
Modern Tunnel Planning –

Amanda Elioff, Working



Modern Tunneling – Exciting Times

In last 20 years, technology and planning methods have more successfully met the demand to safely construct underground space and reduce impacts to the environment and communities



ESCSO - Portland

Underground Now Emerges as the most attractive Alternative

- Least Short and Long Term Environmental Impacts
- Benefits – Allows use of surface for other needs
- Cost competitive
 - Capital Costs and Life Cycle Costs



New Technology and Attention to Community – Key to Modern Tunneling

- Illustrate Through Development of two Recent Projects
 - Los Angeles, California - Metro
 - Seattle, Washington – Large Vehicular Tunnel



Historic Tunnels United States – Early 1900s

- Infrastructure Growth
- Urban Crowding
 - New Sewers, Subways



Another Growth Wave – Post War

- Population Growth
- Advent of the Automobile (and sprawl)
- Water supply and Sewerage systems expanded
- Cities Developed Master Plans for Growth and Transportation – Included Transit and Subways to reduce traffic Congestion
 - San Francisco - BART
 - Washington DC -WMATA
 - Los Angeles – Metro Rail



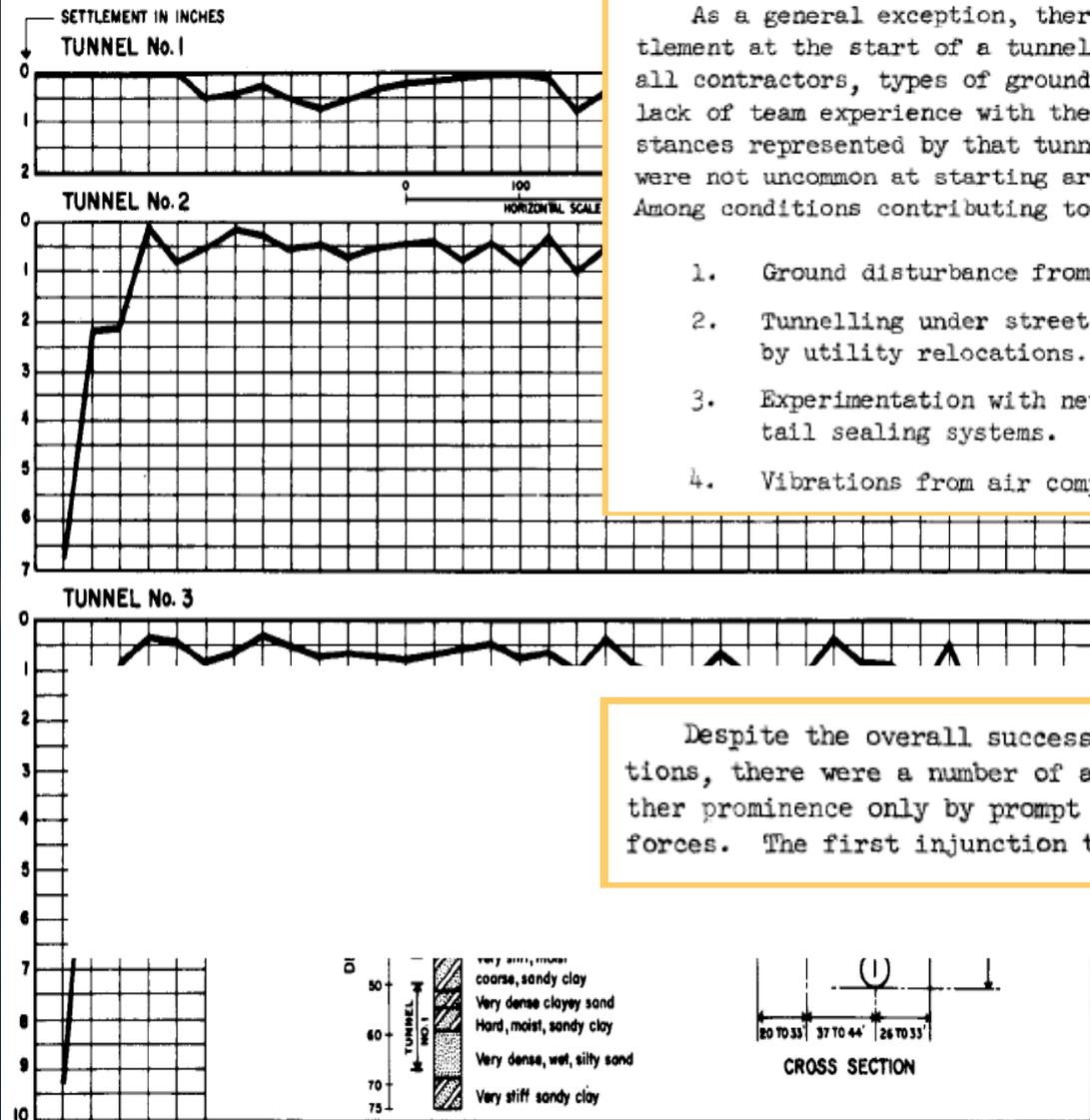
Tunnel Construction 1960s-1980s

- Open Shields
- Dewatering
- Cut and Cover
- Settlement
- Disruption
- Impacts to Community and Business



Published Settlement Records

Bay Area Rapid Transit 1970



As a general exception, there was almost invariably greater settlement at the start of a tunnel drive. This occurred with almost all contractors, types of ground, equipment, and methods, owing to a lack of team experience with the particular combination of circumstances represented by that tunnel. Local settlements of three inches were not uncommon at starting areas -- some cases reached 8 inches. Among conditions contributing to exceptional settlement were:

1. Ground disturbance from construction of shield starting pits.
2. Tunnelling under street intersections repeatedly disturbed by utility relocations.
3. Experimentation with new grouting materials, and new shield tail sealing systems.
4. Vibrations from air compressor plants.

Despite the overall success of BART's soft ground tunnel operations, there were a number of adventures which were saved from further prominence only by prompt remedial action taken by the field forces. The first injunction to tunnellers is vigilance.

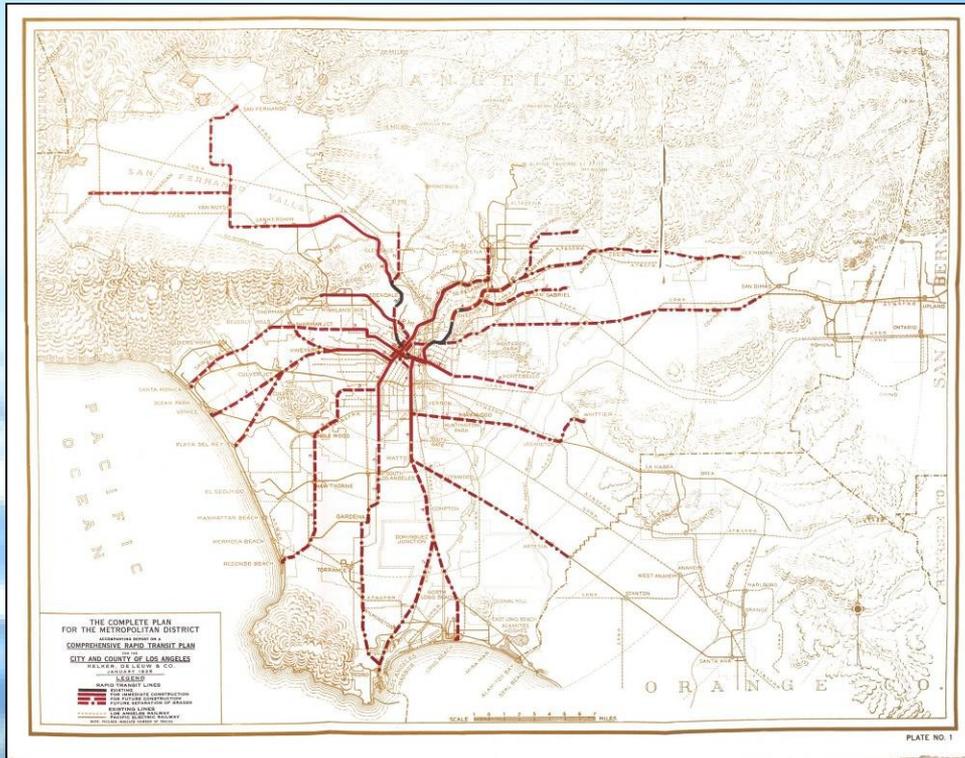
Fig. 13 BROADWAY-OAKLAND TUNNELS--SURFACE SETTLEMENTS

Modern Planning – Public Transit History Los Angeles

Streetcar lines 1940s Including Westside of LA

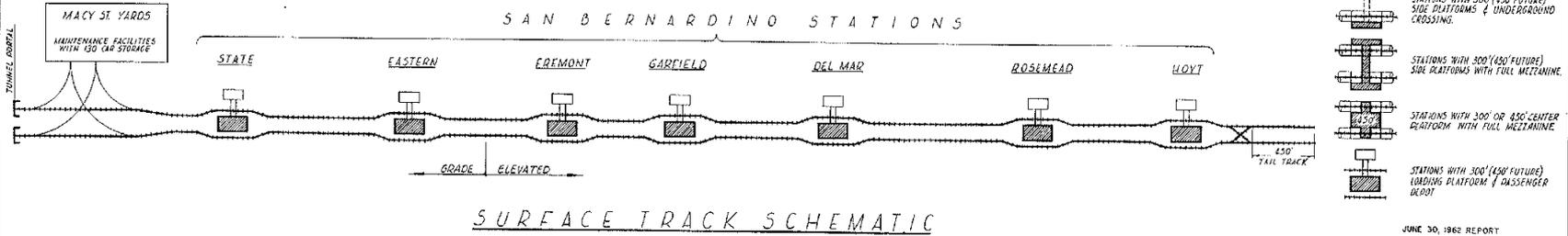
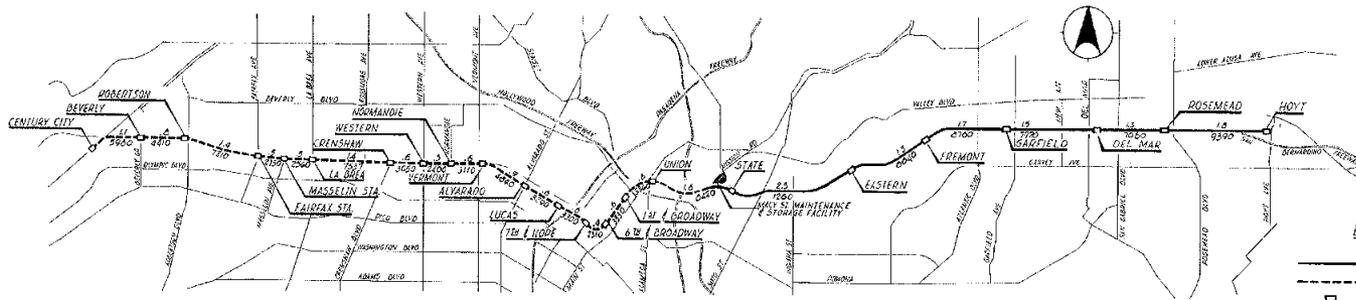
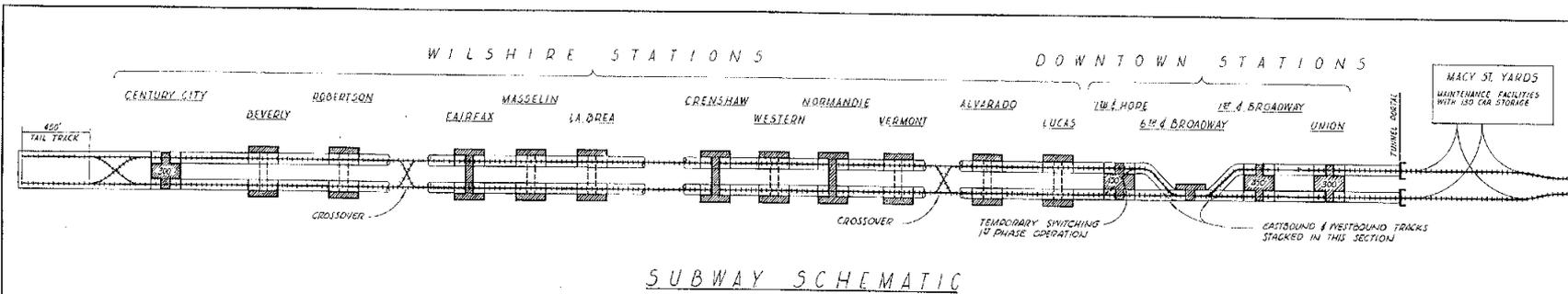


Comprehensive Rail Rapid Transit



- Recommended 200+ km of subway, elevated and at-grade rail, projected cost of \$133,385,000.
- Envisioned 3 Westside subways: from downtown across Hollywood Blvd. to La Brea; along Third to La Brea, then elevated rail to Wilshire Blvd to the ocean; and subway across Pico to Rimpau then elevated to Venice Beach.
- **Rejected by voters** who opposed elevated rail, its cost, and taxation to benefit privately held Pacific Electric.

1962-No Streetcars Remain Backbone Route Proposed

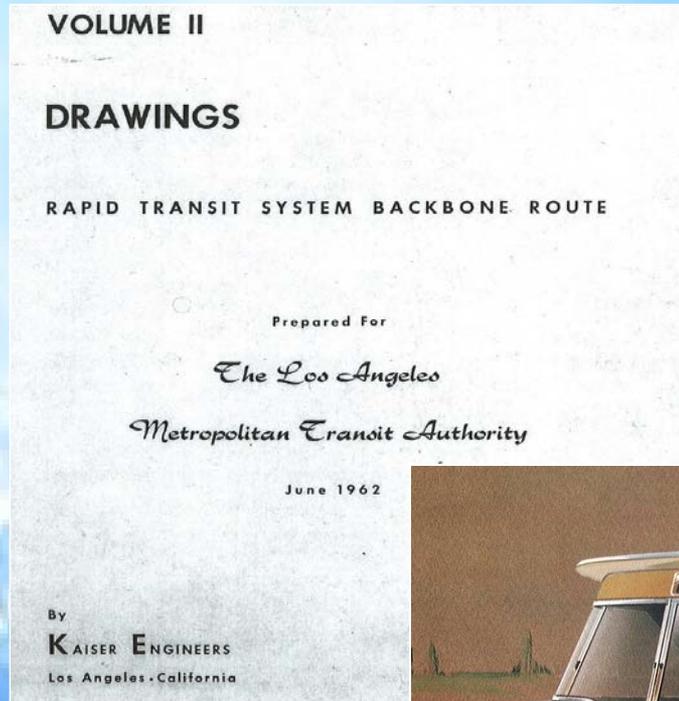


NO.	DATE	REVISION	BY	CHKD.

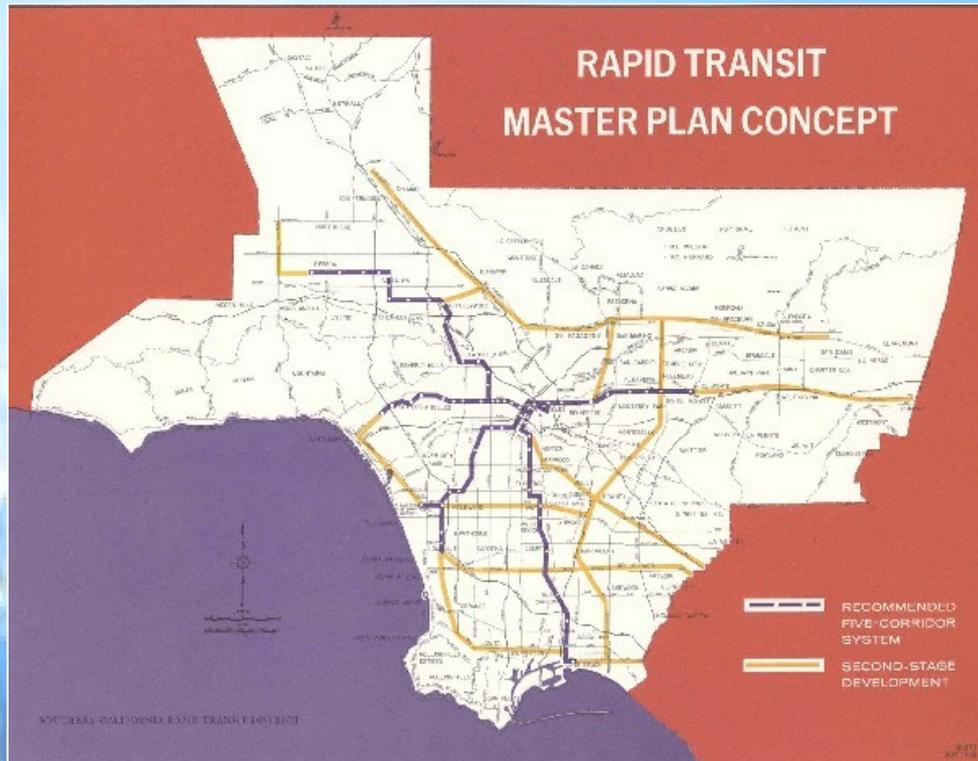
JUNE 30, 1962 REPORT

Kaiser Engineers ARCHITECTS & ENGINEERS LOS ANGELES, CALIFORNIA		LOS ANGELES METROPOLITAN TRANSIT AUTHORITY LOS ANGELES, CALIFORNIA
APPROVALS K.E. [Signature] L.A.M.T.A. [Signature]		
R. BASHUISSE J. B. BROWN J. H. HARRIS J. J. JONES J. K. KANE J. L. LEE J. M. MANNING J. N. NICHOLS J. O. OLSON J. P. PETERSON J. Q. QUINN J. R. RAY J. S. SAMPSON J. T. TAYLOR J. U. UNDERWOOD J. V. VANCE J. W. WALKER J. X. XANTHOPOULOS J. Y. YONGE J. Z. ZIMMERMAN		RAPID TRANSIT SYSTEM LOCATION PLAN AND SYSTEM SCHEMATIC
SHEET NO. 6148 SCALE 1" = 600'	JOB NO. 6148	DRAWING NO. 1-C REVISION

1962 Proposed Backbone Route

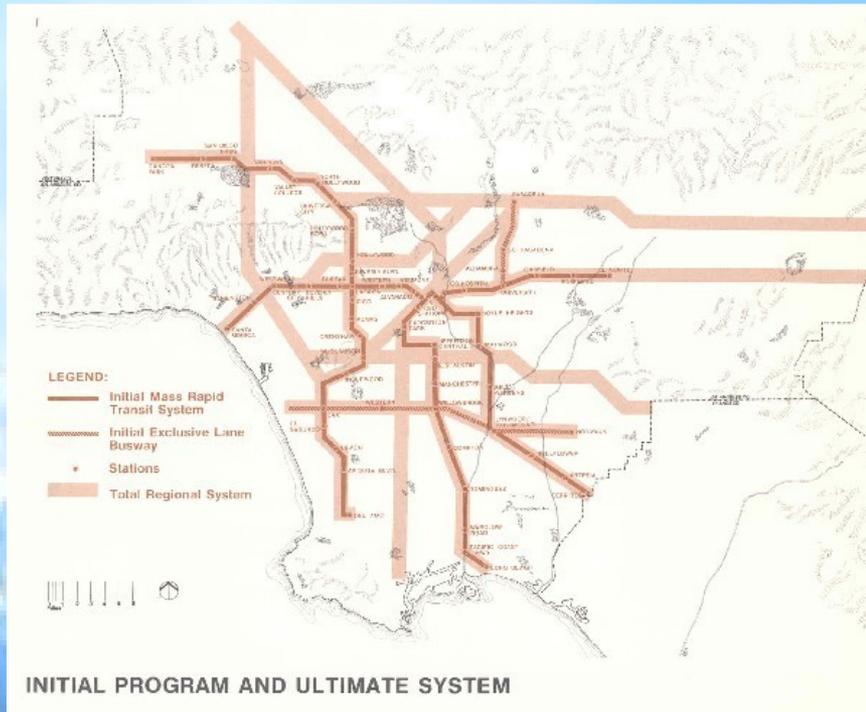


1968 Rail Rapid Transit Plan



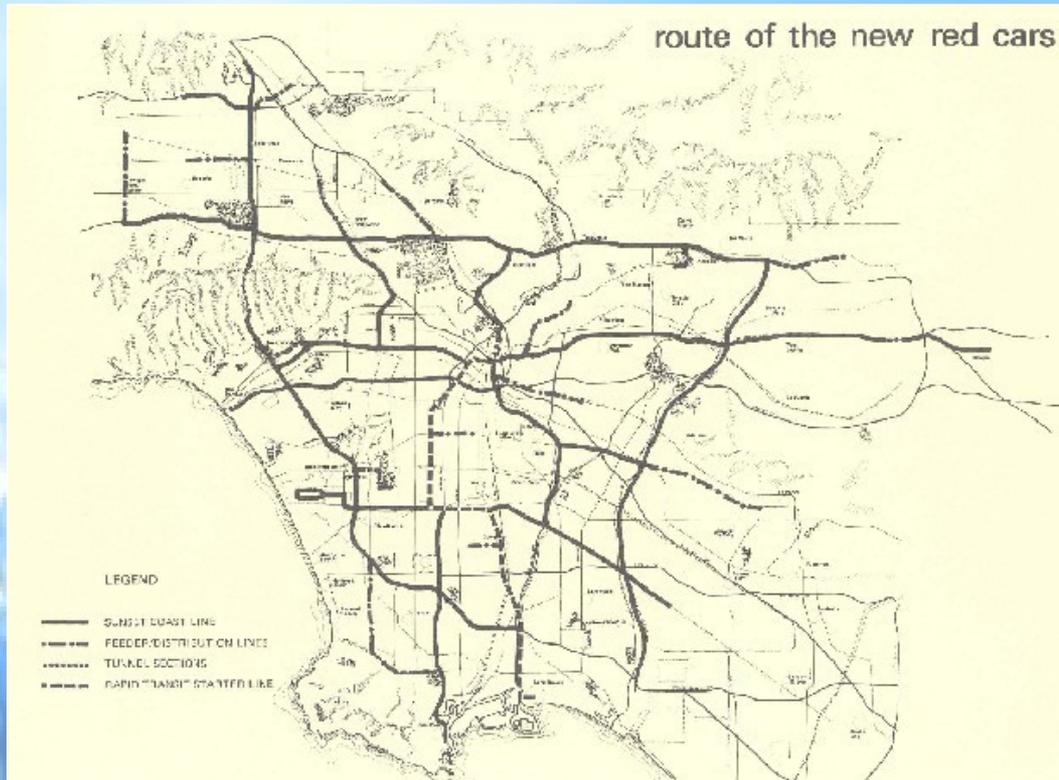
- 1968 rail rapid transit plan concept map for a ballot initiative.
- Initial 100 km four corridor system that could expand to 500 km, projected cost of \$2.5 billion, 8.5 year construction period.
- Underground Wilshire stations along Wilshire Blvd (similar to Backbone route)
- **Ballot initiative failed.**

1974 Rail Rapid Transit Plan



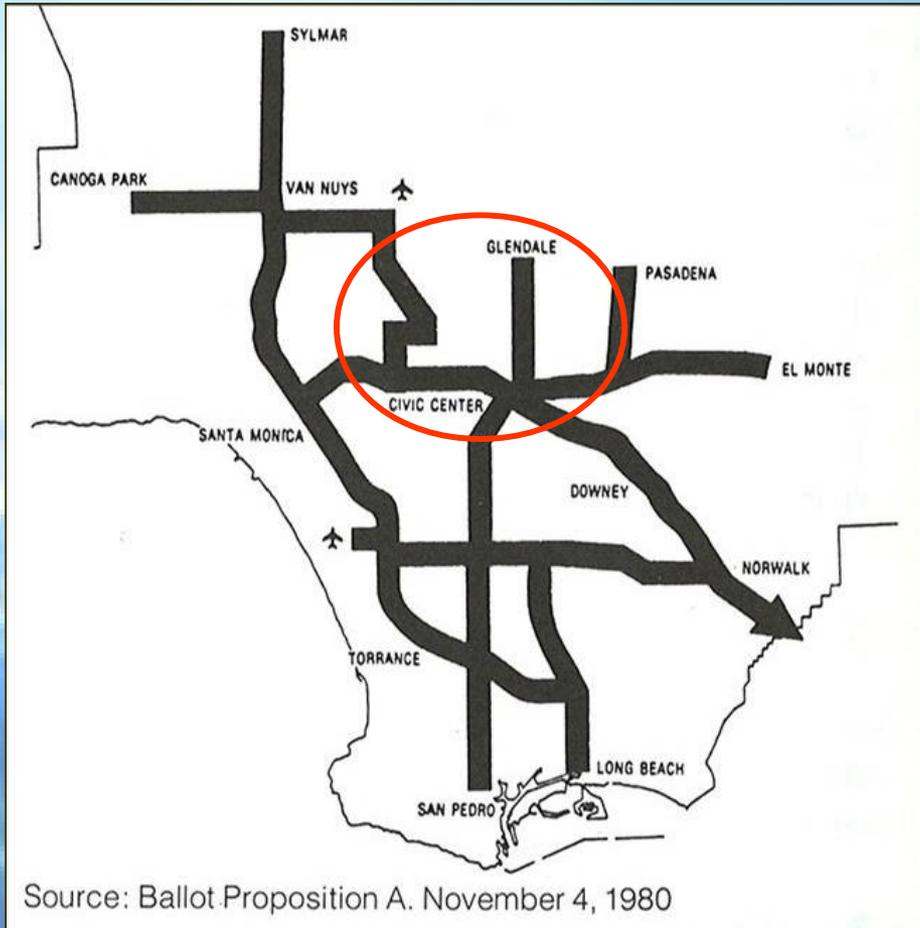
- 1974 rail rapid transit concept map for a ballot initiative.
- Initial 185 km of rail rapid transit that would eventually expand to a 400 km system with 35 km of exclusive lane busways. Projected cost of \$6.6 billion, 12 year construction period.
- Underground Wilshire stations included Crenshaw, La Brea, Fairfax, La Cienega, Beverly Hills, Century City, Westwood, Barrington, and Santa Monica.
- **Ballot initiative failed.**

1976 “Sunset Coast”



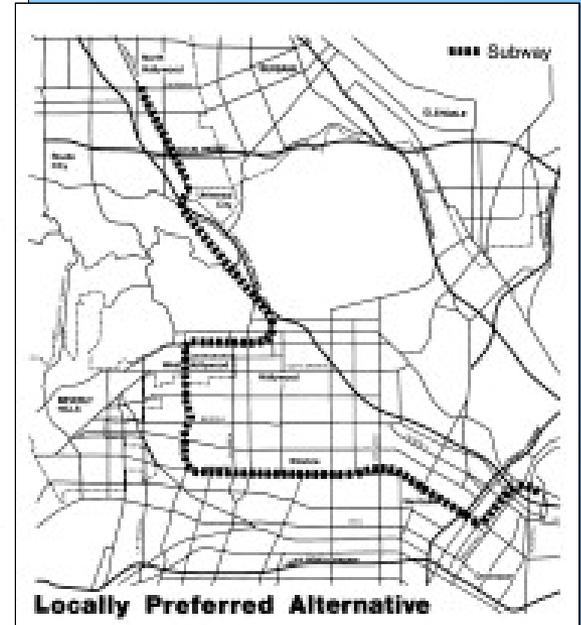
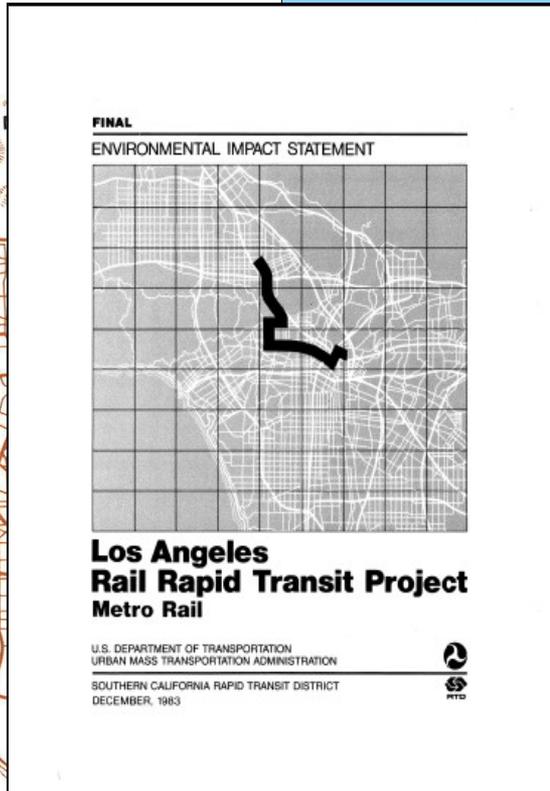
- 1976 “Sunset Coast” rail rapid transit plan for a ballot initiative.
- 450 km system, 370 km of heavy rail and 80 km of light rail, projected cost of \$7.5 billion.
- System proposed mostly elevated rail, including along the Wilshire corridor.
- Ballot initiative failed by a wide margin.

1980 LACTC Rail Rapid Transit Plan Approved

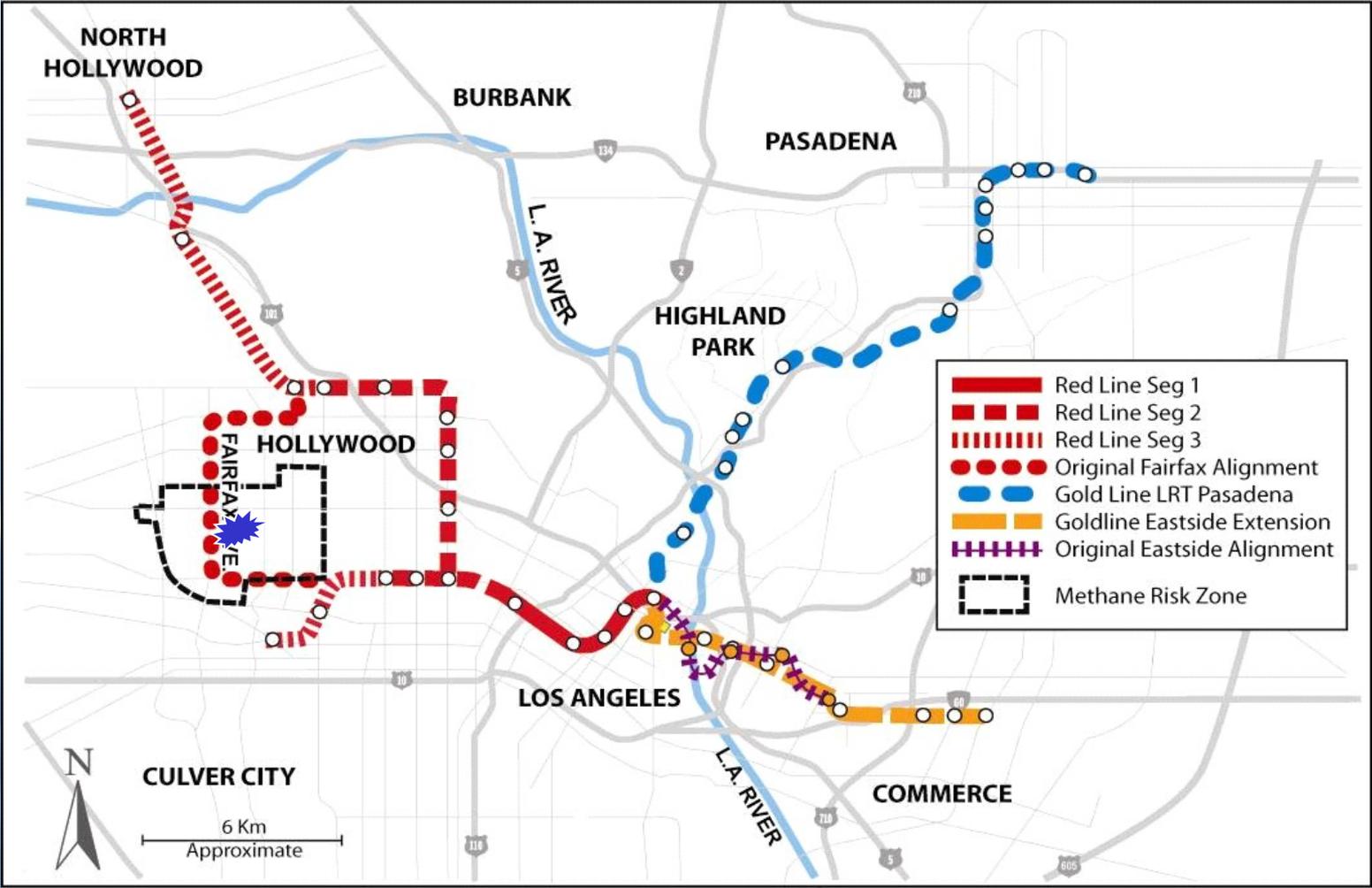


- New approach –
- State created the Los Angeles County Transportation Commission (LACTC) in 1976 to coordinate between municipal transit operators and SCRTD, plan countywide transportation improvements and ensure efficient use of transportation funding.
- In 1980, a majority of Los Angeles County voters approved Proposition A, a half cent sales tax for transportation improvements.

1983 Locally Preferred Alternative



Legislative Changes: Methane Zone



Non-Tunneling related explosion near La Brea Tar Pits

Metro Red Line Construction

- Open shields in alluvium (dense and loose)
- Dewatering
- Wood decking



7th Street 2009



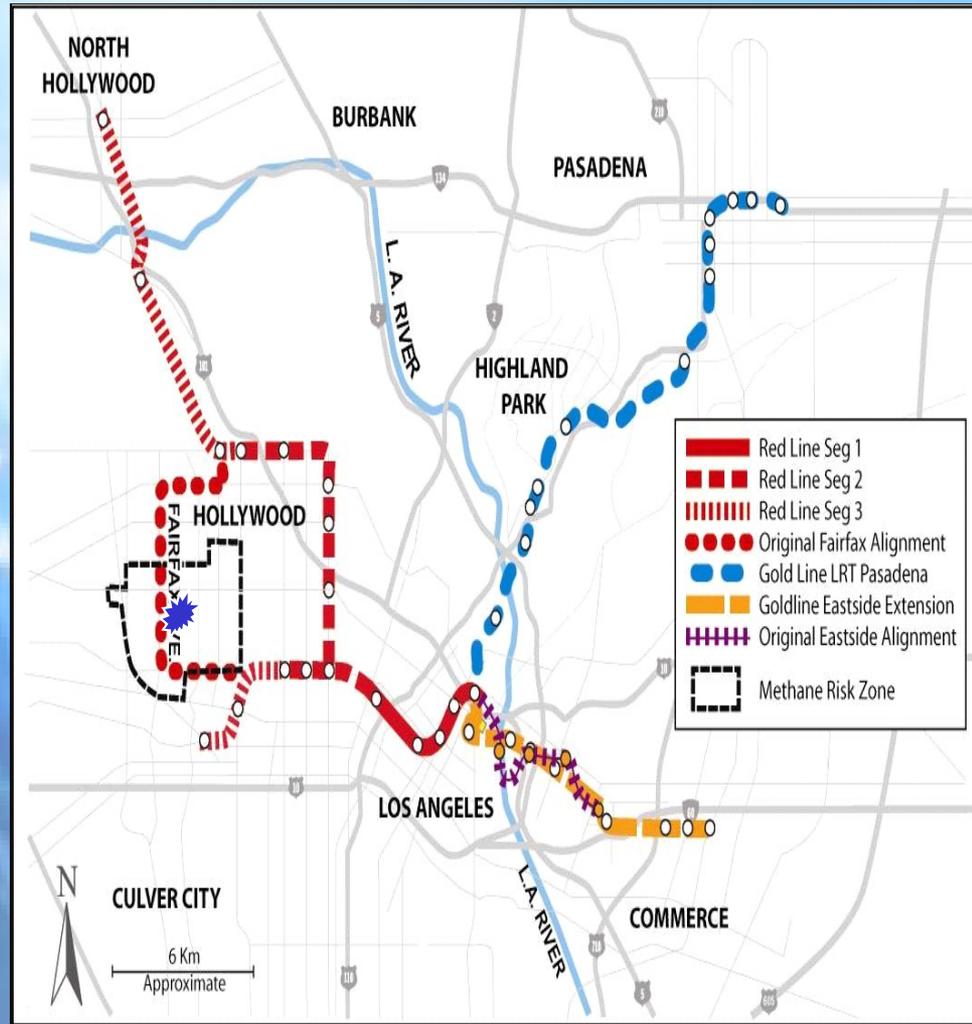
Construction Issues

- Settlement
- Business disruption
- Cost overruns
- Media Attention



Hollywood Boulevard, 1994

New Construction Halted in 1997,



- Confidence Lost
- Voters confirm no sales tax to be used for subways - MTA Reform and Accountability Act of 1998 (Proposition A), which banned the use of county sales tax revenue for the planning or building of subways –
- East side Heavy Rail project in Final Design “shelved”

Transit System 2000



Technology Advances Recognized

- Use of Pressure face Machines would be specified for new soft ground tunnels
- Design Criteria Developed for this Seismic Area
- Active Fault Crossings incorporated in design
- Gas Barriers, detection and alarm systems implemented
- Subway Operated Safely



Fault Crossing – Oversized Section

Planning (Including Tunnels) Continued



Eastside Transit Corridor Study

Los Angeles, California



Re-Evaluation/ Major Investment Study (MIS)

Draft Report



Prepared for:
Los Angeles County
Metropolitan Transportation Authority

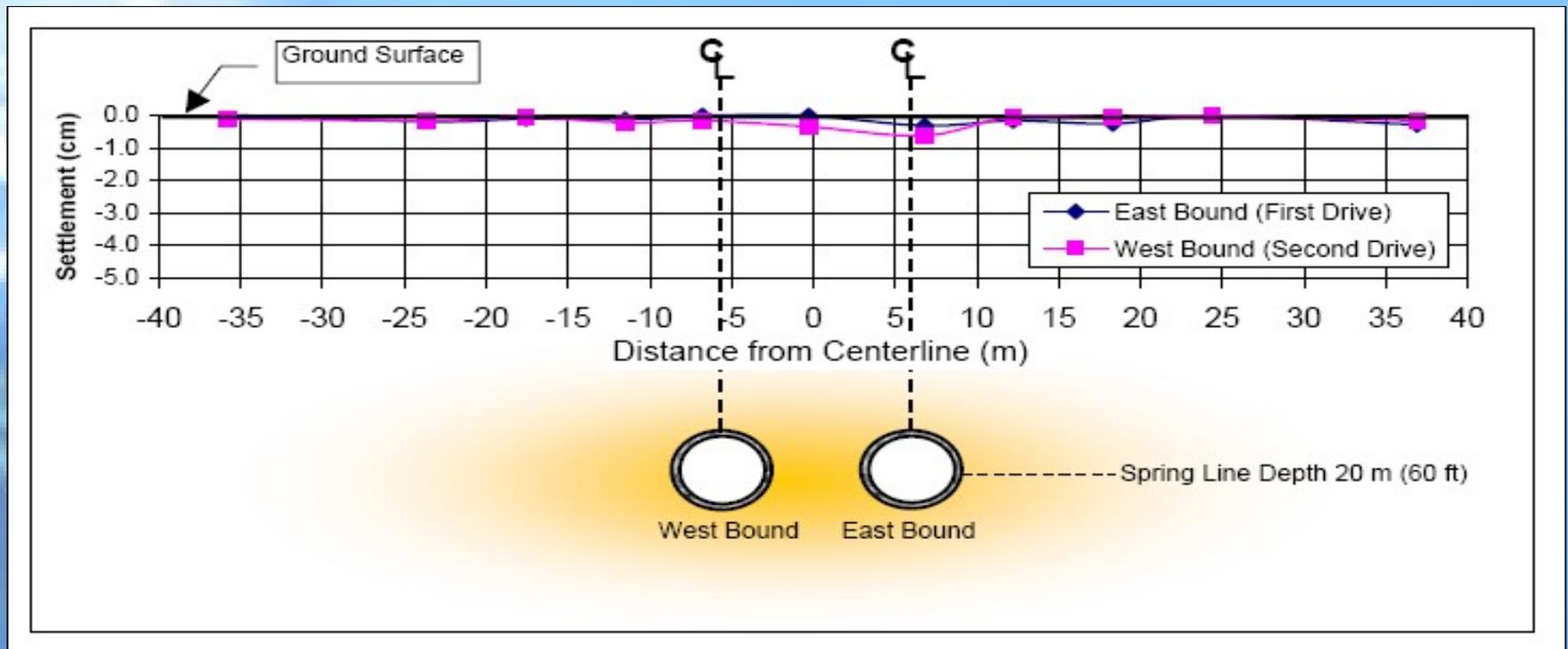
Prepared by:
Eastside Corridor Transit Consultants

February 24, 2000

- Metro's Restructuring Plan focused on alternative fixed guideway systems for areas where projects were suspended
- Planners go back into action
- Light Rail system emerged as preferred alternative to East Los Angeles
- System included 2 km of tunnel below narrow streets
- Success of tunneling critical for future projects

Tunneling Success – Eastside Extension

- Tunneling 2006-2007
- EPB TBMs used
- “zero” settlement
- Compensation



Reduced Risk and Impacts



Improved Technology

- Pressure Face TBMs
- Permeation Grouting at cross passages
- Prepared to use

Cross passage Grouting from Surface



Compensation Grouting used Directional Drilling (not activated)



Technology AND Community Involvement Key



- 10 year history of involving the resident Advisory Committee (RAC) – Planning and during Construction
- Vigilance in notification of construction activity
- Maintaining access to businesses
- Safety Record of Contractor highlighted (~4,000,000 MH, no lost time accidents)

Decking and Full Street Closures



Success of Eastside Means Consideration of More Tunnels in Los Angeles

20
06

House lifts obstacle to Westside subway

By Richard Simon
Times Staff Writer

WASHINGTON - Two decades ago, Rep. Henry Waxman wrote into law a ban on the use of federal funds to build a subway tunnel in the Fairfax district of Los Angeles, worried that construction could trigger an underground gas explosion.

On Wednesday the Los Angeles Democrat - now convinced that new technology could make drilling safe - persuaded the House to repeal his 1985 law, removing a major political obstacle to extending the line to the Westside.

- Special Panel Convened
- Indicates that with PFMs, tunnels can be constructed safely
- Special Consideration For More Gassy Areas



Tunneling Success and Technology

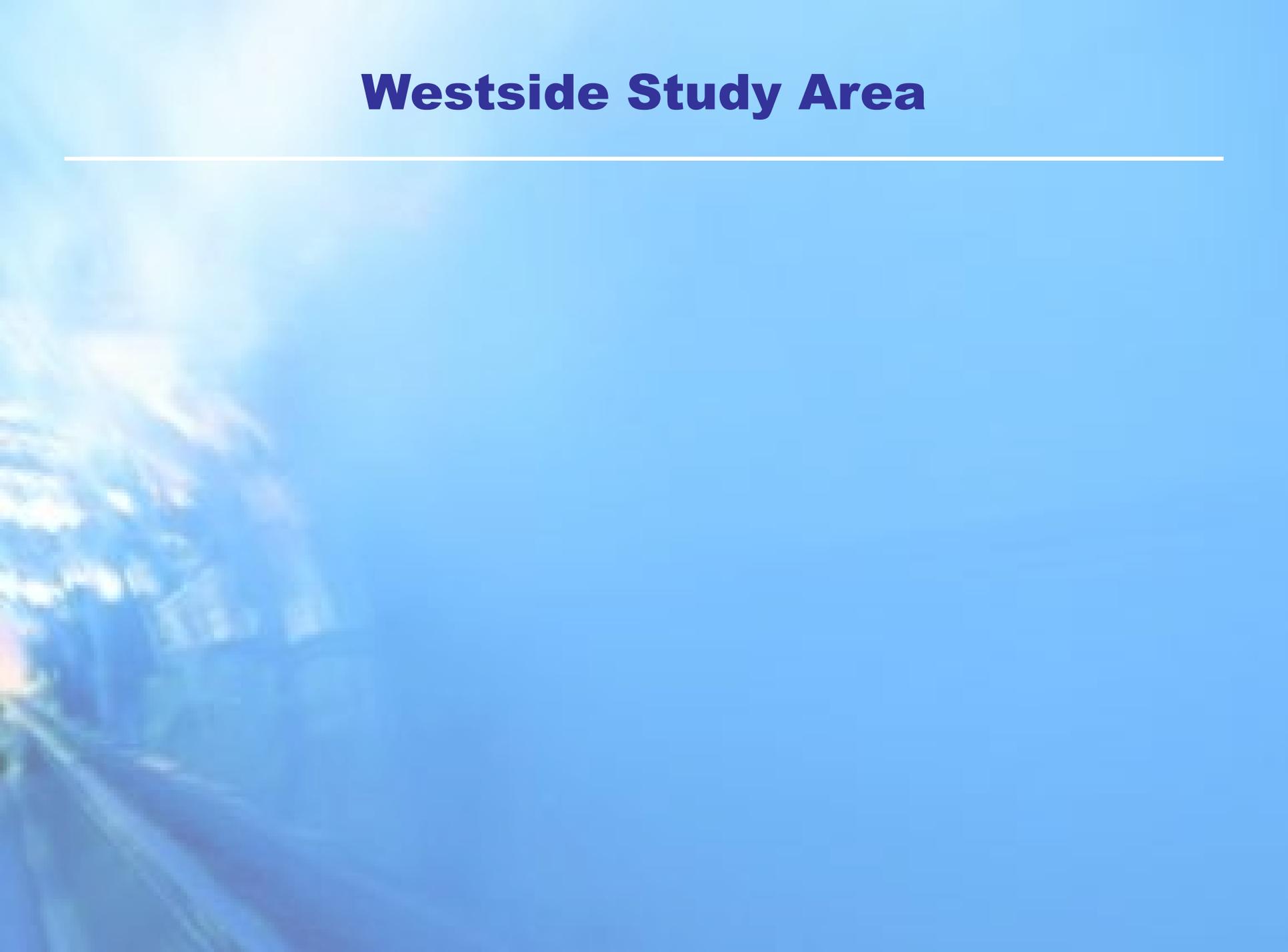
- Allows subway ban to be lifted
- Westside Continues studies in Gas zone area – Including Subways – not allowed since 1986
- Other Transit Modes also examined



Transit System 2009



Westside Study Area



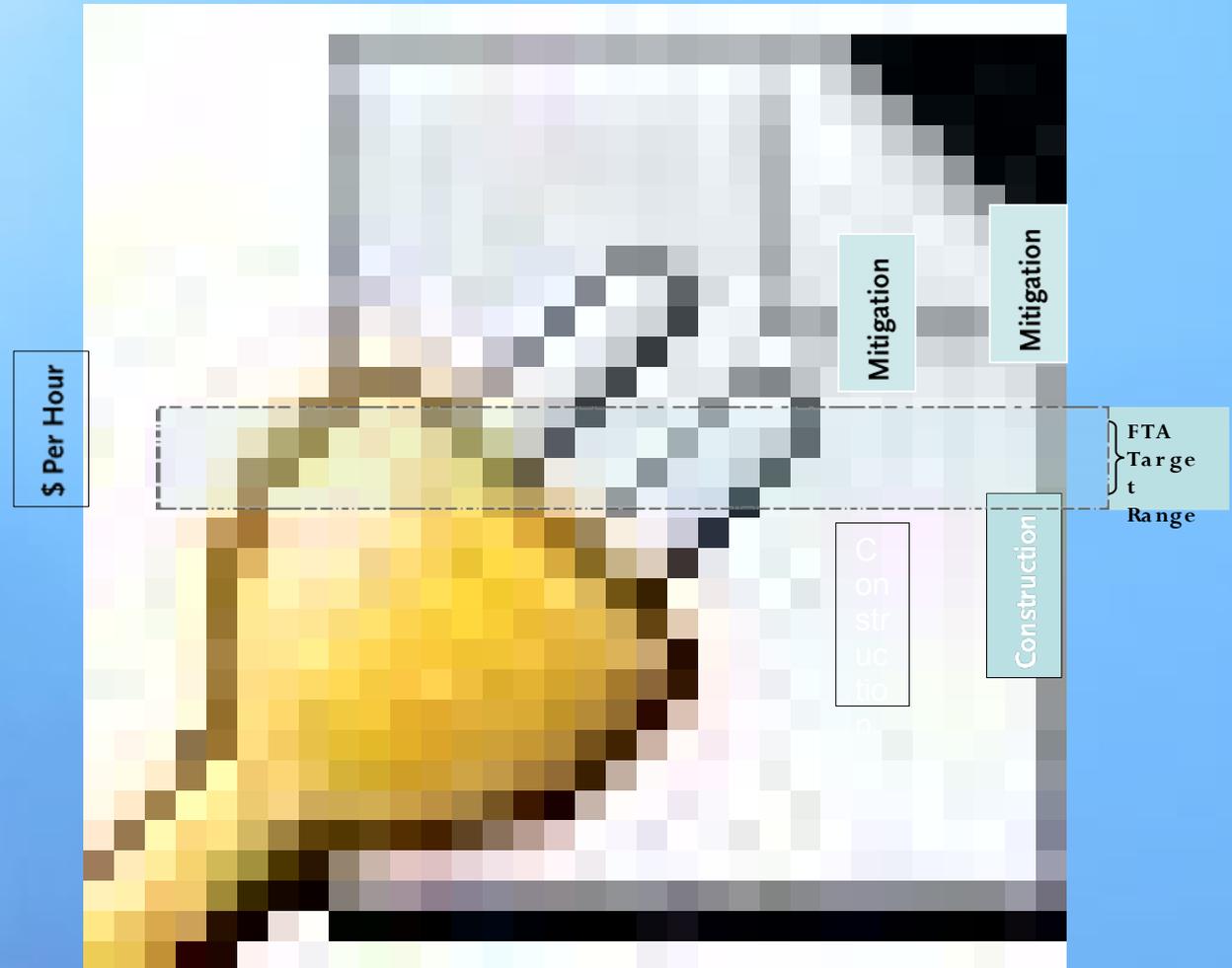
Technologies Studied Included Aerial

- Good U.S. examples of aerial rail but not in dense, urban corridors like Wilshire Blvd.
- Environmental impacts would be considerable and largely eliminate any advantages over subway alternatives
- There are no substantive savings in size or cost from one aerial technology to another
- Heavy Rail
- Light Rail
- Bus Rapid Transit
- Mono Rail
- Subway
- Aerial



Subway Cost Effectiveness Demonstrated

- Mitigation measures increase cost of aerial systems
- Subway compares favorably with Aerial



Alternatives included Various Modes and Cross Sections Including Monorail



Photo Sims Created to Assess Visual Impact



Several Views Considered



Monorail Station at Wilshire and Fairfax



Torti Gallas Partners for Metro

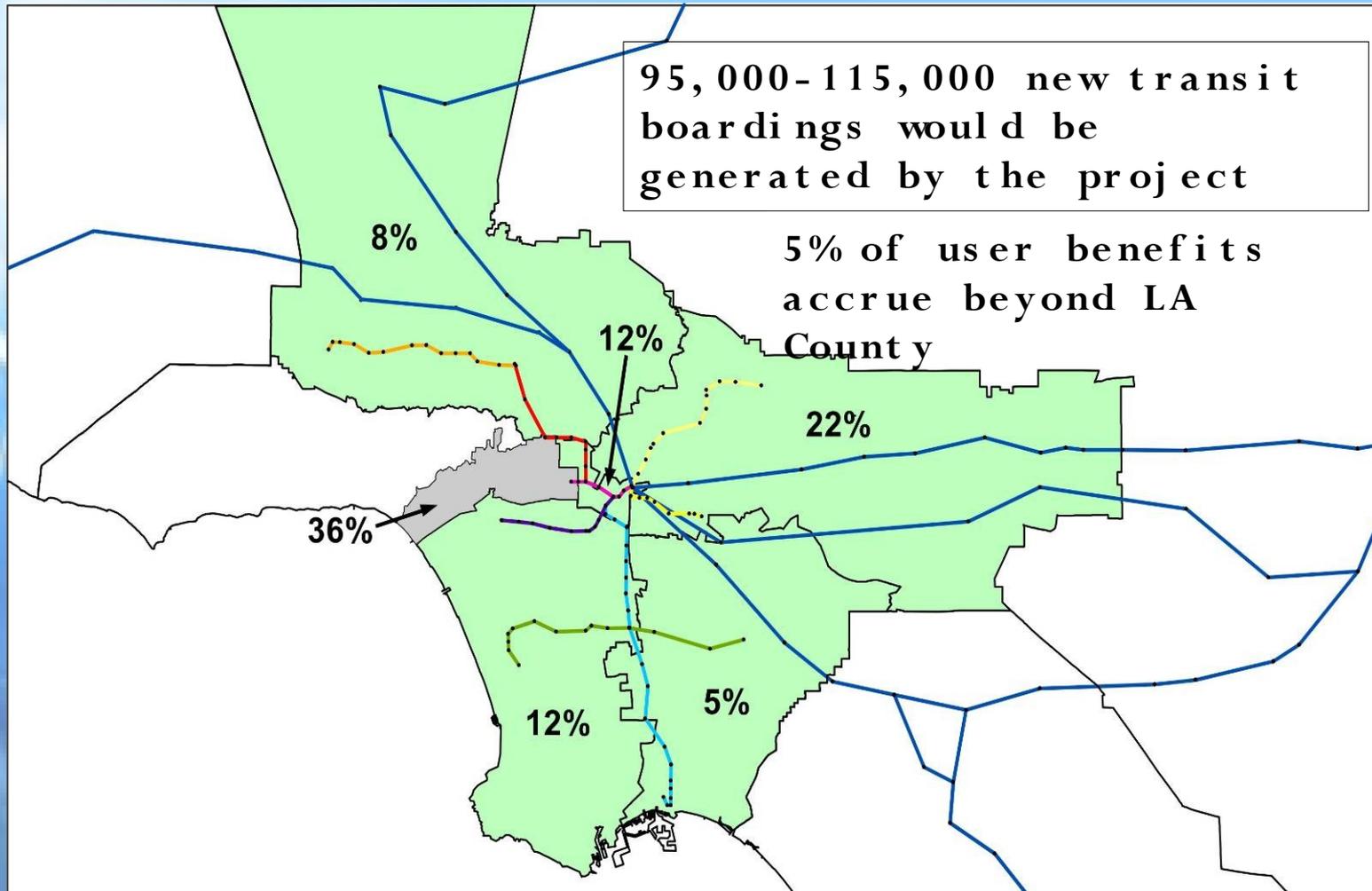
Why Subway Selected in AA

- Transit Capacity
- Speed
- No visual Impacts
- Fewer overall impacts
- Cost Competitive

HRT	Up to 800 passengers/train (6 cars) Top Speed of 110 km/hr Up to 14,000 passenger/hour/direction
LRT	Up to 425 passengers/train (3 cars) Top Speed of 90-100 km/hr (75-90 average) Up to 7,600 passengers/hour/direction
Monorail	Up to 350 passengers/ train (6 cars) Top Speed of 65-80 km/hr (30-50 avg) Up to 6,300 passengers/hour/direction
BRT	Up to 100 passengers/bus (articulated) To Speed of 55 km/hr (20-35 average) Up to 1,800 passengers/hour/direction

Demonstrate Regional Benefits of the Project

Transit User Benefits Countywide



Community Outreach Taken to New

- Scoping meetings
- Photo Simulations
- Responsive to Concerns
- Web pages and Face book sites
- E-mail “blasts”



Facebook Site has 1,500+ members

The screenshot shows a Microsoft Internet Explorer browser window displaying the Facebook page for the "Metro Westside Subway Extension" group. The browser's address bar shows the URL: <http://www.facebook.com/home.php?#/group.php?gid=10040701921>. The Facebook navigation bar includes "Home", "Profile", "Friends", "Inbox", and a search bar. The group name "Metro Westside Subway Extension" is prominently displayed at the top of the page content, with "Global" listed below it.

Basic Info

Type: Organizations - Community Organizations
Description: Welcome to the official Facebook home of Metro's Westside Subway Extension. This is for anyone who lives, works, visits and plays in Los Angeles County, CA to learn about the Westside Extension Subway Extension Draft Environmental Impact Statement/Environmental Impact Report (Draft EIS/EIR). Comments, questions and posts will become part of the official public comment record for the study.

In January 2009, the Metro Board of Directors approved the results of the 18-month Alternatives Analysis (AA) study, and authorized further evaluation of 2 potential subway alternatives for the Westside. Following federal and state requirements, this evaluation – the Draft EIS/EIR – will lead to a recommendation of a Locally Preferred Alternative (LPA).

The project is slated to receive partial funding from Measure R, the half-cent sales tax increase approved by voters in November 2008.

For more information about what was developed during the AA, or about the Draft EIS/EIR as it proceeds, please go to the study web-site at www.metro.net/westside.

Contact Info

Email: WestsideExtension@metro.net
Website: <http://www.metro.net/westside>
Office: Los Angeles, CA
Location: 1 Gateway Plaza, Los Angeles, CA

Recent News

March 30, 2009

Dear MWSE Facebook Member:

I wanted to let you know that scoping for the Draft EIS/EIR for the Westside Subway Extension is officially underway as the notice was published in the Federal Register on March 27. We've got our meetings, and a few other changes, posted up on our website (www.metro.net/westside). The upcoming meetings are also posted as events here on Facebook, but here are the basics:

- Monday, April 13: Los Angeles County Museum of Art, West, 5905 Wilshire Boulevard.
- Tuesday, April 14, West Hollywood Plummer Park, 7377 Santa Monica Boulevard.
- Thursday, April 16, Beverly Hills Public Library, 444 N. Rexford Drive.
- Monday, April 20, Westwood Presbyterian Church, 10822 Wilshire Boulevard.
- Thursday, April 23, Santa Monica Public Library, 601 Santa Monica Boulevard.

All the meetings are 6:00-8:00 PM and the material presented at each will be identical so choose the day and location that is most convenient for you.

May 7 is the deadline for comments related to scoping. However, you may want to wait until you see how we are presenting our plans for the Draft EIS/EIR. If you cannot attend the meetings, we will be posting our scoping presentation on our website (www.metro.net/westside) some time after the first meeting on April 13. We will be continuing to post new information to the web site so keep checking there. Materials about the study are being posted under the "News & Info" tab. You can find out how to send in your comments so they count officially in this scoping phase by clicking on "Contact Us."

The right side of the page features an advertisement for "Catholic Thrive Anaheim" with a logo and text: "Conference for young adults and singles of all ages. May 22-24, 2009 Anaheim Marriot CatholicThrive.com". Below the ad is an advertisement for "AT&T U-verse SM TV" with the text "DVR included on select plans. UNDER \$50.00 /mo. SHOP NOW!".

The bottom of the screenshot shows the Windows taskbar with the Start button, several open application windows (Microsoft Word, Adobe Acrobat), and the system tray showing the time as 11:30 AM and 98% battery.

Success Means Consideration of More Tunnels in Los Angeles:

Jan

Sales tax hike could fund subway to the sea

Voters may decide on the half-cent increase in November's election.

By **STEVE HYMON**
Times Staff Writer

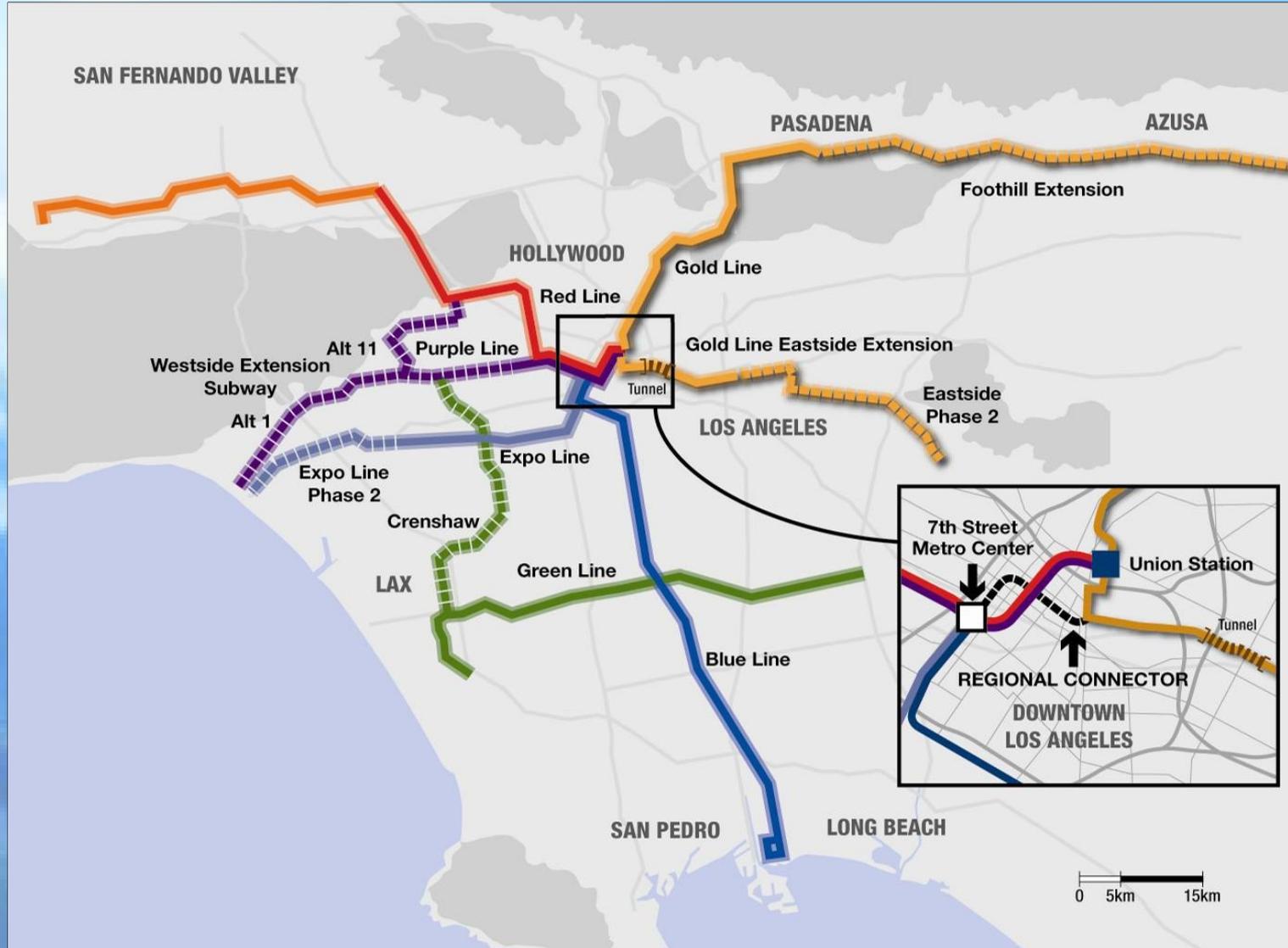
prove a tax increase to partially pay for the so-called "subway to the sea" and a slew of other road and mass transit projects in Los Angeles County.

Several officials raised the possibility of a half-cent sales tax hike. If approved by voters, such an increase would bring the county's sales tax rate to 8.75%.

Measure R Approved

- LA county Voters clearly wanted a change
- November 2008 **Measure R approved by two-thirds majority**, committing a projected **\$40 billion to traffic relief and transportation upgrades** over the next 30 years.
- Includes Westside Subway Extension
- Estimated to Create over 200,000 construction jobs and infuse \$32 B into local economy.
- Goes into effect July 1, 2009
- About \$4 Billion for Westside Subway Extension

Transit System 2020



Alaska Way Viaduct – Seattle

- Main north-south route through Seattle, WA
- Over 50 years old – and rapidly deteriorating
- 2001 6.8 M earthquake damaged viaduct
- FHWA
- WSDOT
- City of Seattle
- King County



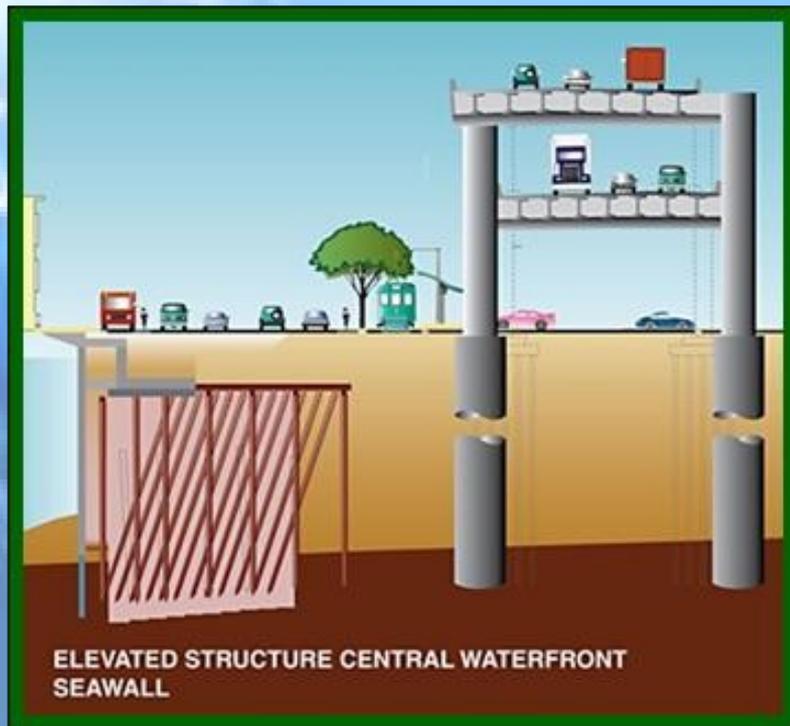
Existing Structure



Original Construction

Alaska Way Viaduct – Seattle

- Existing structure includes a sea wall
- Numerous Alternatives for Replacement studied since 2001



Retrofitting Includes Column Confinement



Alaska Way Viaduct – Seattle

- Preferred alternative – underground
- High cost and changing administrations' delay work
- 2007, voters say “no” on both options
- no decision and competing interests



Aerial Rendering and Video



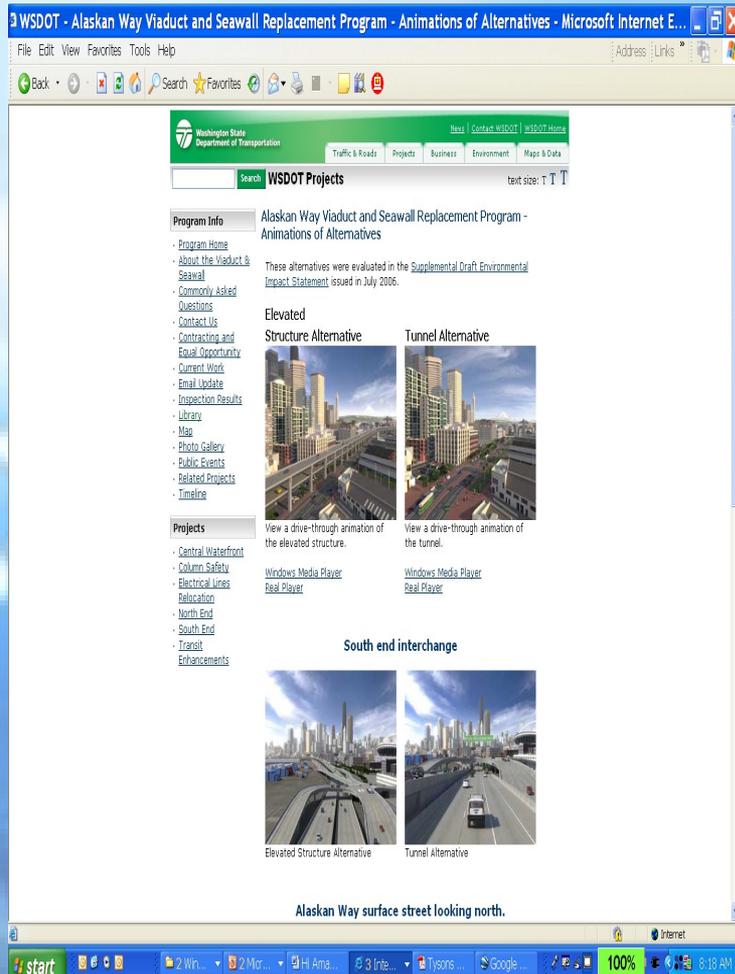
Underground Rendering and Video

Recent Decisions

- January 2009, King County agrees to demolish viaduct and build 16.5 m, 3.5 km tunnel
- Planned to open 2015
- Tunnel selection over aerial attributed to strong public support by downtown stakeholders
- Confidence in technology



Community Outreach Key Alaskan Way WSDOT Site



- Website includes video simulations of underground vs. aerial alternatives
- Photo Gallery

Project Visualizations

- Extremely helpful to show what waterfront would look like with various options
- Used internally with design teams, elected officials, key stakeholders, mass media and General public
- Allowed unlimited perspectives



Surface Boulevard



Elevated



Integrated Aerial



Lidded Trench



Bored Tunnel



Website Visualization Study

Adobe Flash Player 9

File View Control Help

Alaskan Way Viaduct and Seawall Replacement Program

Washington State Department of Transportation

King County

City of Seattle

Home	View							
	1	2	3	4	5	6	7	8
Scenario	A							
	B							
	C							
	D							
	E							
	F							
	G							
	H							

A Visual Study of Eight Central Waterfront Scenarios

◀ Use the grid to the left to compare different scenarios from different viewpoints.

** These images are early concepts for the eight central waterfront scenarios. Surface treatments are for illustrative and comparative purposes only. Green and red coloring along the corridor indicates public open space that is not yet designed.*

www.alaskanwayviaduct.org

Elevated

Adobe Flash Player 9
File View Control Help

Alaskan Way Viaduct and Seawall Replacement Program

Washington State Department of Transportation | King County | City of Seattle

Scenario	View							
	1	2	3	4	5	6	7	8
A								
B								
C								
D								
E								
F								
G								
H								

Pier 54
Scenario D - Elevated

start | 2 Micro... | 2 Wind... | 3 Inter... | 4 Micro... | Docume... | Adobe A... | Adobe Fl... | 98% | 12:05 PM

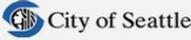
Surface Boulevard

Adobe Flash Player 9
File View Control Help

Alaskan Way Viaduct and Seawall Replacement Program







Home	View							
	1	2	3	4	5	6	7	8
A								
B								
C								
D								
E								
F								
G								
H								

Pier 54
Scenario B - Surface Boulevard





start | 2 Micro... | 2 Wind... | 3 Inter... | 4 Micro... | Docume... | Adobe A... | Adobe Fl... | 98% | 12:05 PM

Integrated Aerial

Adobe Flash Player 9

File View Control Help

Alaskan Way Viaduct and Seawall Replacement Program

Washington State Department of Transportation King County City of Seattle

Home	View								
	1	2	3	4	5	6	7	8	
Scenario	A								
	B								
	C								
	D								
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Pier 54
Scenario E - Integrated Elevated

start

2 Micro... 2 Wind... 3 Inter... 4 Micro... Docume... Adobe A... Adobe FL... 98%

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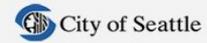
Bored Tunnel

Adobe Flash Player 9

File View Control Help



Alaskan Way Viaduct and Seawall Replacement Program



Home	View								
	1	2	3	4	5	6	7	8	
Scenario	A								
	B								
	C								
	D								
	E								
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Pier 54
Scenario F - Bored Tunnel



Bored Tunnel Video

SR 99 Single Bored Tunnel Under Seattle

January 2009

Bored Tunnel Egress



Visualization Studies

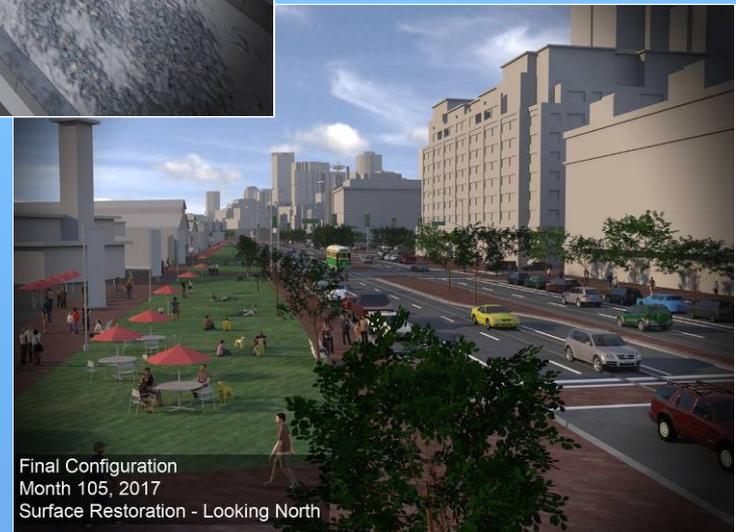


- Include Drive thru animations and construction Sequences
- Communicate Complex Construction Activities to businesses and communities affected
- Allows more educated input in planning process
- Media use increases



Visualizations now and future

- Tool for use from concept through construction



Interactive Traffic Web Tool

Alaskan Way Viaduct - Interactive Map - Microsoft Internet Explorer

Address: P:_DV_Resources\PP1_Presentation\CMAA\Content\AlaskanWayViaduct-Map-051407\def.aulk.htm

ALASKAN WAY VIADUCT AND SEAWALL REPLACEMENT PROJECT

ELEVATED STRUCTURE MAP | TUNNEL MAP

STAGE 1 : 1ST QUARTER, 2008 | ADDRESS FINDER | LEGEND | QUICK ZOOM

2008				2009				2010				2011				2012				2013				2014				2015				2016				2017							
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
STAGE 1				STAGE 2				STAGE 3				S4				STAGE 5				STAGE 6				STAGE 7																			

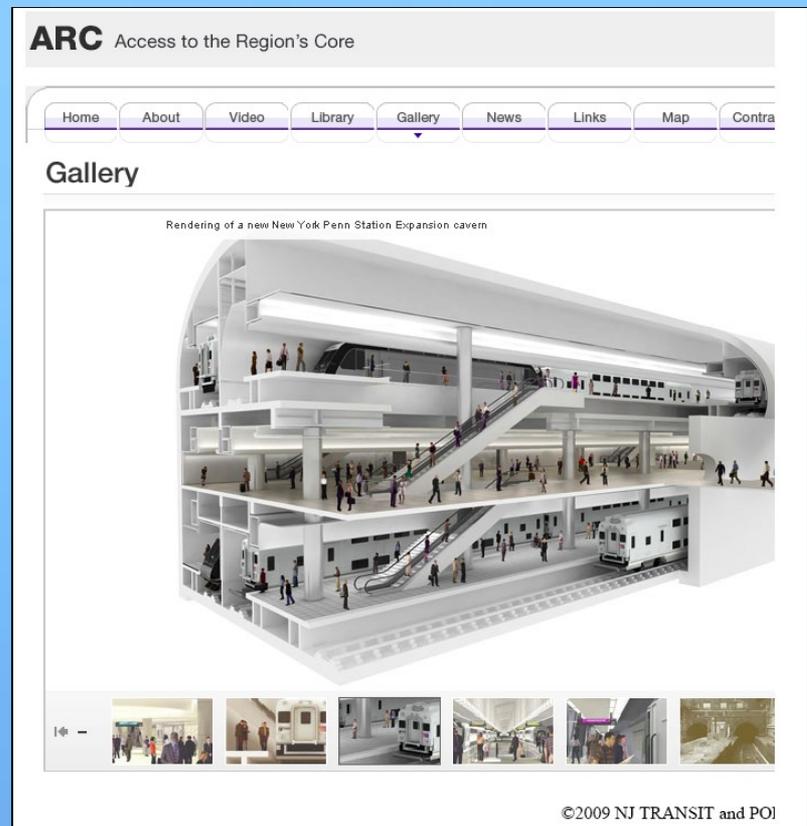
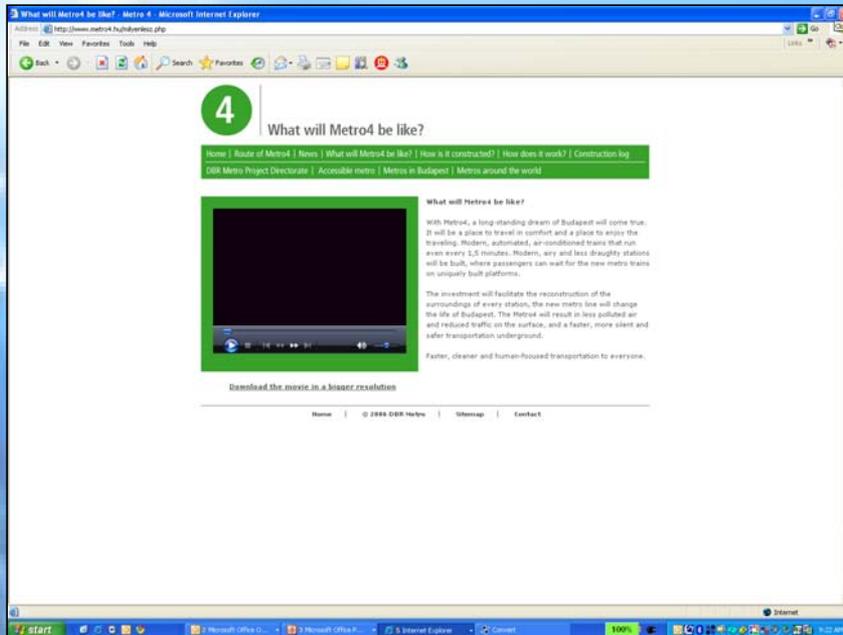
HELP | CLOSE

U.S. Department of Transportation Federal Highway Administration | Washington State Department of Transportation | City of Seattle

Local intranet

Web Sites – Now Essential

- Budapest Metro
- Trans Hudson Express

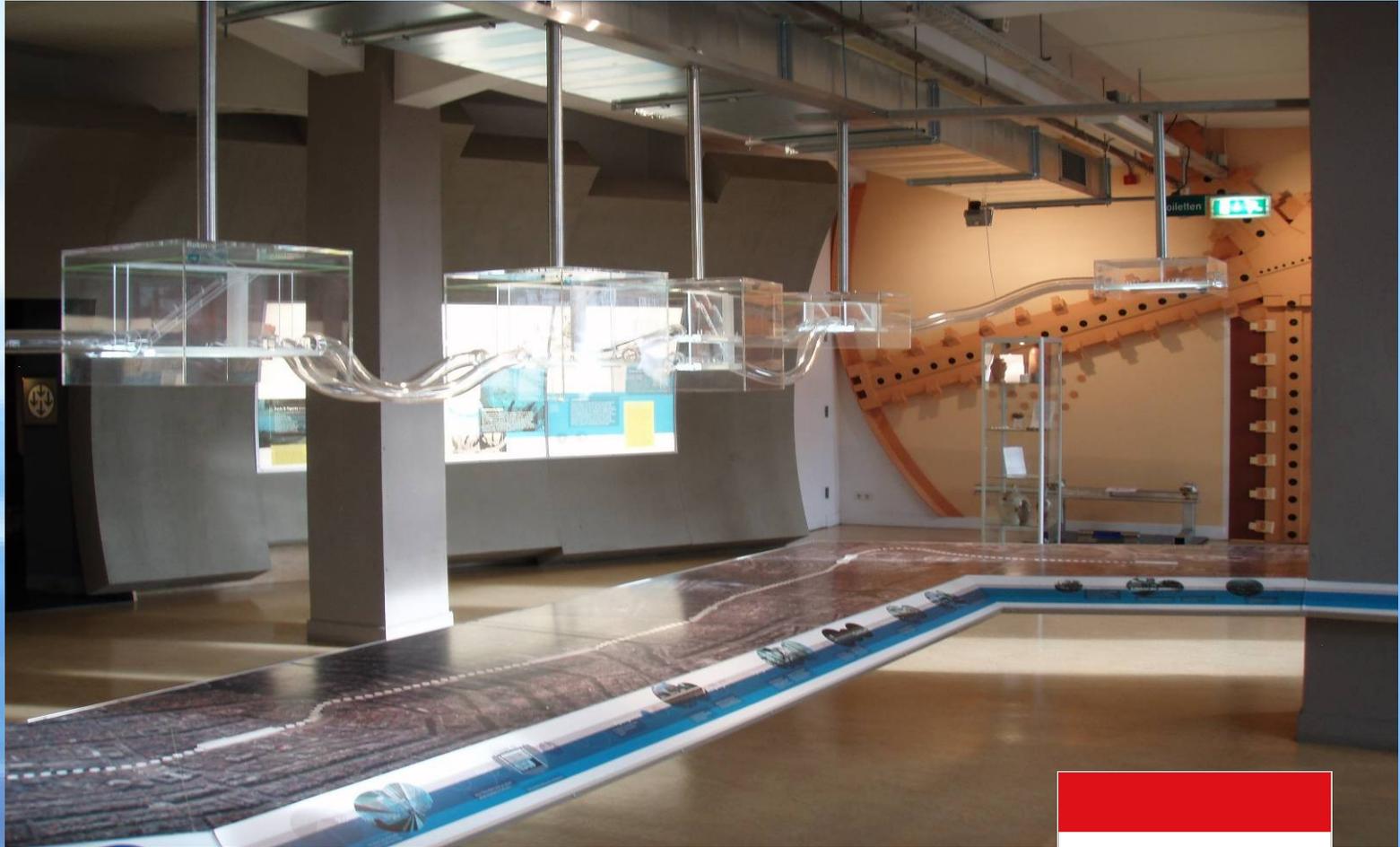


Community Outreach Must be Continued During Construction

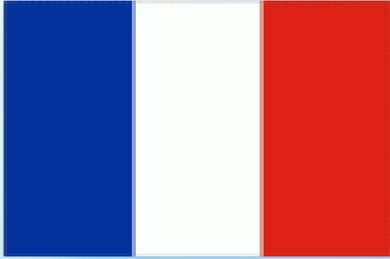
- Visitors Centers
- News Letters
- Web Sites
- Meetings
- Adequate Notification of events
- Site Tours



Amsterdam – Stationsplein 7 Models and Historic Displays



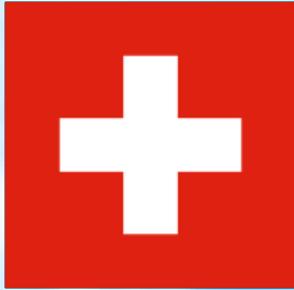
SOCATOP A-86 Tunnel Paris, France



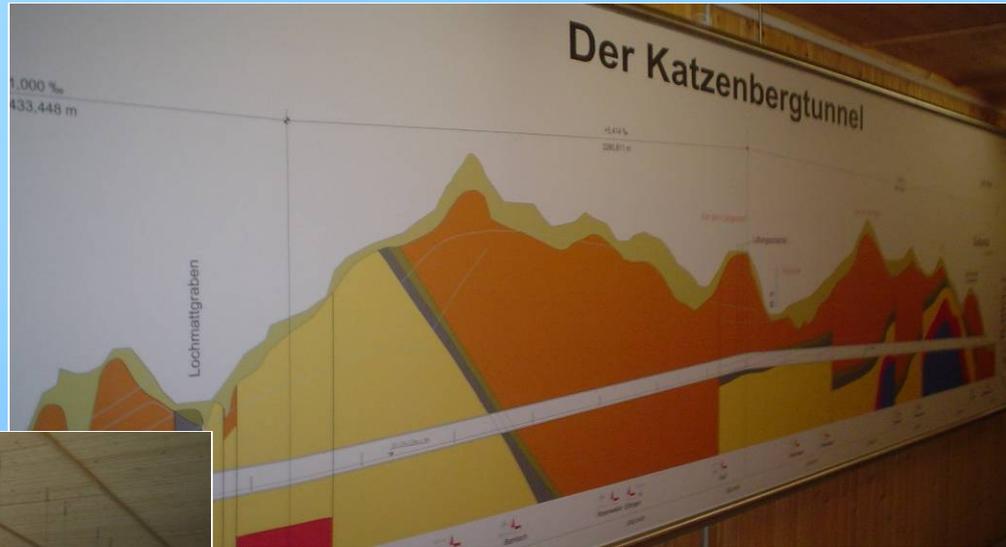
A-86 Visitor's Center Full Scale Tunnel



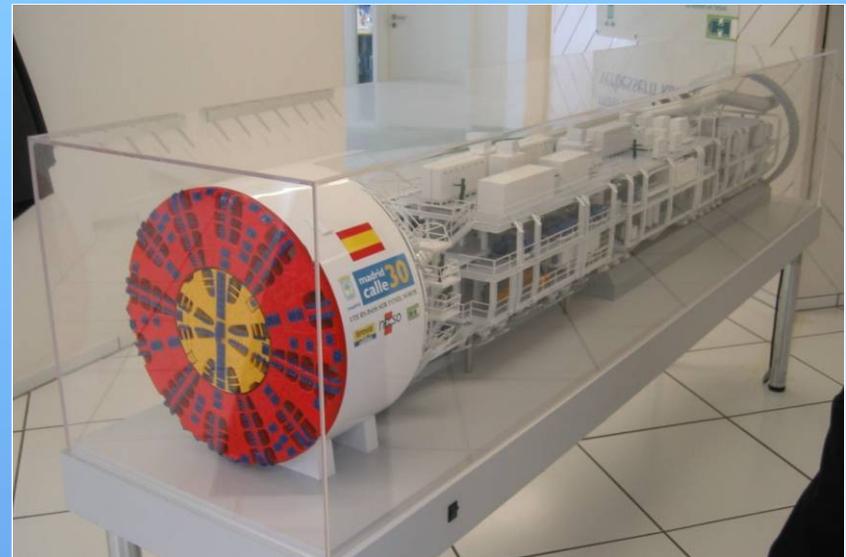
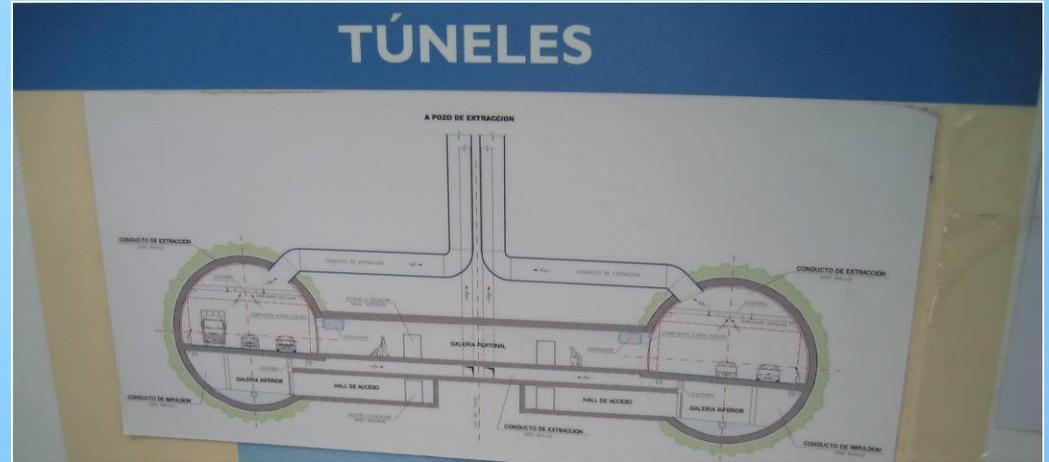
Gotthard Rail Tunnels Sedrun, Switzerland



Katzenberg Rail Tunnels Germany

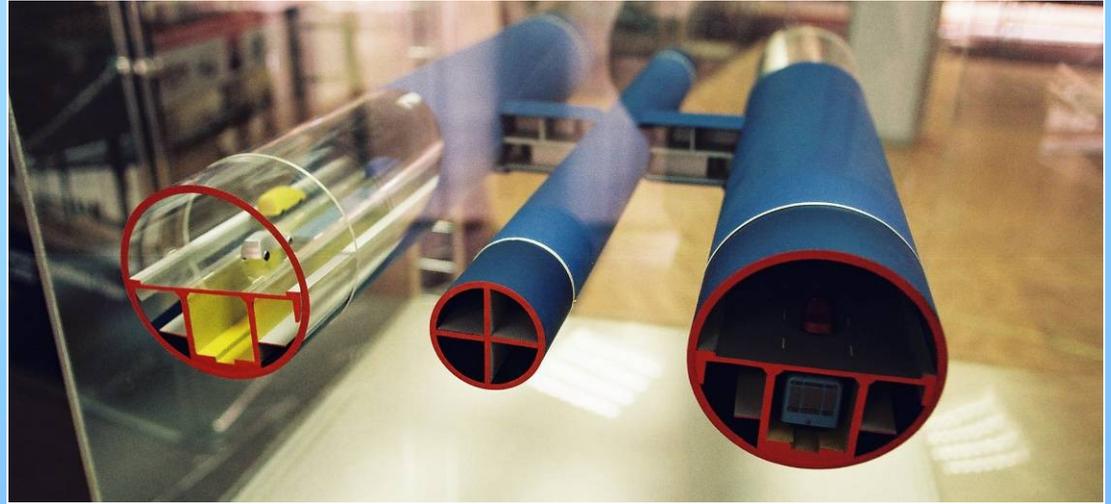


Calle 30 Tunnels Madrid, Spain



Serebriyanoborski Tunnels

Moscow, Russia



Conclusions – Successful Planning For Underground Projects

- Technology
- Community
- Communication
- Education

