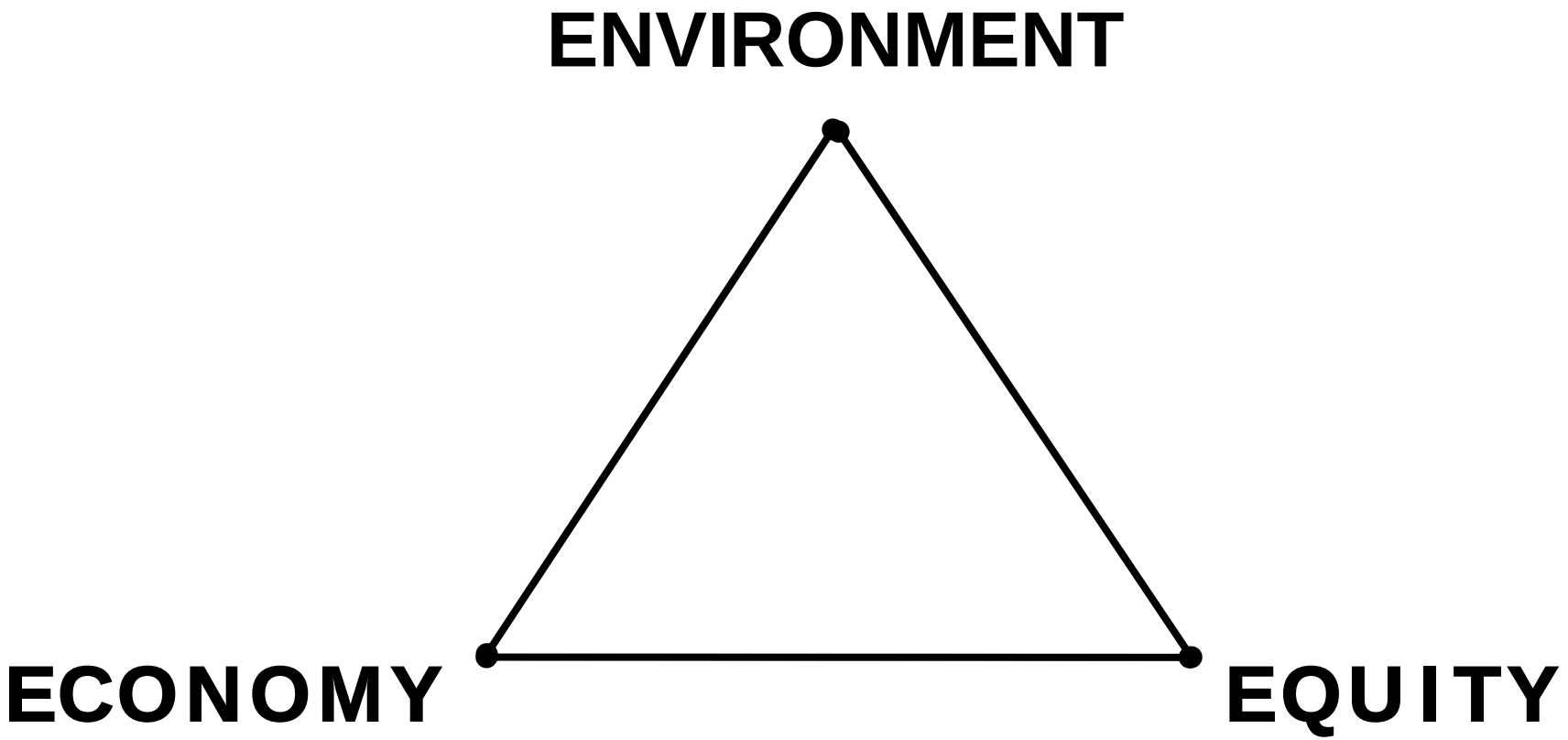
   **Public private partnership -- or privatization**

4. **Modern infrastructure projects have a high technological content, but are not industrial products. They are more similar to “one of a kind” craft production**

# ESCHER PRINT 2



# SUSTAINABILITY -- ETHICAL AND POLITICAL OBSERVATION



# GROWING CONGESTION IN THE TRANSPORTATION SYSTEM

- **Substantial growth in autos**
- **Substantial growth in trucking**
- **Substantial growth in aviation services**

**Value of mobility and access is much higher than its market value, and generates political will to reduce congestion.**

# GROWING ENVIRONMENTAL CONCERN

- Air quality
- Habitat destruction
- Community disruption
- Cancer, asthma, public health

**Value of cleaner environment is not measured in market terms, but produces political will**

# INFRASTRUCTURE RECONSTRUCTION

**Need for reconstruction of aging infrastructure, while maintaining service during reconstruction drives much higher market costs, but avoidance of disruption produces political will to pay.**

- **Night construction**
- **Big Dig**

# BENEFITS OF PROJECT ENORMOUS

A. Avoid gridlock
B. Improve environmental quality
C. Allow growth of downtown economy
D. Enormous short-term construction benefits

# DELAY IMPOSES SERIOUS CONSEQUENCES

A. Inflation drives up construction cost

B. Delay leads to scope changes that may be costly

c. Postponement of benefits (most significant, but never talked about)

# LONG TIMELINE

**Long time periods are required to conceptualize, plan, design, finance, construct, and operate new facilities beyond the reasonably expected terms in office of major public-sector decision makers.**

1. **Technical "cultural" stability**
2. **Political stability**
3. **Labor, business, environmental coalitions**
4. **Public/private partnerships**
5. **Stable public funding base**
6. **Private decision making follows "the tyranny of small decisions"**

# BASIC CHARACTERISTICS WHICH DISTINGUISH VERY LARGE PROJECTS

**Many phases (6) of life of project, over a long period of time, during which new information and changing values may change the context of the project.**

1. **Prehistory**
2. **Project conceptualization, environmental analysis**
3. **Design of project; procurement process**
4. **Construction**
5. **Operation & Maintenance**
6. **Land use accessibility and use changes**

# BASIC CHARACTERISTICS WHICH DISTINGUISH VERY LARGE PROJECTS

- Changes in political leadership may occur every 2 to 4 years, changing the context, and key players appointed by governors are likely to change during course of the project development.
- Technical requirements of 6 phases bring large numbers of specialists and interest groups temporarily into and out of the project, and may change the "culture of the projects."
- Changes in political leadership may change the philosophy of the project

| Phase | Time Scale | Political (Governors Terms) | Transportation Philosophies |
|---|---|---|---|
| Prehistory | Decades (1948-1969) | 2 Year - 1968;<br>4 Year - 1968-present<br>Sargent | Local & state highway, 1958-1956 |
| | | | Federal Highway, 1956-2000<br>Interstate; 90% Federal funds |
| Project<br>Conceptualization<br>EIS | 3-5 Year (1970-1980)<br><br>20-24 Years | Sargent<br>Dukakis<br>King<br>Dukakis<br>Dukakis<br>Weld | Federal Highway<br>National Environmental Policy Act<br>Multi-modal, highway/transit/ rail/airport |
| Procurement<br>Engineering Design<br>Land Acquisition | 2-4 Years (1986-1991)<br>12 Years (1991-2003)<br>6 Years (1991-1997) | Dukakis<br>Weld<br>Cellucci<br>Swift<br>Romney | 1991 ISTEA, 80% Federal funds but funding capped at $6 billion |
| Construction | 10 Years (1987-2000)<br>15 years (1991-2005) | Weld<br>Cellucci<br>Swift<br>Romney | |
| Operation and Maintenance | 50 Years (1996-> 2046) | Weld<br>Cellucci<br>Swift<br>Romney<br>? | |
| Land Use<br>Accessibility<br>and Use Changes<br>“Marketing” | 50 Years (1990 --> 2040) | Weld/<br>Cellucci<br>Swift Romney<br>? | Mayor Menino 2003? |

# TIMELINE

## Pre-1956

- Bottleneck relief
- Unimodal
- Location standards
- Externalize costs
- State and local funds
- Patronage politics

## 1956-1969

- Interstate system - dedicated funding
- 90% Federal funds "cost-plus"; interstate cost estimates
- Uniform highway standards
- Uniform relocation benefits
- Patronage, but less corruption
- Growth in use of models for design

# TIMELINE

## 1966-1991

- Section 4(f)
- National Environmental Policy Act (1969)
- Internalize external costs
- Multi-modal planning
- Boston Transportation Planning Review (1970-1972)
- Interstate transfer, flexibility (1973)
- Operating subsidies for transit
- Growth in use of models for planning

# TIMELINE

## 1991-1997

- ISTEA - flexibility and fixed pot of State funds
- Metropolitan planning organization
- Flexible standards
- Models vs. MPO
- Management studies (bridges, congestion, air quality, etc.)

## 1997 - today

- ISTEA continues
- No Federal transit operating subsidy (1997)
- Less emphasis on management studies

# OVER-ARCHING FEDERAL FUNDING ROLE

- **A Tale of Two Republicans**
  - **Eisenhower (Nixon, Ford)**
  - **Reagan**
- **Nature of Public/Private Relationship**

# OVER-ARCHING FEDERAL FUNDING ROLE

**Strong Federal Role with bipartisan support helps set priorities (Eisenhower, Nixon, Ford)**

- **reduces peanut butter effect**
- **prioritizes future**
- **accepts responsibility for external costs of Federal program**
- **dedicated funding**

***vs.***

**Ambiguous Federal role**

**Congressional Earmarks**

**Politicization of program (Reagan)**

**Weakening of dedicated funding**

# PRIVATIZED MODEL

**The privatized model works in a small subset of cases, but is not stable or sustainable.**

1. **Tension between cost control and base of political support**
2. **High prices required for viability depend on scarcity of service, monopoly supply.**
3. **Benefits to users a small subset of public benefits such as economic growth -- very difficult and unlikely to be monetised**
4. **Risks to private sector are enormously high [Big Dig, Chunnel]**

# PROBLEMS WITH GOVERNMENT AUSTERITY

1. Lack of a stable “deep pocket”
2. Unreliability of public partner
3. Small feasible set of investment forces cut-throat competition among worthy non-competitive projects
4. 51 / 49 politics, but $(.9)^6 < 50\%$
5. Lack of competency
6. “Peanut butter” projects more competitive in austere environment
7. Delay caused increased cost - inflation rate higher than interest rate
8. Delay caused delay in capturing economic growth

# ENLIGHTENED SELF-INTEREST

1. Enlightened and competent
2. Clear, reliable public funding streams
3. Public/private partnerships
4. Regulated utility, arbitration
5. Eisenhower and the US Interstate Highway System

Plus the National Environmental Policy Act of 1970

# DOING THE RIGHT JOB

- Project Conceptualization and EIS
- Physical concept developed through interactive process of communication with key constituencies during EIS process
- Building the political will for public finance and priority in Boston
- Building support in Massachusetts required a coalition to support transportation outside Boston
- Building support nationally required a coalition with other cities and states throughout the U.S.
- Transparency

# WHOSE IDEA WAS THE BIG DIG?

John Volpe

Vincent Barletta

Kevin Lynch

Paul Lusk

Tony DiSarcina

Bill Reynolds

Kevin White

Tom Winship

Bill Lamb

Miguel Rosales

Rebecca Barnes

Norm Leventhal

Bob Weinberg

# HEISENBERG PRINCIPLE AND THE PRESS

- Supportive
- Contrarian
- Conflict will exist, so how does it work for you?
- Complex nature of projects creates “gotcha journalism” opportunities
- Develop consensus with key reference groups
- Internet creates opportunity to constrain “gotcha” journalism
- Transparency

# BUILDING POLITICAL SUPPORT

## Development of Political Constituency of Support

- Identification of Opponents

## Development of Modification and Mitigation to Compensate "Losers"

- Develop a Pareto Optimum - Mitigation
- Refuse to Pay Extortion
- Broaden Constituency around Joint Benefit

## Embrace the EIS

- Institutionalize the Constituency
- Adopt Clear Mechanisms for Modification

# DOING THE JOB RIGHT

- Construction technology
- Maintenance of traffic during construction
- Excellent safety record
- Strong public and private management
- Second opinion committee

# DOING THE JOB NOT SO RIGHT

- No designation of "owner" with O&M responsibility
- Weakening of public oversight
  - -- Dismantling of second opinion capacity
  - -- other public agencies
  - -- interfaces between basic design/final design
  - -- value engineering threatening
  - -- reduction of benefits and cost-shifting
  - -- right-of-way acquisition
  - -- government oversight of environmental commitments weak, excessive reliance on unfunded advocacy groups
  - -- neglect of "building opportunities program"
  - -- unprogrammed traffic mitigation
- No longer an ICE process
- Lack of transparency

# KEY QUESTIONS

## A. Why are costs up?

| | |
|---|---|
| 1983 (uninflated) | $2.8 billion |
| 1990 (including mitigation and inflation) | $6 billion |
| 2001 | $15 billion |

Not environmental mitigation but land taking settlements and delay

Post 1991 scope changes

# COMPARE BIG DIG AND BOSTON HARBOR CLEANUP: A Tale of Two Projects

- 1990: estimate $6 billion, complete by 2000
- 2000: Big Dig incomplete at $15 billion
  Harbor Cleanup complete at $6 billion
- Big Dig: more visible, potentially disruptive; priority to contain disruption
- Harbor Cleanup: more transparency, statutory advisory board; but less political visibility
- Federal withdrawl of support common to both
- Harbor Cleanup less "Escher-like" than Big Dig

# KEY QUESTIONS

**B. Is the project still worth it?**

**For the Boston Metropolitan area?**

- **Fiscal stimulus**
- **Economic value of core**

**C. Why should the Federal government pay for this?**

- **National equity**
- **Rebuilding infrastructure is essential to the national economy**
- **Key projects won't occur without the Federal government because of the "peanut butter effect"**

# PUBLIC TRANSPARENCY AND OVERSIGHT ESSENTIAL

1. Construction quality
2. Continuous optimization of benefits and synergy
3. Environmental commitment implementation
4. I.C.E. and inflation, scope changes, new conditions
5. Adequate funding essential

# AGENCY COSTS vs PUBLIC COSTS

**Visible public agency cost of infrastructure is very large, but modest in comparison to private expenditure on vehicles, insurance, fuel, and parking**

1. **1 million vehicles cost $3-7 billion each year**
2. **Vehicle fuel cost leave the region**

   **Infrastructure costs stay in regional economy and recirculate**
3. **Parking costs in garages $10-30 billion for 1 million spaces. Each vehicle requires over 2 spaces.**
4. **Smart growth serves more trip needs on foot than on public transport, and more on public transport than in autos**
5. **Public transport system capacity and quality must improve dramatically to permit growth**

# DANGEROUS MYTHS

- "On time and within budget"
  -- leads to cost shifting
- Contingency funds
  -- invite cost increase
- Contractor profits excessive
  -- check bankruptcies
- Privatizing eliminates risk
  -- or hides it
- Privatization can produce a "free lunch"
  -- but you pay more

# TRADITIONAL PROJECT DELIVERY MECHANISMS PROBLEMATIC

- Low bid substantially different from full cost after Change Orders and settlements
- Adversarial relationship with contractors and providers poisonous
- Interfaces among contracts create opportunities for destructive leverage
- Honest disclosure, transparency, and "open" attitude towards re-engineering clashes with traditional procurement
- Public/private partnerships must be based on symbiotic strengths, not strength and power dominance of multiple interfaces
- Non-traditional and fair mechanisms for dispute resolution in real time essential to successive sequencing of multiple contracts
- Lack of fair, stable sharing of cost and risk between central and regional government leads to destructive behaviour

# ENLIGHTENED SELF-INTEREST

1. Enlightened and competent
2. Clear, reliable national funding streams
3. National/local partnerships
4. Eisenhower and the US Interstate Highway System plus the National Environmental Policy Act
5. Interstate cost estimate, periodic update with fixed shares vs. "full funding" grant agreement oxymoron

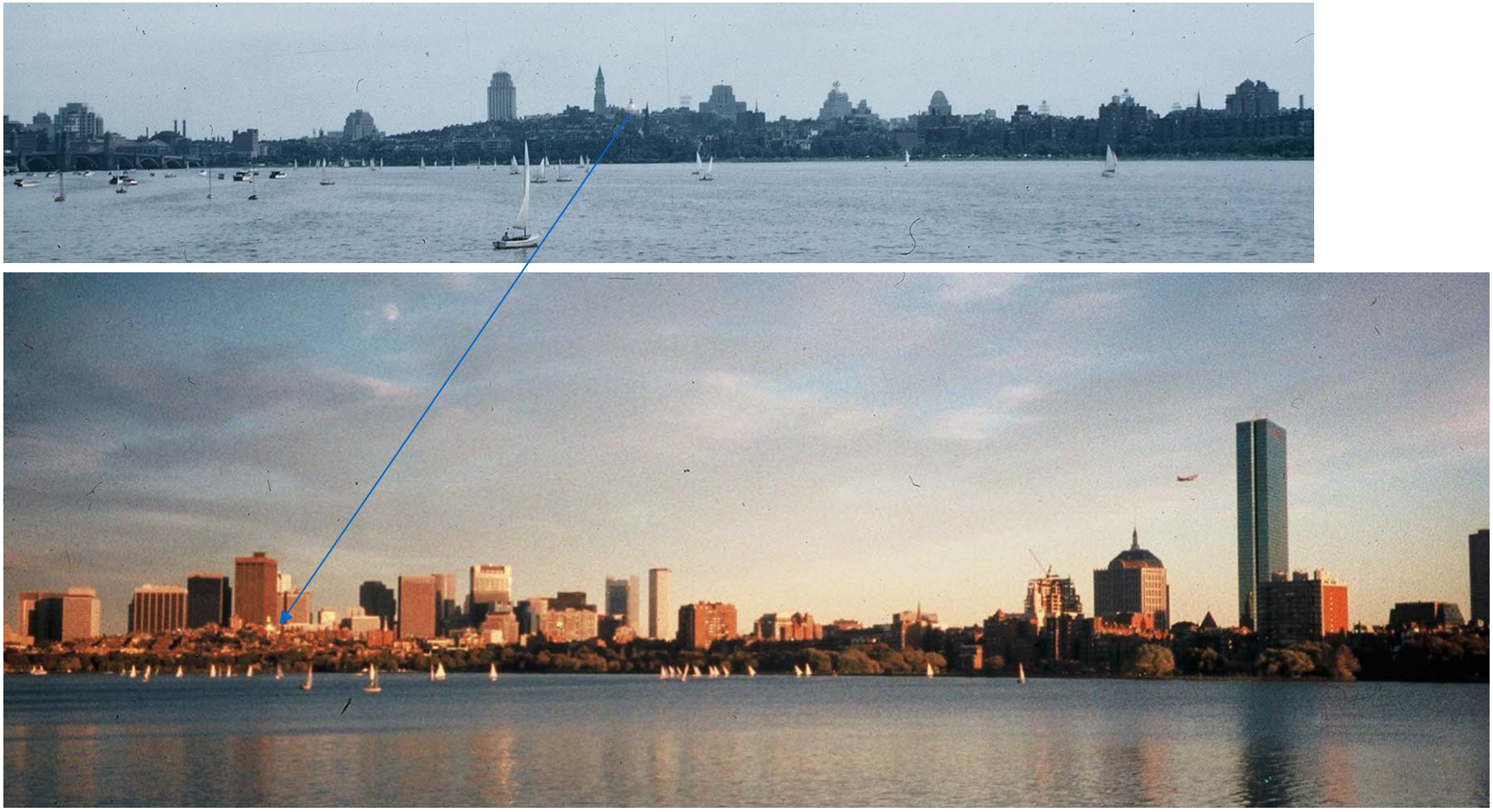
# GOVERNMENT /PRIVATE RELATIONSHIP

| GOVERNMENT / PRIVATE | Honest & competent | Honest & incompetent | Dishonest |
|---|---|---|---|
| Honest & competent | | | |
| Honest & incompetent | | | |
| Dishonest | | | |

# NATIONAL/LOCAL GOVERNMENT RELATIONSHIP

| GOVERNMENT<br>NATIONAL<br>LOCAL | Honourable & competent | Honourable & incompetent | Dishonourable |
|---|---|---|---|
| Honourable & competent | | | |
| Honourable & incompetent | | | |
| Dishonourable | | | |

# BOSTON SKYLINE: 1958 - 1995



# POSSIBLE LESSONS of BIG DIG

- **Local initiative essential**
- **Stable local political consensus of great strength required**
- **Synergistic benefits produce political support, not value capture**
- **Sustained support of central government essential**

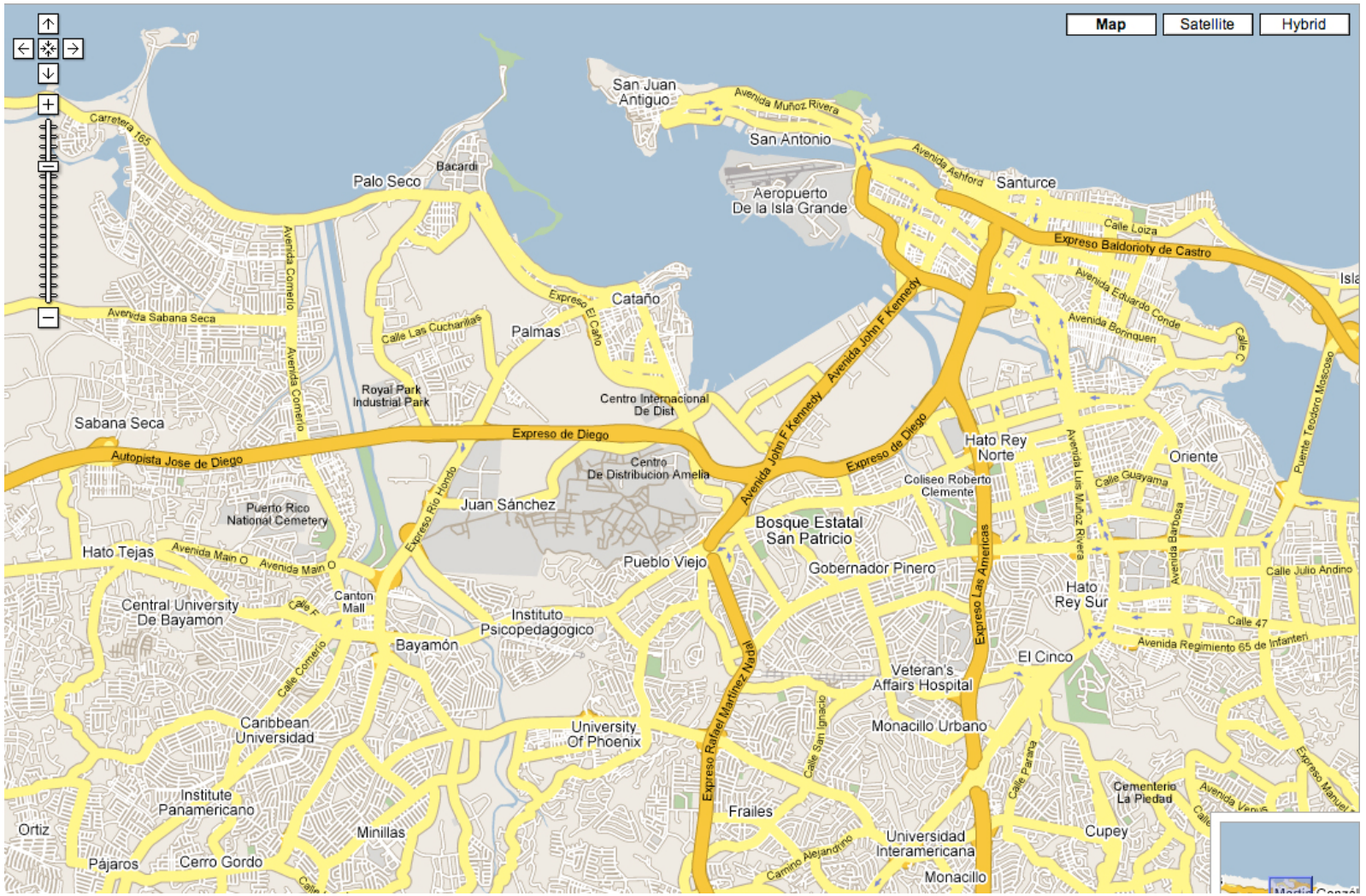
# POSSIBLE LESSONS of BIG DIG

- **Non-adversarial construction procedures highly desirable**
- **Dedicated funding, stable cost-sharing, transparency highly desirable**
- **Delay costs billions in construction inflation, but even more in deferral of benefits, impediment to economic growth**
- **Modern infrastructure projects have a high technological content, but are not industrial products. They are more like “one of a kind” craft products**

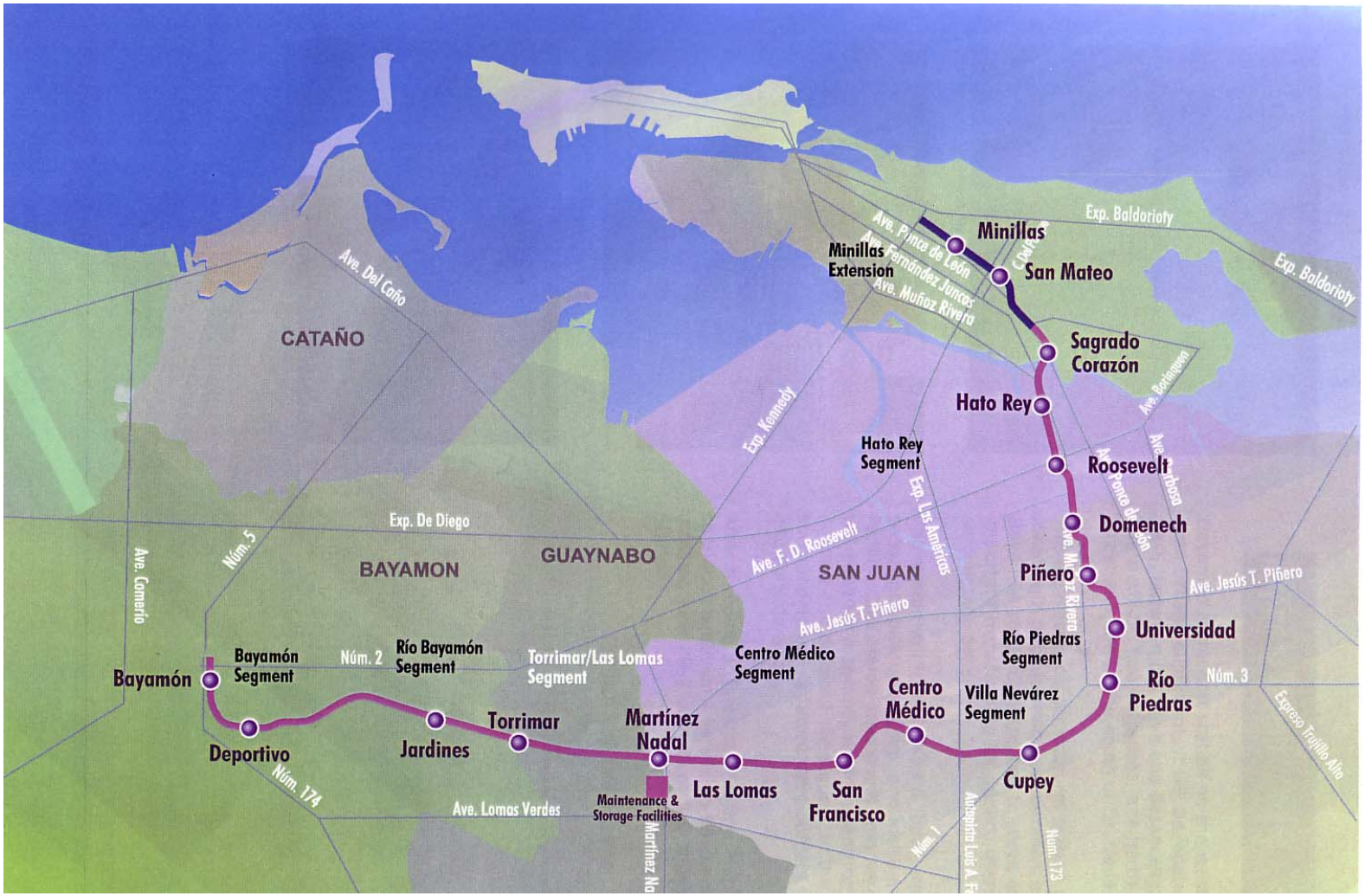
# Tren Urbano
## Setting Up a New Transit System based on Lessons Learned from the Big Dig

# Map of Puerto Rico

# Map of San Juan



# Map of Tren Urbano



# TREN URBANO

## 1. Situation in San Juan in early 1990s: Bad News

(a) Very strong car culture overwhelming infrastructure

Highest number of autos per lane mile of street in the U.S.

(b) Lowest per capita income in U.S.

1/2 the level of Mississippi, combined with high auto expenditures

(c) Terrible bus service provided by public agency

-- one run for the company, one for me

-- very long rides, infrequent point-to-point services

-- buses trapped by congestion

(d) Very customer-unfriendly jitney services (*carros públicos*)

No schedule, old vehicles, often with air-conditioning not working

Many jitney operators said to be ex-bus drivers

# TREN URBANO

## 2. Situation in San Juan in early 1990s: Good News

(a) Functioning exclusive contraflow lanes from Old San Juan to Santurce to Hato Rey to Rio Piedras

(b) Contracted service every 6 minutes with good reliability

(c) Legislative commission recommending contracting out of entire bus system

(d) 25-year old idea of Metro service

(e) P.E.I.S. of starter "light rail" link from Bayamon to Centro Medico to Rio Piedras to Hato Rey to Sagrado Corazon

(f) Base of political support of mayors of San Juan (red), Guaynabo (blue), Bayamon (blue), and Carolina (red)

# TREN URBANO

## 2. Situation in San Juan in early 1990s: Good News

(g) Coalition formed by Hermenegildo Ortiz Quiñones (Red Party) successful in being included in Federal blue-ribbon design-build demonstration

(h) PRHTA statutorily strong Department of Transportation

Contraflow lanes plus design-build Moscosco Bridge

(i) New, action-oriented Governor ("se puede")

New Secretary of Transportation Pesquera

PhD from Cornell in Structures; Professor at UPR

(j) Strong memory of street car services, which had disappeared 50 years ago ("Stop 18")

# TREN URBANO

## 3. Review and Recommendation by John Attanucci Group

(a) Merits of Tren Urbano highest in the U.S. (based on least dollars / net new riders)

(b) Potential for success of grade-separated service high

(c) Seek Federal funding

(d) Modify alignment of PEIS to increase accessibility, even though costs would increase because subway costs high; support TOP

(e) Simultaneously increase and upgrade bus services, to build public transit ridership during construction, feeder stations when Tren Urbano would open

(f) Design - Build - <u>Operate</u> and <u>Maintain</u>

# TREN URBANO

## 3. Review and Recommendation by John Attanucci Group

(g) Establish "Technology Transfer program for

-- just-in-time university research

-- Formation of Puerto Rican expertise

-- partnerships with mainland for future joint efforts in Puerto Rico, Caribbean

-- human capital part of train

-- small % of $2 billion provides high stabilitiy, multi-year university program

# TREN URBANO

## 4. Boston Connections

- Governor Rossello
- Sergio Gonzales
- John Attanucci
- Orange Line and Big Dig graduates:

MIT
Macomber Development Associates
F.R. Harris
Stone & Webster
Jane Garvey
Palmer Dodge
McDermott O'Neill
Alternate Concepts
Perini

# TREN URBANO

## 5. Political Strategy

(a) Get Federal money (1/3 to reduce opposition of local highway lobby

(b) Involve local design and construction community

(c) Use Design-Build-Operate-Maintain

- increase credibility of quality
- keep Federal interest
- get a shovel into the ground before the next election

(d) Long-range plan to reach Old San Juan, Airport, Carolina, Caguas?

(e) Build a base of community support through intensive community participation

(f) Build a base of intellectual support through MIT-UPR partnership

(g) St. Francis strategy

# WHAT HAPPENED?

## Good News

(a) Carlos Pesquera and community participation

(b) Federal environmental and funding success

(c) Congressman Randall and Chichi Rodriguez

(d) Procurement success

(e) Shovel in ground by August of election year

(f) Strong community support for station locations

(g) Successful restructuring of bus service

(h) Transit-oriented development

# WHAT HAPPENED?

## Bad News

(a) Construction firm incompetency / arrogance

(b) Government ambivalence on enforcing contracts

(c) Siemens performance

(d) Schedule slippage (intentional)

(e) Cost increases

(f) Pesquera candidate for Governor

(g) New government political ambivalence on Tren Urbano

(h) Bus restructuring failure

(i) Público strategy not implemented

(j) Car culture, alive and well, parking everywhere

# HOPE FOR THE FUTURE

(A) Great physical infrastructure, stations

(B) Potential for expansion

(C) Bus reform possible

(D) Still possible to activate Siemens added 5-year responsibility

(E) Alternate Concepts still central

(F) Design-Build-Operate-Maintain and "Just-in-Time" university partnerships are replicable strategies