CALIFORNIA
High-Speed Rail Authority

TUNNELING IN NORTHERN CALIFORNIA

Construction of California's high-speed rail system will require between 40 and 50 miles of tunneling through mountainous regions in both Northern and Southern California. High-speed trains in Northern California will traverse 15 miles of tunnels through Pacheco Pass in the Diablo Range (Figure 1), a critical link between the San Francisco Bay Area and the Central Valley:

- Tunnel 1 will be a 1.6-mile tunnel located just west of Casa de Fruta.
- Tunnel 2 will be a 13.5-mile tunnel running along the north side of the San Luis Reservoir.

The terrain of Pacheco Pass necessitates tunnels. Steep grades and sharp curves prevent trains from traveling safely at high speeds. Tunnels will permit the rail line to maintain a relatively straight and level path in such terrain. Crossing these mountains will provide the critical connection between the Silicon Valley and the Central Valley, reducing travel times from three or more hours by car to about one hour by train.

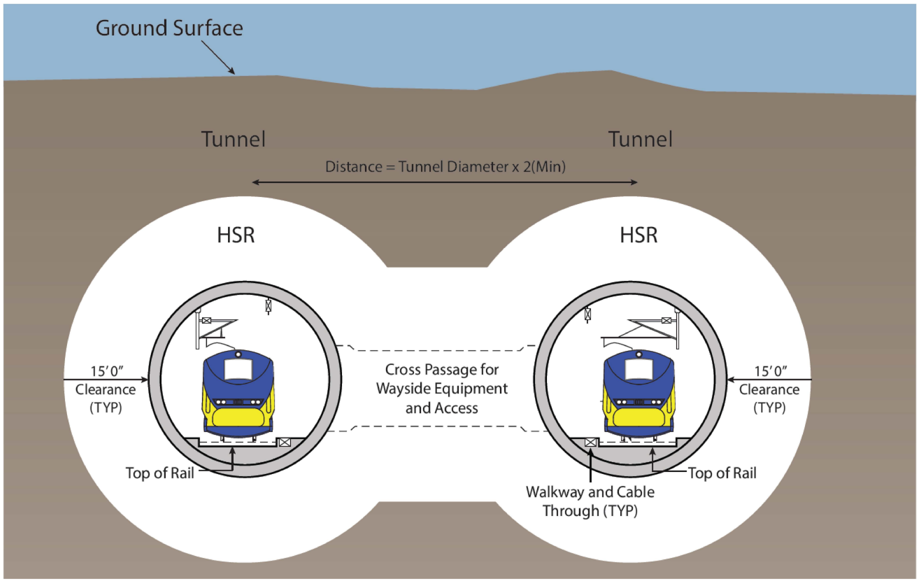

Figure 1. Illustrated cross-section showing the typical configuration of a dual-bore tunnel.

International Examples

As tunneling sections are among the most challenging elements of the high-speed rail system, project engineers draw upon international expertise to deliver the first mountain pass crossing for high-speed rail in the United States.

International examples include Japan and China, which are home to 14 of the 20 longest railway tunnels in the world; the United Kingdom, whose HS2 project connecting London and Scotland includes extensive tunnel sections; and Switzerland, Italy, and Austria, whose high-speed rail tunnels connect cities and countries located on opposite sides of the Alps.

Figure 2. Photo of tunnel boring machines constructing a dual-bore tunnel.

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Tunnel Fast Facts

- At 13.5 miles in length, Tunnel 2 is the longest contemplated tunnel for Phase 1 of the California High-Speed Rail project, and once built, it will be the longest intercity rail tunnel in the United States.
- High-speed trains can maintain top speed in the tunnels. A train traveling south will pick up speed as it leaves Gilroy, reaching up to 220 miles per hour, and will continue at that speed through the tunnels and into the Central Valley.
- Typical tunnel configuration is dual-bore tunnels with a single track in each tunnel (Figure 1), although a single-bore with two tracks is also feasible.
- Once construction begins, Tunnel 1 is expected to take two to three years to build, while Tunnel 2 is expected to take up to six years.

Potential Challenges

The remote location of the tunnels in Pacheco Pass contributes to challenges in surveying and construction. Issues under consideration when designing tunnels include:

- Building infrastructure and resources to support construction: tunneling requires large amounts of water and electricity.
- Geological conditions in Pacheco Pass: poor quality rock formations, faults and shear zones, and potentially high groundwater inflows all affect tunnel stability and pose risks to biological and natural resources.

Tunnel Construction Methods

Typical methods of tunnel construction include:

- Tunnel boring machine (TBM), a rotating cutter head that breaks up rock and soil (Figure 2)
- Roadheaders, which act like a dog's front paws as they dig through material
- Cut-and-cover technique, which involves the excavation and covering of a trench
- Blasting, the controlled use of explosives to break rock for excavation

Preliminary engineering analyses have identified a TBM as the most likely means of construction of the high-speed rail tunnels in Pacheco Pass. Roadheaders will be used to dig the cross passages (Figure 1), which are constructed at certain intervals to move equipment and for evacuations in an emergency. These methods will be confirmed in a future phase of design, once the contractor has been selected and final design has been completed.

Tunnel Safety

To design the safest possible tunnels, the Authority is using the best available practices from around the world. Identification of ground conditions, such as fault zones and liquifiable soil, are highly important. Tunnels need to be wide enough to account for the maximum displacement that an earthquake could cause, so tracks can be realigned and service can be reinstated as quickly as possible.

The Authority has safety protocols in place in the event of an emergency occurring while the train is in a tunnel. Fire hazards are limited by using noncombustible materials and fire suppression techniques during construction. Also, if the train needs to stop in a tunnel, cross passages will be available for passengers and workers to use for emergency evacuation.

The Authority will also be using an Early Earthquake Detection System (EEDS) as shown in Figure 4. Seismic detectors will be located at regular intervals along the guideway and linked via a dedicated high-speed rail communications system.

All trains are autonomously brought to a stop when the detectors sense a seismic event of a certain magnitude, and other trains are prevented from entering the area. This type of technology was essential in bringing Japanese high-speed trains to a safe stop during a major earthquake in 2011.

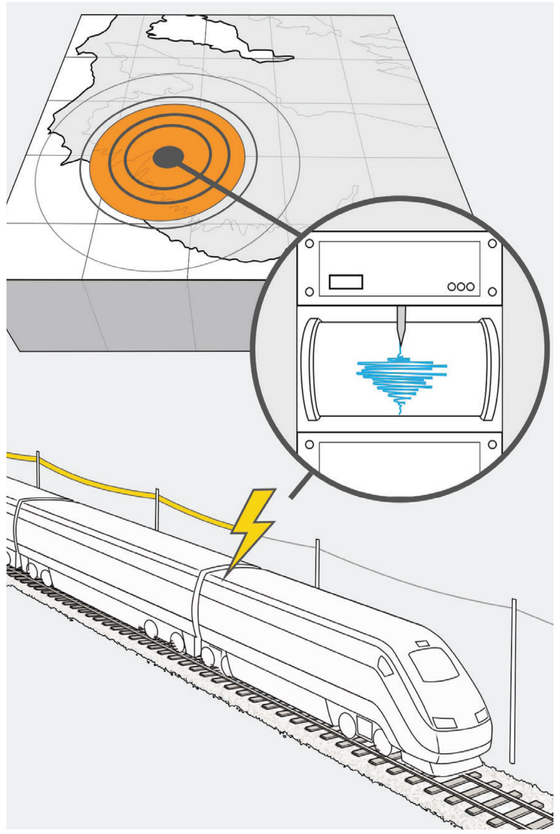

Figure 4. A diagram of the EEDS detecting an earthquake and alerting a high-speed train.

Wildlife Ecology and Conservation

Pacheco Pass is home to a number of sensitive wildlife corridors, natural habitats, and ecologically sensitive lands, such as Cottonwood Creek Wildlife Area and Pacheco Creek Reserve. Ensuring that these places remain pristine for generations to come is a priority for the California High-Speed Rail Authority.

By tunneling portions of high-speed rail underground, the surface area will remain similar to today's conditions and maintain established wildlife movement corridors and habitats in the Pacheco Pass area (such as those of the mountain lion and tule elk shown in Figure 5).

Figure 5. Mountain lions and Tule Elk are two of the many species that live in the Pacheco Pass area.

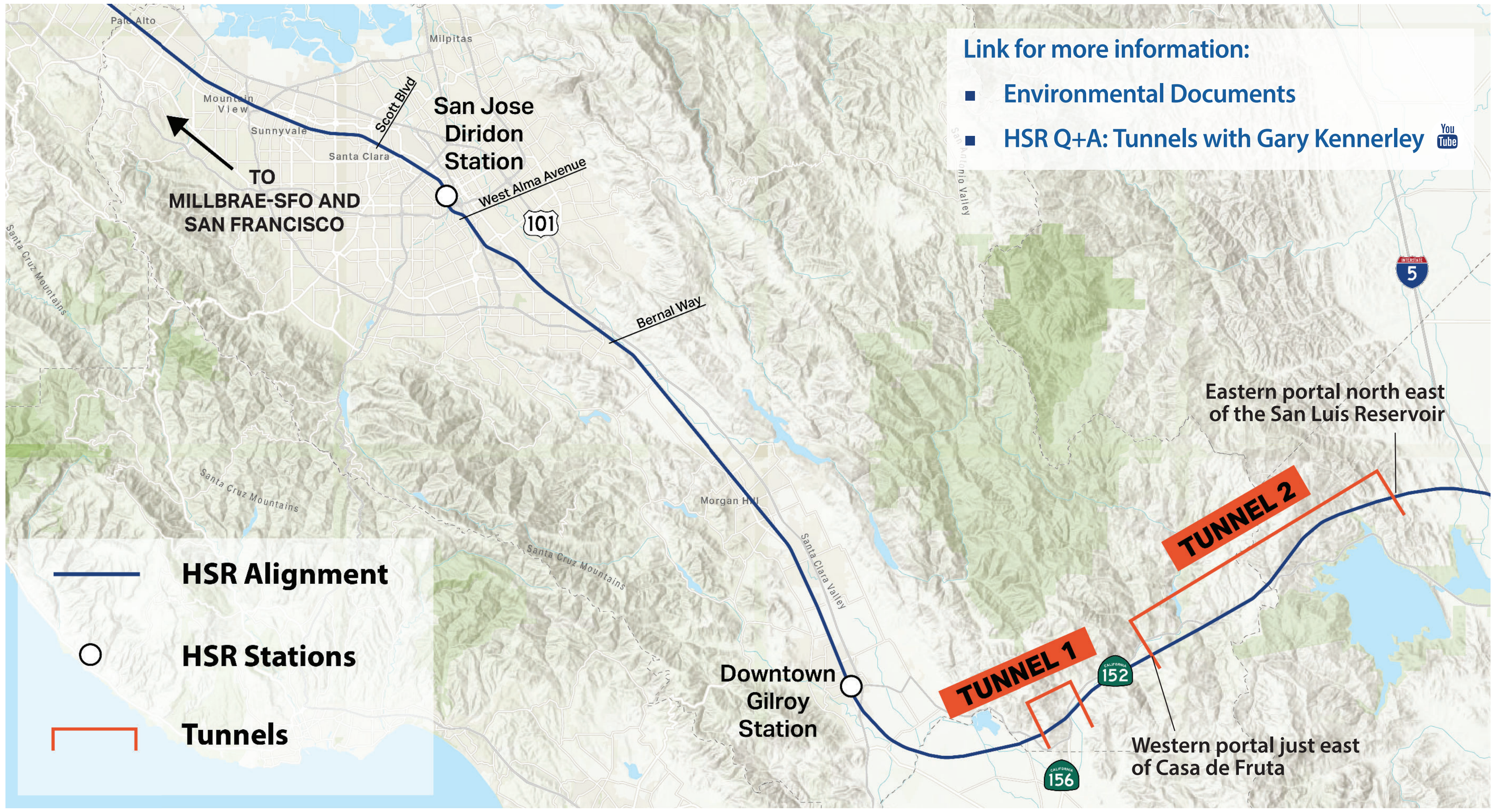

Figure 3. Map showing the location of of Tunnel 1 east of Gilroy and Tunnel 2 through the Pacheco Pass.

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