CALIFORNIA
High-Speed Rail Authority

A TRANSFORMATIVE INVESTMENT IN CALIFORNIA'S FUTURE

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CONNECTING CALIFORNIA: PROJECT SCOPE

- **Phase I:**
  - » 520 Miles
  - » San Francisco to Los Angeles/Anaheim
- **Phase II:**
  - » Extends 300 Miles
  - » Connections to Sacramento & San Diego
- **Proposition 1A**
  - » At Least 200 mph
  - » San Francisco-Los Angeles Union Station: Under 3 hours
  - » 24 total stations

PROGRAM DELIVERY STATUS: DESIGN AND CONSTRUCTION

- **Construction Package 1**
  - » 29 miles between Madera and Fresno
  - » Construction underway

- **Construction Package 2-3**
  - » 65 miles between Fresno and Tulare-Kern County line
  - » Executed in July 2015
  - » Baseline schedules due for ROW, design and construction.

- **Construction Package 4**
  - » 22 miles between Tulare-Kern County line and North of Bakersfield
  - » Design-Build Award Early 2016
  - » SOQ for Project and Construction Management (PCM), awarded to HNTB Corporation

PROGRAM DELIVERY STATUS: STATION COMMUNITIES

- **Up to 24 Stations**
  - » Some built from ground-up (Palmdale, Burbank)
  - » Some intergraded into existing stations (San Jose, LA Union Station, ARTIC)

- **Stations Communities will Enhance Surrounding Areas Through:**
  - » Active Transportation Opportunities (Bikes, Walking, etc.)
  - » Creating Vibrant, Urban Centers and Livable Spaces
  - » Access to the Heart of Downtown Areas
  - » Designed to Integrate with Existing Transportation Systems and Economies

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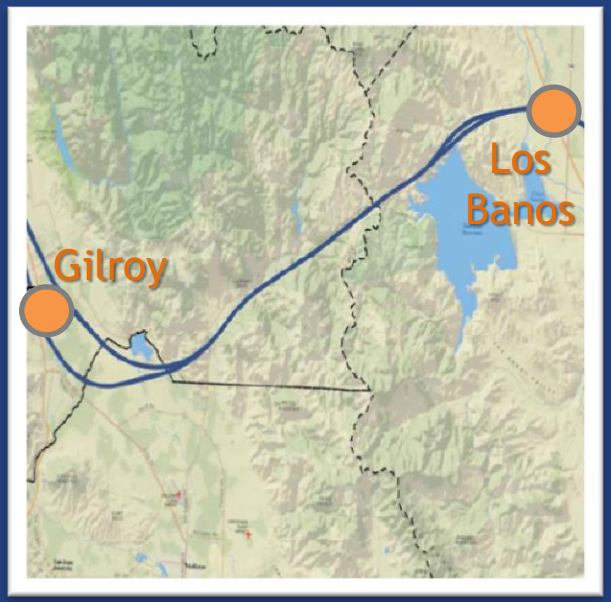
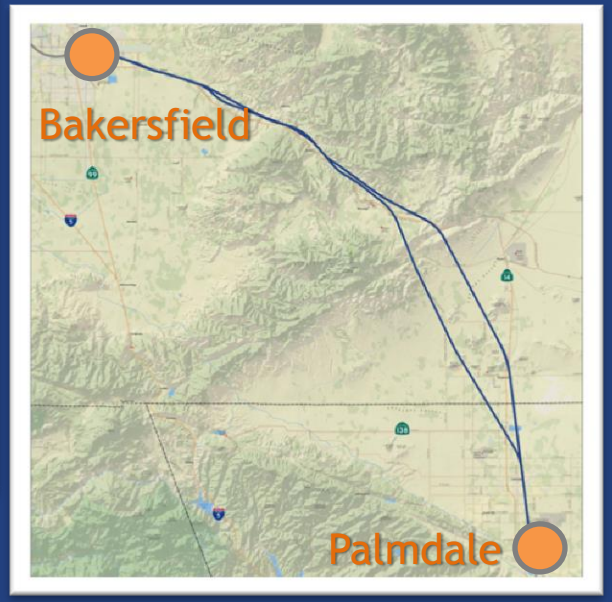
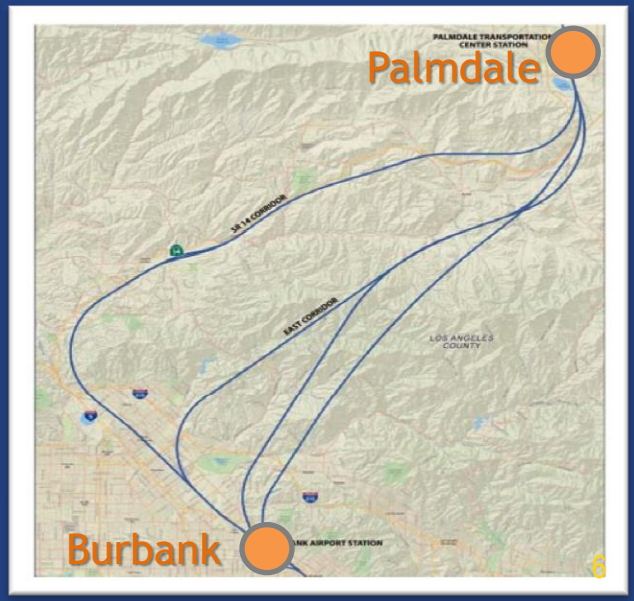
ENGINEERING CHALLENGES

ENGINEERING CHALLENGES: MAJOR INVESTIGATION SEGMENTS

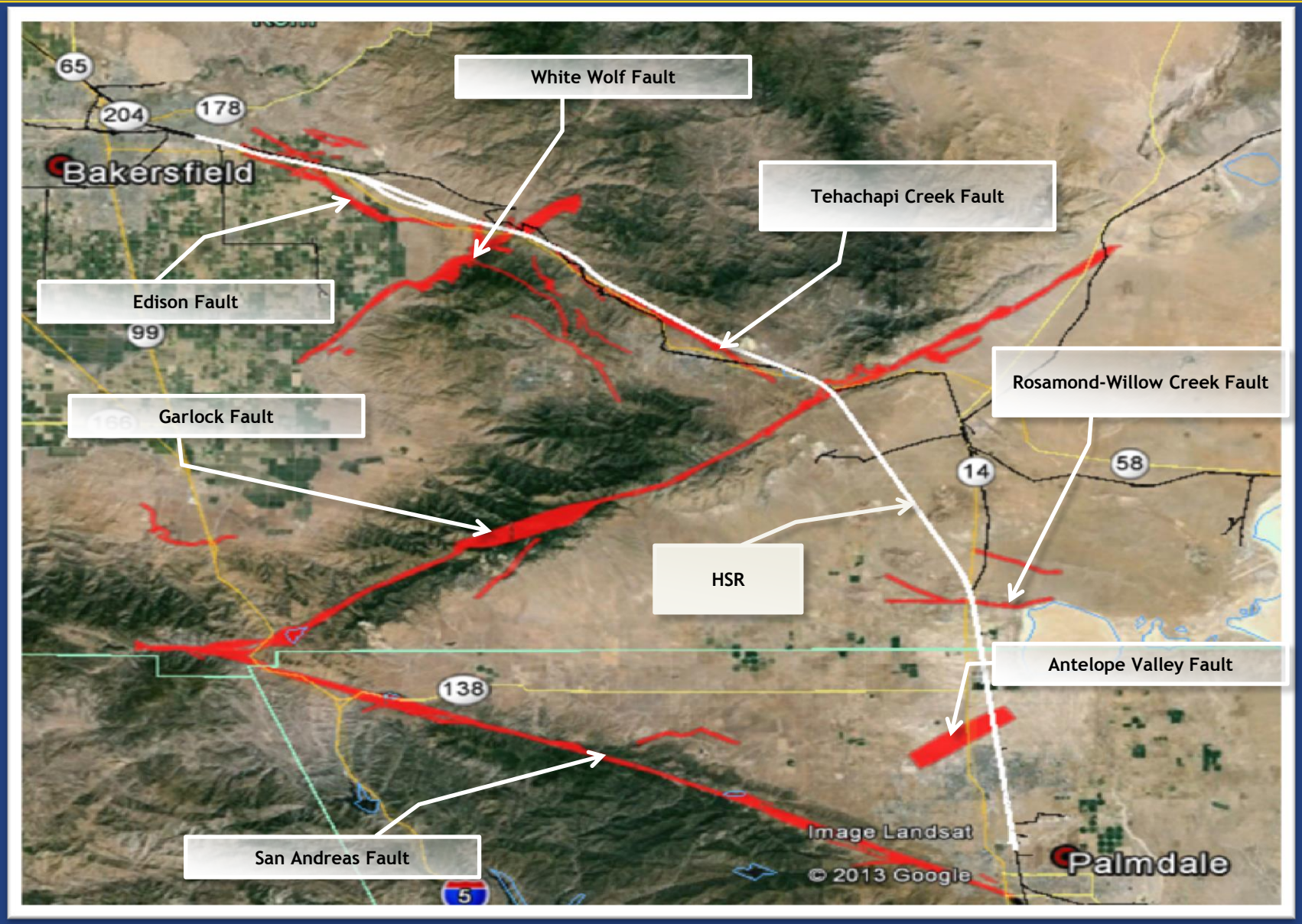
- **Three segments for investigation.**
  - » Gilroy to Los Banos (Pacheco Pass)
  - » Bakersfield to Palmdale
  - » Palmdale to Burbank





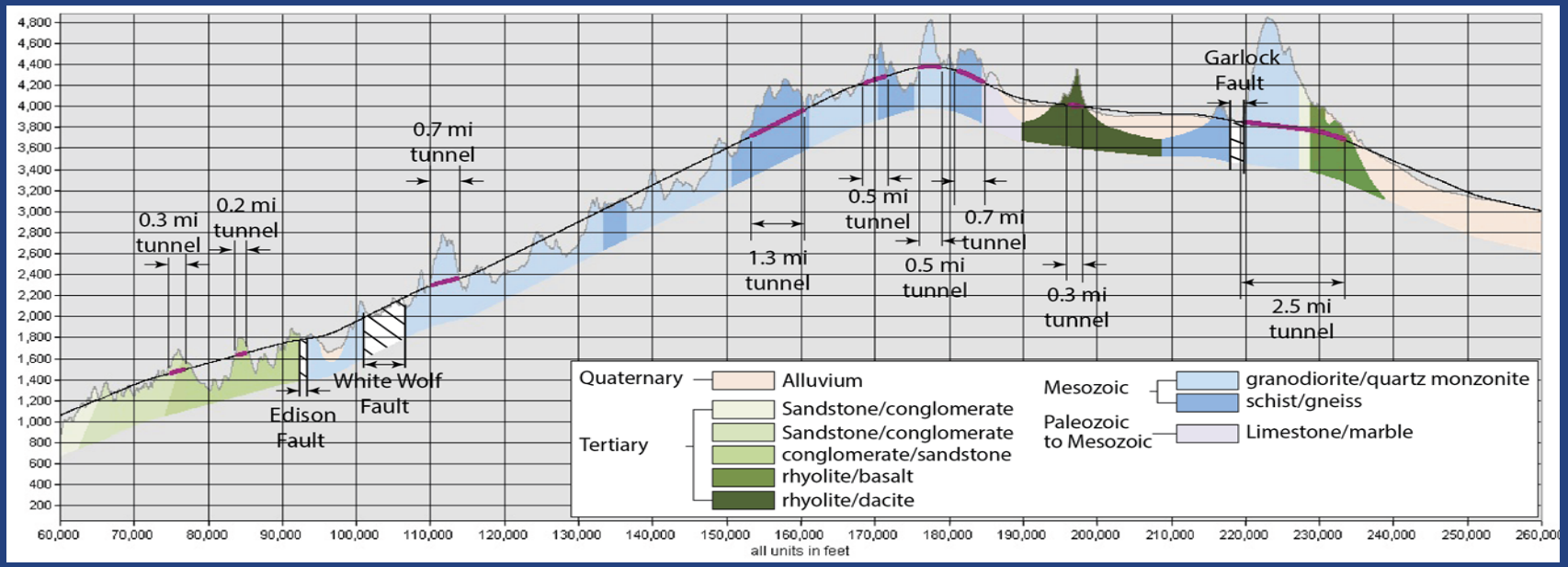


ENGINEERING CHALLENGES: SEISMIC FAULTS BAKERSFIELD TO PALMDALE



ENGINEERING CHALLENGES

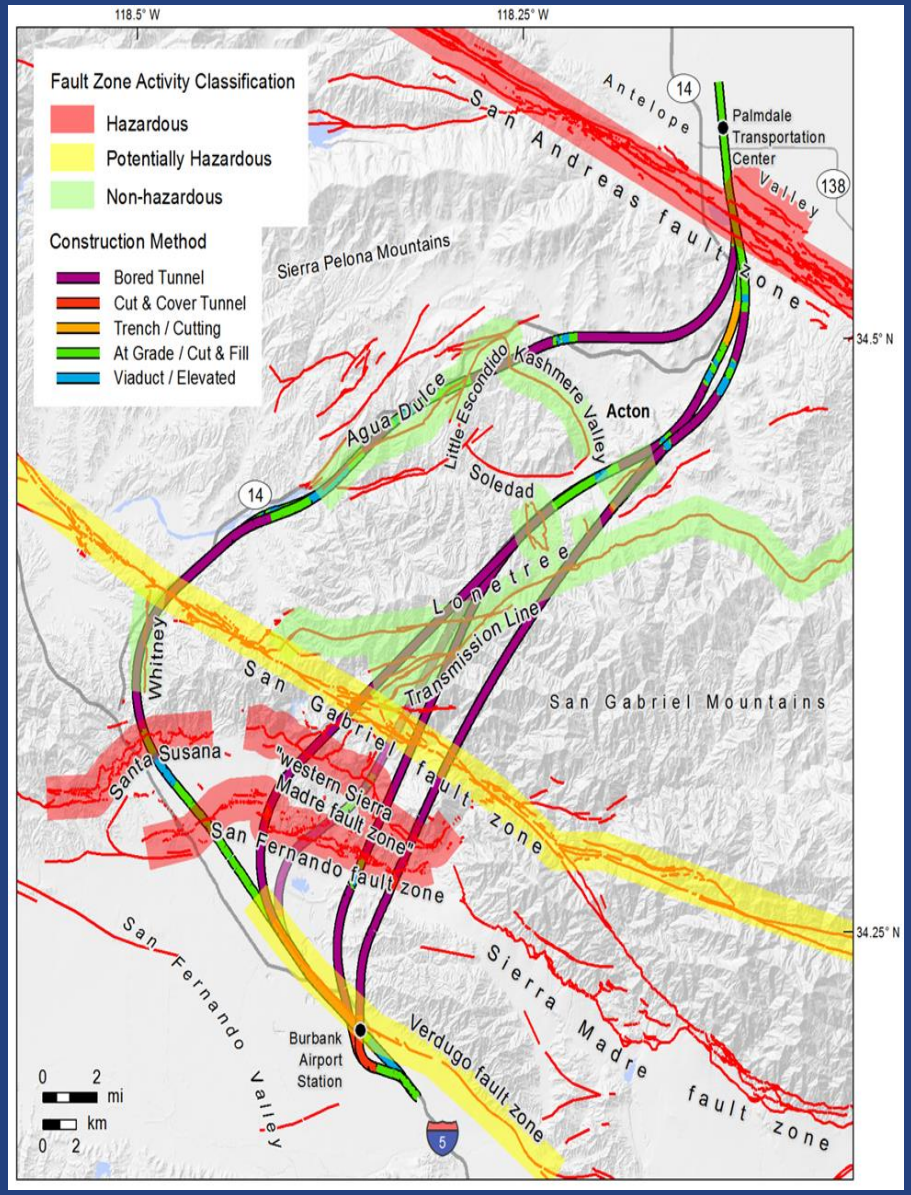
- Overall tunneling in variable geology
- Seismically active areas with multiple fault crossings
- Investigation on ground water impacts
- Permitting, investigations and tunneling in environmentally sensitive areas
- Expanded geotechnical investigations



ENGINEERING CHALLENGES: PALMDALE TO BURBANK – FAULTS AND CROSSINGS BY HIGH-SPEED RAIL ELEMENTS

- 4 Major Fault Zones
- 6 Significant Secondary (Sympathetic) Fault Splays
- Fault Zone Crossing Details:

Fault Zone	Designation (TM 2.10.6)	Average width (ft)	No. of strands	Mean Displ (D) (ft)	Sense of Slip
San Gabriel Fault Zone	Potentially Hazardous	5,000	4 +	4.8	Strike-slip
Sierra Madre Fault Zone (West)	Hazardous	2,500	2 +/-	4.4	Reverse
Sierra Madre Fault Zone (San Fernando Fault)	Hazardous	3,000	2 +/-	2.0	Reverse
Verdugo Fault	Potentially Hazardous	3,600	2 +/-	2.6	Reverse



SEISMIC PERFORMANCE CRITERIA

- **No Collapse Performance Level Objectives**
  - » Limit structural damage and prevent collapse during and after a Maximum Considered Earthquake (MCE)
    - No collapse
    - Safe evacuation of passengers and personnel
    - No flooding or mud inflow for underground structures

- **Operability Performance Level Objectives**
  - » Protect track structure so that disruption of service is minimal following a Operating Basis Earthquake (OBE).
    - No derailment. Trains can safely brake to stop
    - Rail deformation and stresses limited
    - No concrete spalling or measurable deformations
    - No rocking of bridge foundations
    - Resumption of normal service in a few hours
    - Safe performance during aftershocks

PROPOSED LIDAR BASED STUDY AND MODEL

Proposed LiDAR Study – Assess Potential Geohazards

- 10 KM swath of airborne LiDAR flown
- Develop digital elevation model to serve as top of 3D geological and structural model
- LiDAR model to be incorporated into Fledermaus interactive 4D geo-spatial model for processing & analysis
- End product – better intel for planned geotechnical exploration
- Note subsidence areas

HSR vs. Highway Structures

- Deformation and displacement control
  - HSR - Heavier superstructure
    - Higher inertial force demand
  - Larger stiffness of substructure
    - Larger plastic hinge moment for foundation
- Stress on tracks control
  - Track-Structure-Interaction (TSI)
- Train stability (derailment) control
  - Dynamic Vehicle-Track-Structure Interaction (DVTSI)

Seismic Performance Criteria

Caltrans Bridges

Bridge Category	Seismic Hazard Evaluation Level	Post Earthquake Damage Level	Post Earthquake Service Level
Important	Functional	Minimal	Immediate
	Safety	Repairable	Limited
Ordinary	**Safety**	**Significant**	**No Collapse**

CHSR Type1 Structures

Two levels of seismic performance criteria		
Performance Level & Design Earthquake	**Performance Objectives**	**Acceptable Damage**
Operability Performance Level (OPL) & Operating Basis Earthquake (OBE)	-Elastic structural response **-No derailment** **- Structure and track designed to comply with Track-Structure Interaction**	- Minor inelastic behavior, no spalling. - No damage to HST track, track support, and rail fasteners
No Collapse Performance Level (NCL) & MCE	-No collapse -Occupants safely evacuate	Significant yielding with no collapse

- Challenges(Very Tall Bridges at High Seismic Zone):
  - Continue to operate at OBE without derailment.
  - OBE combined with Track-Structure-Interaction without damaging tracks.

Challenge Looking Ahead

- Operating Basis Earthquake(OBE)
  - Stringent deformation and displacement
  - Combination with Track-Structure-Interaction
    - Results in Heavier and stiffer structure

- Maximum Considered Earthquake(MCE)
  - Displacement-based seismic design criteria
    - Result in flexible structure with high ductility
    - Result in large residue deformation and displacement

Area of Interest for research

- Address OBE & MCE events
  - Energy dissipation, Base Isolation
- Stop train operation during OBE & MCE
  - Earthquake Early Warning and Detection Systems (EEWDS)

Area of Interest for research

- Tunnel
  - Ground motion effect on tunnel
  - Fault directly crossing tunnels
- New Technologies
  - LiDAR to identify new fault
  - Aerogravity/Aeromagnetic technologies on geotechnical and tunnel design

THANK YOU

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