Tunneling Conference

California High-Speed Train Program EIR/EIS

U.S. Department of Transportation
Federal Railroad Administration

California High-Speed Rail Authority
December 3 - 4, 2001

Conference Overview

Purpose

- Confirm Feasibility
  - Physical
  - Technical
- Confirm/Revise Assumptions
  - Construction Methods
  - Cost Estimates

Agenda

- Day 1
  - Background
  - Requirements/Assumptions
  - Construction Methods
  - Construction Costs
- Day 2
  - Method/Cost Conclusions
  - Implementation and Other Issues

Background

High-Speed Train Corridors

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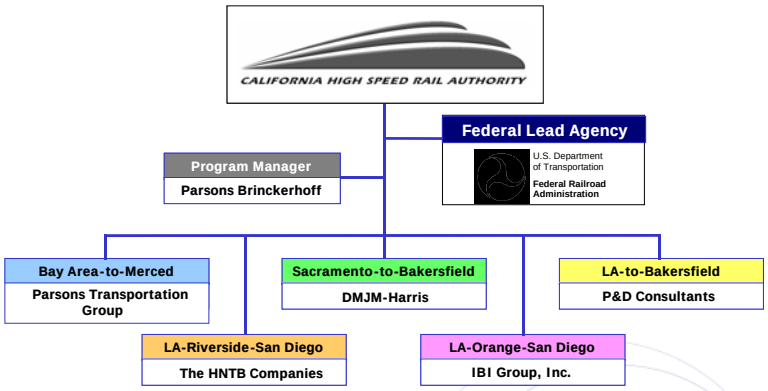
Project Team



Environmental Process

- Program EIR/EIS Outcomes
  - Meet State & Federal Requirements
  - Identify Preferred Alternative
  - Identify Corridor/Right-of-Way Preservation Needs
  - Establish Agency Relationships
  - Streamline Environmental Process for Future Implementation

Screening Evaluation

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- Purpose:
  - Identify Range of Alignment & Station Options
  - Evaluate Reasonable & Practical Options
    - Consistent & Broad Level of Analysis
    - Statewide Methodology
  - Screen Non-Viable Options
    - Cost
    - Impact
  - Focus Upcoming Technical Studies

Project Description

High-Speed Train Systems for Further Evaluation

Performance Criteria

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- System Design Criteria
  - Electric Propulsion
  - Full Grade Separation
  - Full Access Control
  - High Standard of Passenger Comfort

Performance Criteria

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- System Capabilities
  - All Weather / All Season
  - Sustained 3.5% Grades
  - Parcel and Special Freight Service
  - Maximum Speed Over 200 mph
  - 3 Minute Headways
  - Redundant Communications/Control System

Performance Criteria

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- System Capacity
  - Dual Track System
  - Off-Line Station Stops

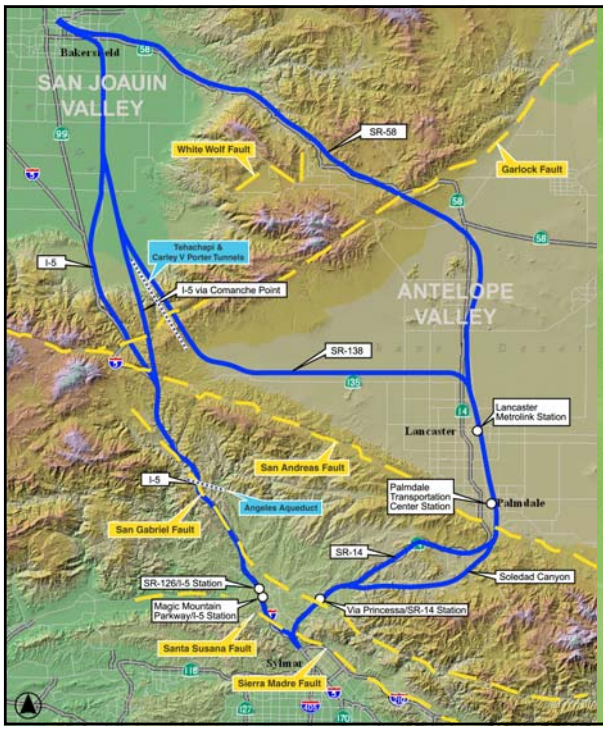
- Level of Service
  - Variety of Services (Local to Express)
  - Flexible - Based on Market Demand

Performance Goals

- Travel Time Goals

City Pair	Antelope Valley Corridor (hours: minutes)	I-5 Grapevine Corridor (hours: minutes)
Los Angeles to San Francisco / Oakland	2:42	2:30
Los Angeles to Sacramento	2:22	2:10
Los Angeles to San Jose	2:12	2:00
San Francisco / Oakland to San Jose	0:30	0:30
Los Angeles to San Diego	1:00	1:00
Fresno to Sacramento	0:55	0:55
Fresno to San Jose	0:45	0:45
Fresno to Los Angeles	1:32	1:20
Bakersfield to Los Angeles	0:62	0:50
Bakersfield to Sacramento	1:25	1:25
Bakersfield to San Jose	1:20	1:20
Santa Clarita[1] to San Jose	1:57	1:45
Santa Clarita[1] to Sacramento	2:02	1:50
Santa Clarita[1] to Fresno	1:12	1:00

NOTE:
[1] The location of the Santa Clarita station varies by alternative.



Significant Fault Crossings

Tehachapi Mountain Crossing

Geologic Conditions

Rock Conditions

Type	RQD	Q	INTACT UNCONFINED	ROCK	SUPPORT	LENGTH
I	90-100	25(+)	>36000 psi	Massive, Unweathered; Sedimentary	Random dowels	5.7 mi (19%)
II	75-90	10-25	14500 – 36000	Fractured Slight weathering; Sedimentary	Pattern dowels w/straps	10.0 mi (34%)
III	50-75	0.1-10	7300 – 14500	High weathering, fracturing; Sedimentary and Metamorphic	Pattern dowels w/shotcrete	10.0 mi (33%)
IV	25-50	0.1(-)	3600 – 7300	Extreme weathering, fracturing; gouge, slicks; Sedimentary and Metamorphic	Lattice girders, shotcrete Ribs & Boards	2.1 mi (7%) 2.1 mi (7%)
						30.0 mi (100%)

Notes:
- 2 Single Track TBM 20%
- Double Track D&S 80%

Geologic Conditions

Other Geologic Constraints

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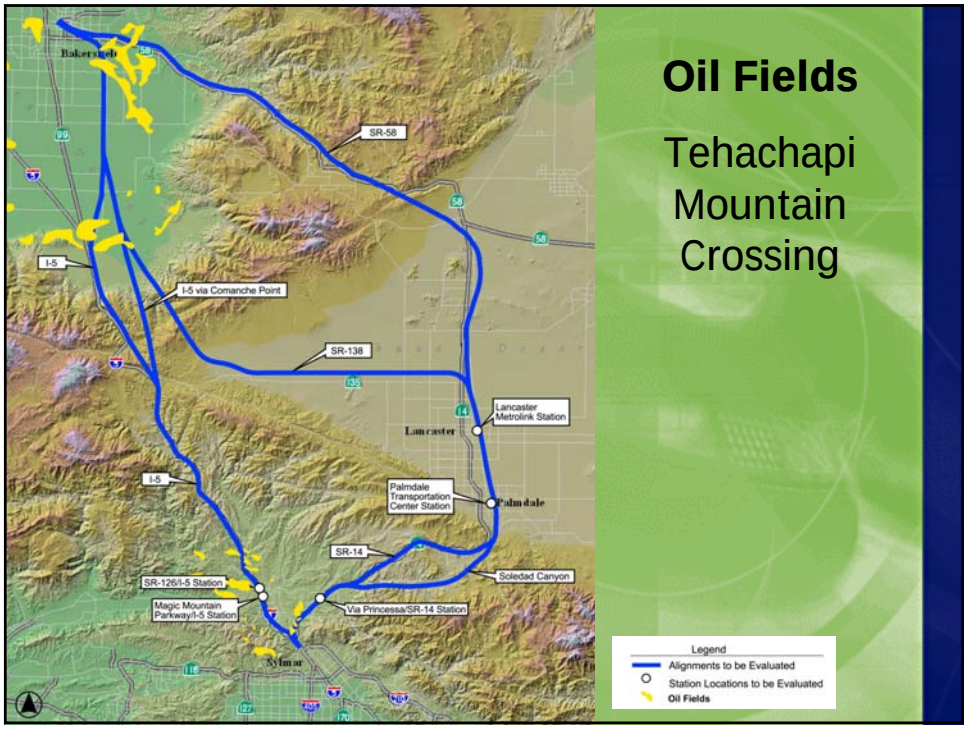
Oil & Gas	• Several fields traversed • Oil and gas seepage (methane)
Groundwater	• 1000 psi possible in Tehachapis (fault zone) • Up to 280 gpm from fractures • Seeps or drips away from fault
Slope Stability	• West portion of Soledad basin • Ridge basin between Castaic and Gorman • Hills near Grapevine
Subsidence	• Antelope Valley • San Joaquin Valley
Liquefaction	• North LA Basin • San Fernando, Castaic, Peace, South San Joaquin, and Central Antelope Valleys • West Soledad Canyon



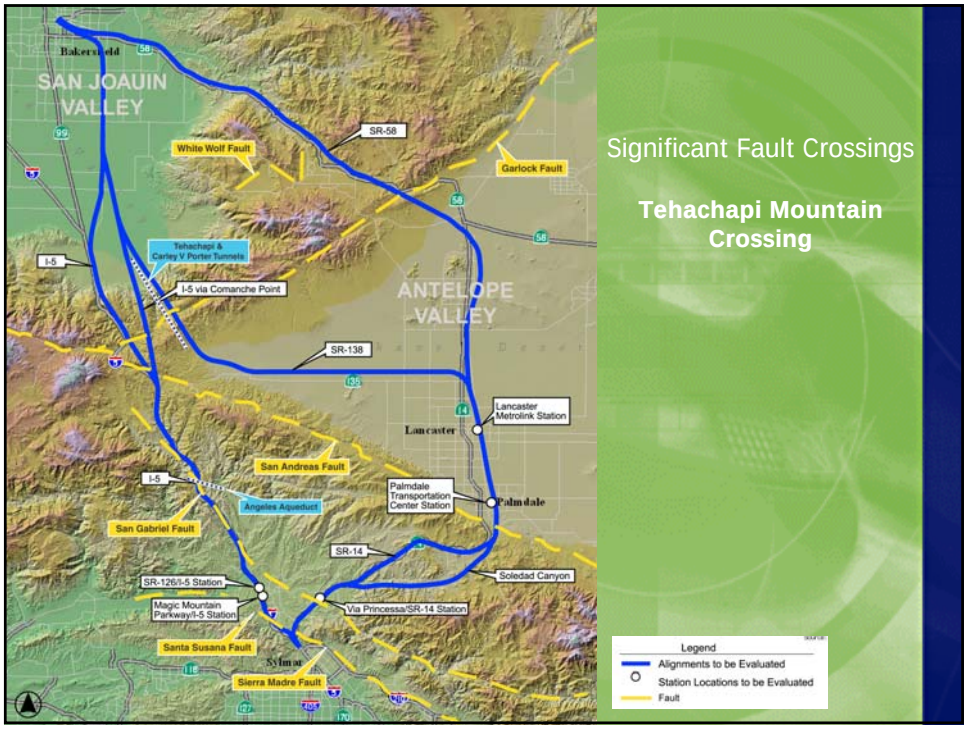
Geologic Conditions

FAULT CROSSINGS

FAULT	ACTIVITY	SLIP RATE MM/YR	MCE (MW)	RECURRENCE INTERVAL, YRS	LAST QUAKE	DUE
San Andreas	Active	20-30	8.0	65-270	1857	2027
Garlock	Active	10	7.75	820-910	895-1285	1955
San Gabriel	Active	5	7.5	N/A	700	N/A
Pleito Thrust	Active	0.2-14	7.0	1470	N/A	
Santa Susana – Sierra Madre	Potentially Active	8	7.0	630	1893	2523
Pastoria; Whitney; Others	N/A	N/A	N/A	N/A	N/A	

All told:

- Cross 25 known faults
- Four – Historically active – rupture (since 1769)
- Seven – Active – rupture in last 10,000 yr
- Six – Potentially active – rupture in last 1.6 X 10^6 yr
- One - > 1.6 x 10^6 yr
- Seven – Not studied
- Blind Faults - Unknown



Geologic Conditions

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- **GARLOCK FAULT**
  - Southwest Trending
  - Boundary (155 mi) Between Tehachapi Mountains and Sierra Nevada on North and Desert on South
  - Greatest Seismic Hazard (of 25 traversed)
  - 8.2 to 9.1 M Offset
  - Up to 1 M Vertical
  - Fault Plane 2 to 3 Meters Wide
  - Fault Zone of Intensely Fractured Rock 600 Meters Wide (0.4 mile)
  - Oversize Chamber 4.5 m; Twin Track Tunnel
  - Left Lateral Strike Slip (40 mi)
  - No Historic Quakes – but in recent geologic past
  - Due (1955)

Geologic Conditions

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- **CARLEY V. PORTER TUNNEL**
  - 4.7 Miles Long; 20 Feet ID; D & B; 8 Inch Ribs
  - Mostly granite, very little fresh
  - Micro sheared
  - Decomposed granite became fluid when saturated
  - Numerous faults, slip planes
  - No gas
  - Large surges of water – several hundred gpm – several hundred yards of running muck
  - 900 gpm after holing through
  - Decomposed granite – gray, weak, often plastic
  - Water flow tends to decrease gradually, sometimes dries

Geologic Conditions

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- **Tehachapi #1**
  - 1.5 Miles long; 23.5 Feet ID; D & B; 8 Inch Ribs
  - Diorite Gneiss, hard-foliated to completely crushed, slicks
  - Plastic, squeezing clay gouge
  - Water limited to fractures and crushed joints
  - 140 gpm at clay seam (dam)
  - Conventional drill and blast; 23.5 ft wide; 8” ribs; additional support in weak areas
- **Tehachapi #2**
  - 0.5 Mile Long; 23.5 Feet ID;
  - Similar to #1; D&B; ribs and bolts
  - Hard-foliated to moderately blocky and seamy diorite gneiss
  - No squeezing ground
  - Water inflows very low – maximum 3 gpm at N. portal

Geologic Conditions

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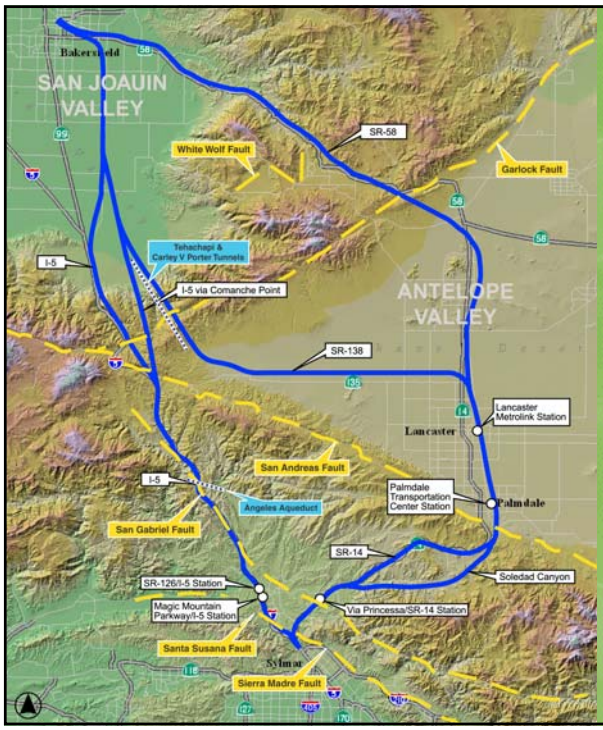
- **Tehachapi #3**
  - 1.1 Miles Long; 23.5 ID; M8X40 and M8X58 Ribs; 1 Foot to 6 Foot Spacing
  - Drill and blast – "difficult" – 57% driven full face
  - Tunnel within a fault block between N. Garlock & Garlock; numerous shears
  - Schist – moderately jointed to completely crushed – average moderately blocky and seamy
  - Squeezing ground – associated with faults and shears – with water, blocks came out along clay-coated planes
  - Water – 0 to 210 gpm; average 80 gpm – maximum 100 gpm at fault gouge zone took 5 days to subside



Significant Fault Crossings

Tehachapi Mountain Crossing

Geologic Conditions

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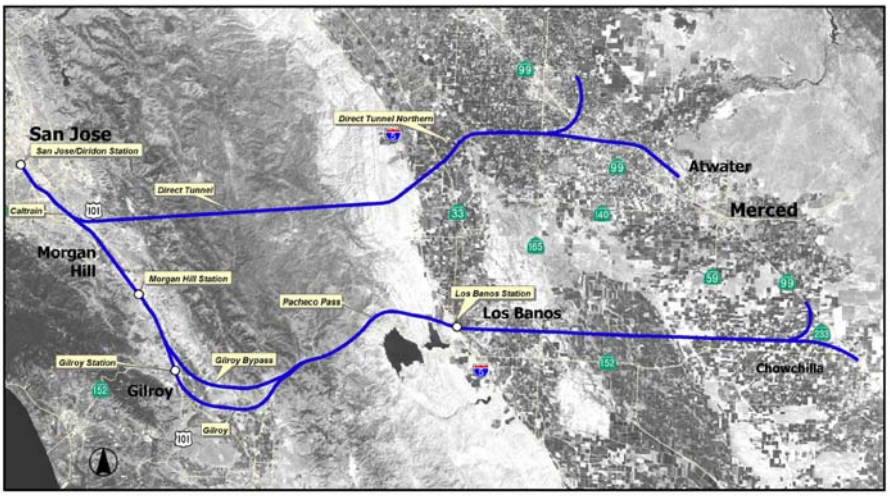
- **ANGELES AQUEDUCT TUNNEL**
  - 7.1 Miles long; 30 Feet ID; D & B; Heading & Bench;
  - Pyramid Lake to Castaic Power Plant
  - Sandstone, Siltstone, Shale, Argillite, Gouge
  - Faulted, Jointed
    - Sawtooth Crown (Blocky)
  - Groundwater
    - Maximum 200 gpm
    - Up to 100 gpm from each heading at hole through
    - Higher at low cover
    - Above shaley interbeds
    - Drained from sandstone in 2-5 hours
  - Methane and Hydrogen Sulfide
    - Explosion

Tunnel Requirements

Corridor Segments Requiring Tunneling

Bay Area to Merced (Diablo Mountain Crossing)



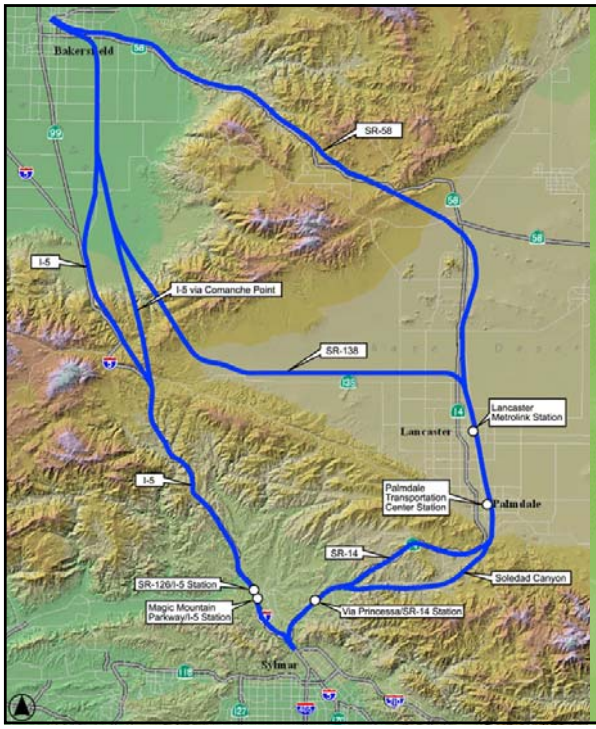
Legend

Alignments to be Evaluated

Station Locations to be Evaluated

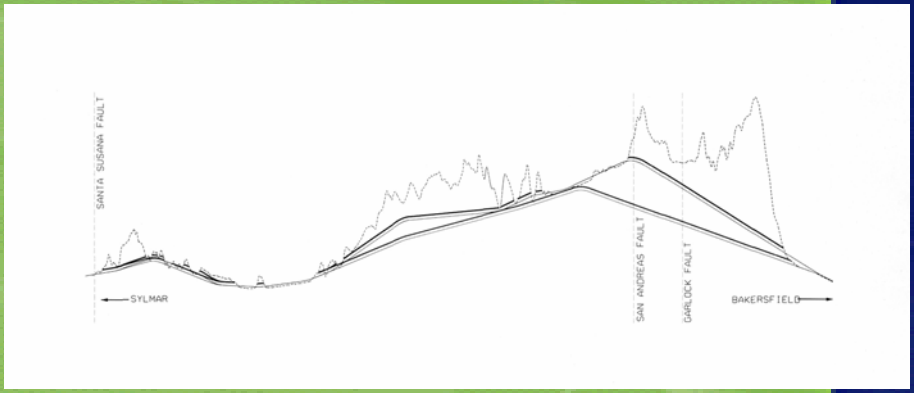
Draft First Screening Report
California High-Speed Train Program EIR/EIS

Alignment and Station Locations to be Evaluated
Merced to San Jose Segment
Figure 1-6



Bakersfield to Los Angeles (Tehachapi Mountain Crossing)

I-5 / Grapevine Corridor – Alternative Profiles (2.5 – 3.5%)



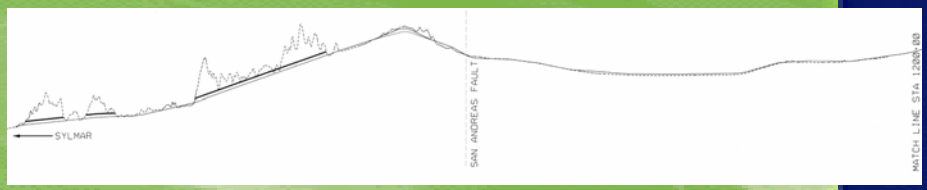
2.5% Maximum Grade

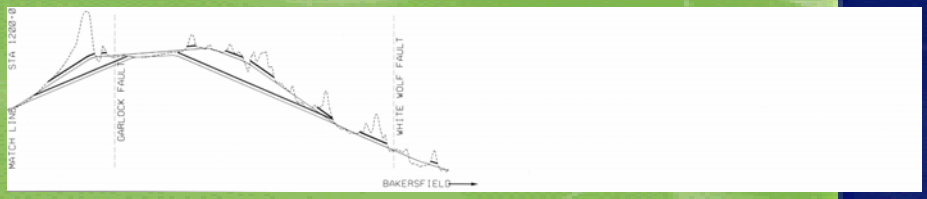
- 45 Miles Tunneling
- Longest Segment = 36 Miles
- Depth > 1000 Feet

3.5% Maximum Grade

- 26 - 34 Miles Tunneling
- Longest Segment = 9 – 12 Miles
- Depth > 1000 Feet

SR-58 / Mojave Corridor – Alternative Profiles (2.5 – 3.5%)





2.5% Maximum Grade

- 41 Miles Tunneling
- Longest Segment > 6 Miles
- Depth > 600 Feet

3.5% Maximum Grade

- 11 - 21 Miles Tunneling
- Longest Segment < 5 Miles
- Depth > 500 Feet

Vertical Grades (2.5% vs. 3.5%)

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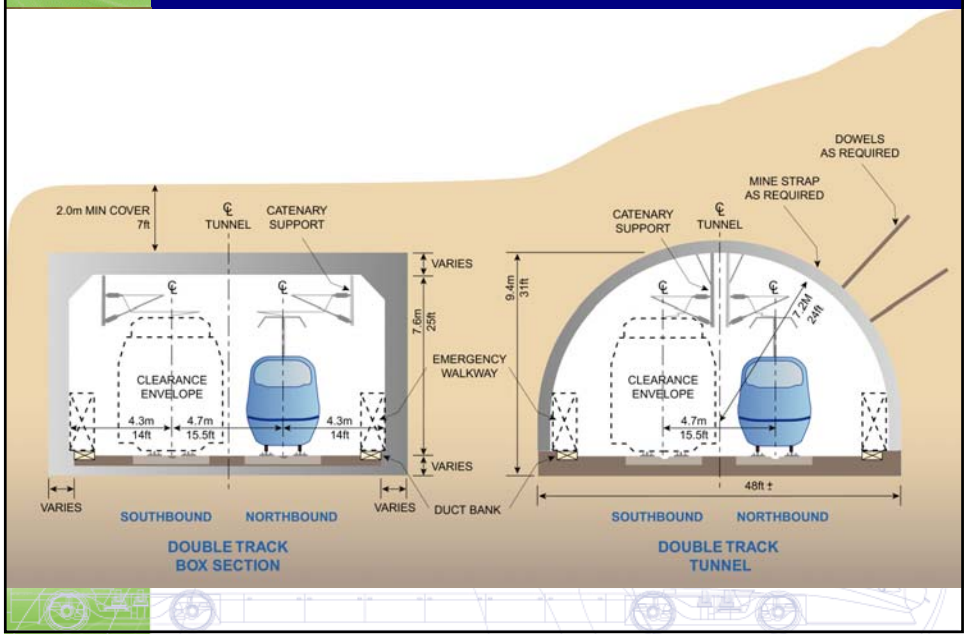
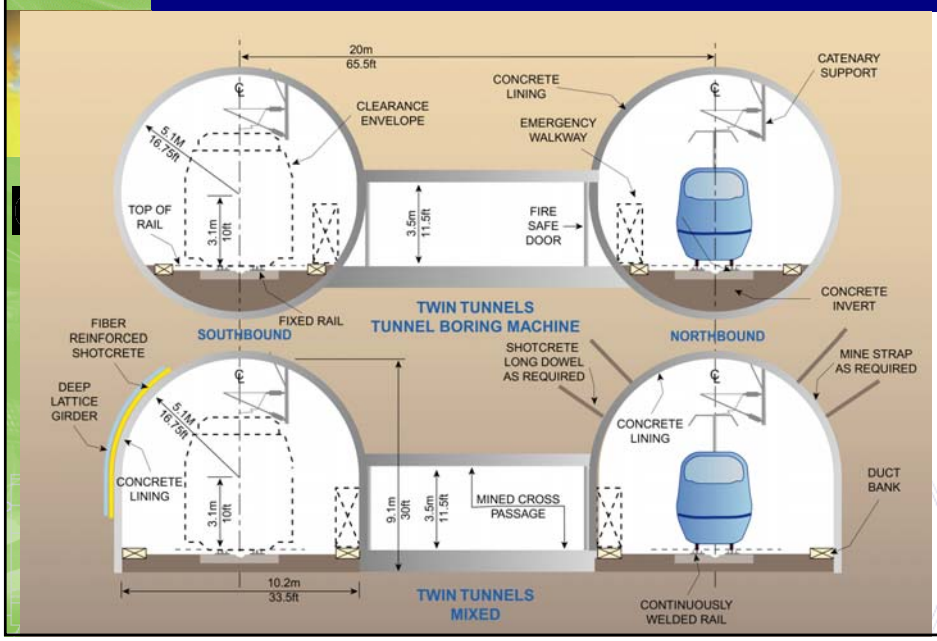
- Lower Grades Offer
  - Decreased Travel Time
  - Decreased Power Usage
  - Potential Construction Efficiencies
- Lower Grades Require
  - Longer Tunnels / Greater Cost
  - Extensive Fire/Life Safety Systems
  - Ventilation/Cooling Systems

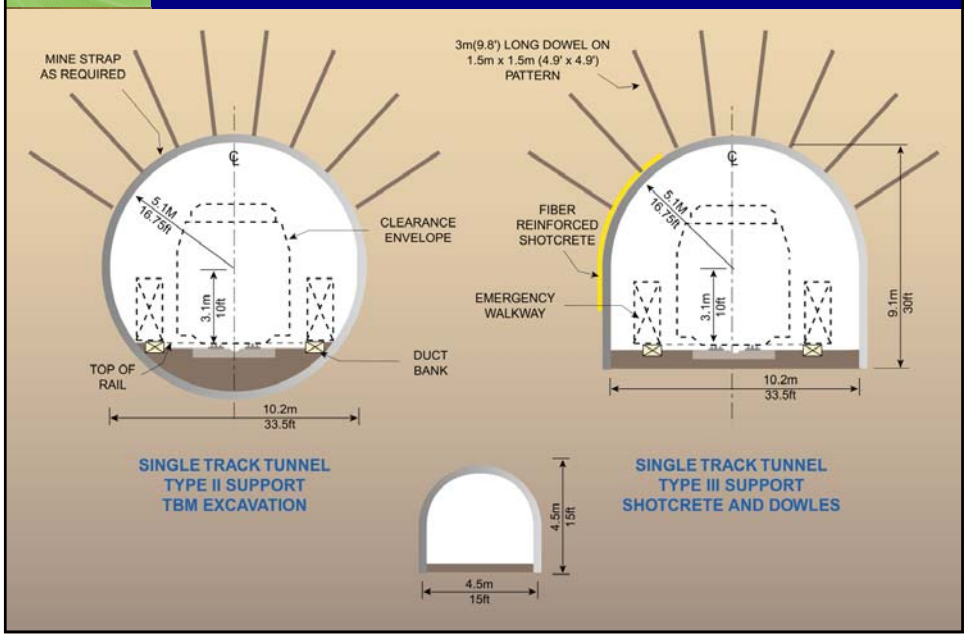
Tunnel Cross Sections



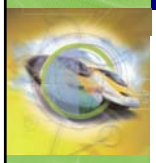
Tunnel Cross Sections



Tunnel Cross Sections



Fault Crossing Chamber



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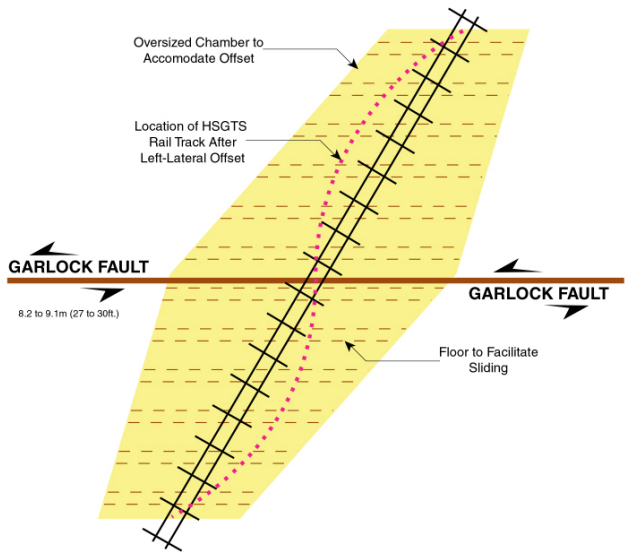
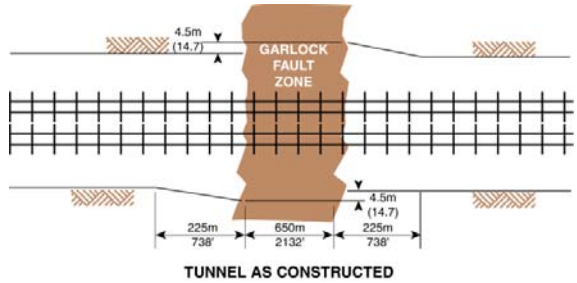
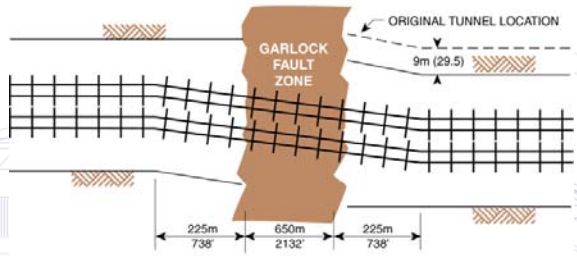


NOTE: Offset of 8.2 to 9.1meters (27 to 30 feet) along Garlock Fault based upon offset measured during each of two pre-historic earthquakes (Guptill et al., (1979). Offset likely to decrease west towards the San Andreas Fault/Garlock Fault intersection.

Fault Crossing Chamber



TUNNEL AS CONSTRUCTED



TUNNEL AFTER 9M FAULT SLIP WITH REALIGNED RAILS

Ventilation Issues

- Emergencies Involving Stopped Trains
  - Ventilation
  - Evacuation
  - Emergency personnel ingress
- Aerodynamic Drag Relief
- Pressure Transients
  - Portal entry
  - In-tunnel
- Tunnel Heating
  - Heat from trains
  - Aerodynamic heating caused by friction

Ventilation Assumptions

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- Depend on Tunnel Length and Headway
- Tunnel-to-Tunnel Venting
  - Control of in-tunnel pressure transients and aerodynamic drag
  - 6.6 feet diameter pressure relief ducts on 800 foot centers (~0.04 sqft/ft)
  - Butterfly dampers to be closed during an emergency
- Tunnel-To-Tunnel Cross Passages
  - Emergency evacuation, emergency ingress and maintenance access
- Flared Portals
  - Control of portal entry pressure transients
  - Depends on train sealing

Ventilation Assumptions

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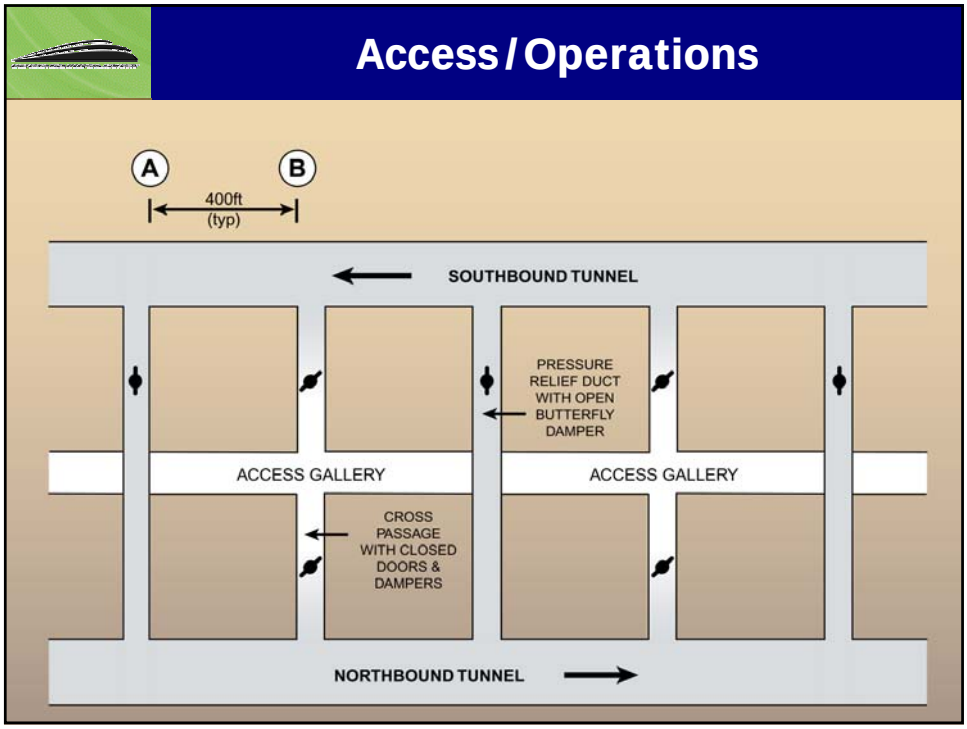
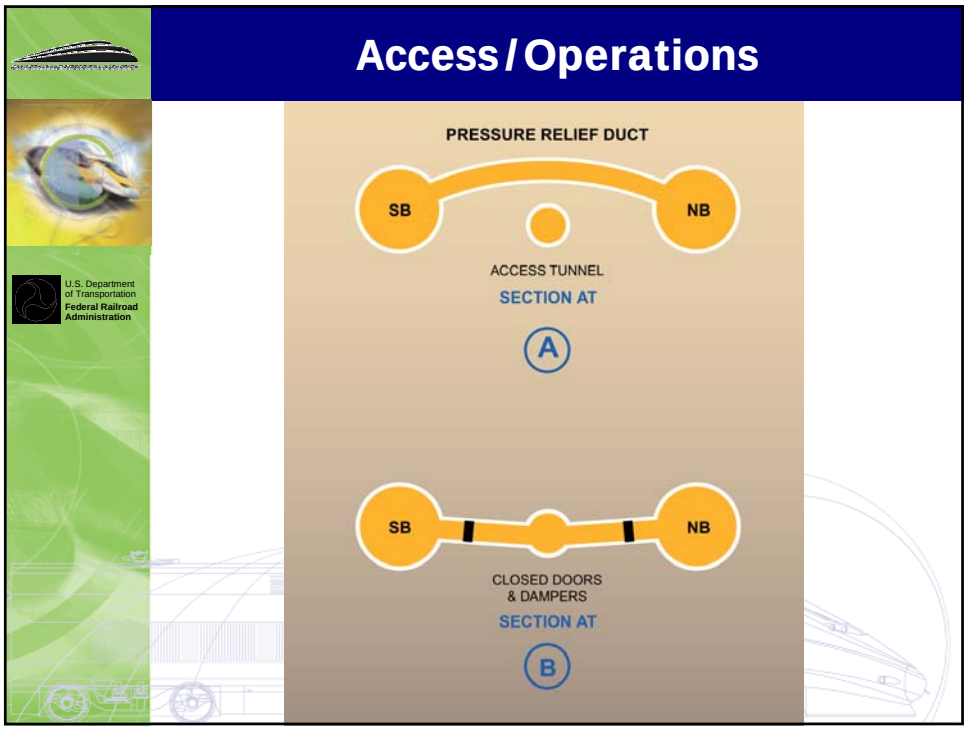
- Ventilation Shafts
  - Emergency ventilation
  - Located at tunnel portals or in tunnel depending on tunnel length, train headway and speed
  - Each shaft serves both tunnels
  - Equipment rooms in tunnel or at surface
- Tunnel Cooling
  - Offsets tunnel heating
  - Chilled-water pipe extending length of tunnel
  - Air-conditioning plant required
  - Not needed for short tunnels
- Center Gallery
  - Emergency evacuation, emergency ingress and maintenance access
  - Not needed for short tunnels


Access / Operations
A
B
400ft
(typ)
SOUTHBOUND TUNNEL
PRESSURE
RELIEF DUCT
WITH OPEN
BUTTERFLY
DAMPER
ACCESS GALLERY
ACCESS GALLERY
CROSS
PASSAGE
WITH CLOSED
DOORS &
DAMPERS
NORTHBOUND TUNNEL


Access / Operations
U.S. Department
of Transportation
Federal Railroad
Administration
PRESSURE RELIEF DUCT
SB
NB
ACCESS TUNNEL
SECTION AT
A
SB
NB
CLOSED DOORS
& DAMPERS
SECTION AT
B

Ventilation Assumptions

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- Validation
  - English Channel Tunnel
  - Extensive Modeling by Two Competing Firms Using Different Software

Access / Operations

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- ***Train Control***
  - **Signaling and train spacing**
  - **Precise train location detection**
  - **Seismic detection**
  - **Traction power fault detection**
  - **Broken or misaligned rail detection**
  - **Fire / smoke detection**
  - **Air quality detection**
  - **Emergency ventilation system**

Access / Operations

- ***Communications***
  - Normal operations
  - Emergency operations
  - Redundancy
  - Malfunction detection
  - Constant under all conditions
- ***Impact of Aerodynamic Drag***
  - Trainset design
  - Ambient temperature
  - Speed
  - Approaching portal entrance / exit
  - Inside the tunnel
  - Trip time Power consumption

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Access / Operations

- ***Maintaining the Physical Plant***
  - Design for maintenance windows
  - Cross passageway access
  - Surface access
  - Pilot tunnel access
  - High speed track crossovers
- ***Zones of Refuge***
  - Regular interval spacing
  - Double track tunnel
  - Two single track tunnels
  - Two single track tunnels with pilot tunnel
  - Cross / connecting passageways

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Access / Operations

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- **Power provision**
  - normal and emergency (auxiliary) conditions
- ***Fire Suppression System***
- ***Emergency Access / Egress***
  - Evacuation
  - Ingress for emergency personnel
  - Design for specialized rescue equipment

Construction Methods

Construction Methods / Issues

- Excavation Methods
  - Drill & Blast
  - TBM
- Rock as Specified
- Groundwater
- Mixed Face
- Length of Drive
  - Machine Overhaul
  - Muck Removal
- Advance Rates
  - TBM (50-100 feet/day)
  - D&B Single (21 feet/day)
  - D&B Double (17 feet/day)

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Construction Methods / Issues

- Potential Gasses
  - Machine
  - Loco, Lights, Ventilation
- Access
- Tolerances
- Water Tightness
  - Leaks Allowed
- Final Lining
- Portals

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Construction Methods / Issues

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- Seismic Chambers
- Work Site
  - Number
  - Size
- Working Hours

Construction Costs

Construction Costs

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- Excavation Method Assumptions
- Grade Limitations
- Access Limitations
- Seismic Chambers
- Final Lining
- Tolerances
- Water Tightness
- Contingencies
- Change Order Work