High Speed Rail in California

A Systems Overview
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Project Objectives

- This project will explore what a high-speed rail (HSR) system is and what are the pros and cons of the other public transportation options.
- It will then investigate previous HSR systems from a case studies perspective in order to create a lessons learned database to build the design on.
- Then the top level goals and requirements will be reviewed to better define specific needs and requirements of this system.
- Architectural views of the system will be created using these top level definitions, goals and lessons learned.
- Major risk areas and ethical issues will be identified and possible mitigation efforts suggested.
- A final review will summarize the findings and recommendations.
Project merits as a candidate for study

A high speed rail system in California has merit for study in the systems Engineering field because:

- It will be a large complex system involving electrical, mechanical, communications and human interface systems
- It will be a large financial and manpower endeavor having a big impact on local, state and even federal coffers and employment rates and on the general population
- It will have a major positive or negative effect on the environment in terms of pollution, noise, land use, efficiency, wasted or saved commute times and other quality of life issues
- The scope of the task requires that many different shareholders, users, financiers, designers, engineers and various levels of government work together to create a mutually acceptable and advantageous product
How the project is a system of systems

- Each train station will have electrical, mechanical and human interface aspects requiring communications, energy supply, security, safety elements and maintenance.
- Each train will have all those requirements plus mobility (rolling stock) and braking systems.
- There will also need to be on and off-site physical and electronic ticketing and billing systems.
- During the construction and use phases there will also be numerous civil, mechanical, electrical, plumbing and drainage issues.
- As with any large construction effort, there will also be scheduling, financial and earned value systems.
Project milestones and expected completion dates

- Project outline first draft  • 2-7-2013
- Project outline Review with Professor Galloway  • 2-12-2013
- Project outline completed  • 2-14-2013
- Text body 33% complete, focus on previous endeavors  • 3-12-2013
- Review with Professor Galloway  • 3-19-2013
- Text body 66% complete, focus on architecture  • 4-9-2013
- Review with Professor Galloway  • 4-16-2013
- Final package complete and turned in  • 4-30-2013
- Final Review and feedback with Professor Galloway  • 5-3-2013
- Final presentation  • 5-6-2013
Distinctions between HSR, conventional trains & Magnetic Levitation

What is HSR?
• Speed definitions for High Speed Rail
  – “Reasonably expected to reach sustained speeds of more than 125 miles per hour,” United States Code
  – “Top speeds at 90 mph and above”, The Federal Railroad Administration
• High speed rail usually has the same width track and can even run on conventional tracks once within city centers
  – Highest speeds not used within city centers for safety reasons
  – Prevents having to build expensive, disruptive new lines within the city that, for example, Magnetic Levitation (Mag-Lev) would require
Distinctions between HSR, conventional trains & Magnetic Levitation, cont.

• Because most of the length of high speed rail lines are dedicated to high speed trains, which have high power and low weight compared to freight trains, they can actually achieve much higher gradients allowing shorter, cheaper lines and faster trips
  – The Cologne to Frankfurt line reaches 4 % gradient!
  – Diesel-powered locomotives are limited to no more than about 2 % gradients
• Because of their high level of momentum, high speed trains can also climb slopes quickly without greatly increasing their energy consumption or wear on the motors
• Because their speed is more narrowly defined (there are no slow freight trains on the tracks) a higher level of banking can be built into the system reducing turn radii, costs, and travel times
Mag-Lev vs. HSR

Pros

• Mag-Lev can support even higher gradients
  – Up to 10% gradient
• Mag-Lev can support even higher speeds
  – Up to 50% faster
• Mag-Levs are quieter
  – No rolling stock noises

Cons

• Requires completely new track all the way through the city center
• Mag-Lev typically uses expensive, proprietary technology
  – Knowledge may not be easily shared from project to project
  – Can create single sourcing problems and throughput problems
• The upper end possibilities often become limited by other factors
  – “A recent study of a proposed Mag-Lev line between LAX Airport and Ontario Airport, via downtown Los Angeles, demonstrated very few advantages over a more traditional one — it would be about 10% faster, would attract about 10% more customers, but would cost an eye-popping 60% more to build” *B
Buses on freeways vs. HSR

Pros
- Smaller initial outlay and is a well known technology
- Can be better implemented in stages than many other options
- Can implement natural gas, electric, or other green technologies in the buses
Buses on freeways vs. HSR, cont.

Cons

- Susceptible to traffic congestion & delays
  - To be practical, requires use of High Occupancy Vehicle (HOV) lane
  - Cost of a fleet of buses and two HOV lanes (going & coming back) nears costs of HSR system
  - Implementing this option can actually decrease the efficiency of the freeway for everyone else
- Slower than HSR even when unimpeded by traffic
- Less efficient & less green than a rail system
  - Because of the low friction of steel wheels running on steel rails, railroads are inherently more energy efficient, less polluting, and less expensive to operate than any vehicle carrying the same load using rubber wheels; about 3 times more efficient than passenger cars
  - Due to their higher value but smaller numbers, locomotives should get better & more frequent maintenance and these costs should be lower due to no wear and tear from potholes, road debris, vehicle collisions or rubber tire wear
- Really only suitable for much shorter trips and with lower volume of people than HSR system would typically service
Airplanes vs. HSR

Pros
- Faster

Cons
- More susceptible to delays due to weather, even due to weather nowhere near the local airport
- Planes inherently have long check-in, screening, boarding, and taxiing times than other modes of travel
- Due to their nature, trains will never suffer the same level of security scrutiny as airplanes
  - You can’t drive a train into the Pentagon
  - Control center has a greater degree of control over trains, such as over track switches
  - You can safely, remotely “turn off” a locomotive in mid trip if needed
- Planes are less green, 2 to 6 times more CO\(_2\) produced per passenger mile
- Airports are often singular and are outside the city center, requiring an additional form of transportation, time, and money to get to the actual final destination

The busiest short-haul air market in the country is between the Los Angeles and San Francisco. It is also one of the most delay-prone in the nation, with approximately 25% of flights delayed by about an hour.
Some Background on HSR

- HSR has existed in Japan since 1964
  - Mature technology with almost 50 years of experience
- Countries with HSR include
  - Japan
  - Germany
  - Spain
  - France
  - Italy
  - Taiwan
  - China
  - South Korea
  - Poland
  - Turkey
- Acela Express Line service was inaugurated in December 2000 from Washington DC to Boston and was an immediate success \(^H\)
  - Generated 25% of all Amtrak profits in 2012
- HSR can achieve excellent on time travel records

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<thead>
<tr>
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<td>43.51%</td>
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<th>2008 Punctuality (within 5 minutes)</th>
<th>2009 Punctuality (within 5 minutes)</th>
<th>2010 Punctuality (within 5 minutes)</th>
<th>2011 Punctuality (within 5 minutes)</th>
<th>2012 Punctuality (within 5 minutes)</th>
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<tbody>
<tr>
<td></td>
<td>99.47%</td>
<td>99.19%</td>
<td>99.25%</td>
<td>99.21%</td>
<td>99.87%</td>
<td>99.44%</td>
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</table>

Taiwan HSR ridership and punctuality
HSR will *enhance* other modes of public transportation

- When high-speed rail service was introduced between Madrid and Seville, the share of trips taken by plane was reduced from 40 percent to 13 percent, and rail trips grew from 16 percent to 51 percent *N*
- This reduction in air travel means that limited airport capacity can be better used for longer-haul routes
- A shift from automobiles and airplanes to high-speed trains has been the consistent experience internationally; from Taiwan to Germany, France, and Spain
HSR will *enhance* other modes of public transportation, cont.

- The increased mobility from HSR prompts greater travel, generating more economic activity, not just a reallocation between modes.
- On the HSR line between Paris and Lyon, France, for example, half of the trips taken are new trips.
- China has seen an improvement in efficiency and air quality as faster passenger lines freed up track space and allowed more freight trains, reducing the dependence on costlier, dirtier diesel trucks to move freight.
  - Each passenger car removed from commuter trains makes room for 3 freight cars.
Current Status on California’s HSR

California has received final sealed bids for the first leg

- $8 billion was set aside for HSR in the 2009 stimulus package
- California has issued request for purchasing HS rail locomotives and passenger cars
- California is breaking ground this year on track construction
- 220 mph maximum operating speed

Dispelling some myths

Claim: “There are no profitable HSR system in the world, they are all government subsidized”
   - False and true
   - The Acela Express Line, the TGV in France, and other lines have been making profits for years
   - Other transportation systems such as the National highway system and major airports also highly involved with government actions & support
      - Imminent domain actions
      - National and state level safety requirements, signage standards, fuel efficiency requirements, smog certification, security requirements, etc.
      - FAA, air traffic control, and TSA funding
      - State funding through CALTRANS, CHP, call boxes, lighting, rest stops
   - To try to use this argument against HSR without admitting the same issues apply to every reasonable alternative is hypocritical
Dispelling some myths, cont.

Claim: “You know that these big projects like high-speed rail never end at or under budget”

- In the past this has been largely true but this doesn’t have to be
- The stimulus package places a tremendous emphasis on making sure every dollar is spent in a transparent way. This kind of transparency is very helpful to prevent enormous overruns **P**
- The I-35W bridge that collapsed over the Mississippi River in Minneapolis in 2007 was contracted to be rebuilt in just 437 days, and actually came in ahead of schedule and under budget. There is no reason we can’t expedite the same process for other projects around the country **P**
- The biggest offenders, such as the Big Dig, should be studied; there are always ‘lessons learned’ to be gathered from them
- A recent audit by the GAO gave the California High-speed Rail Authority (CHSRA) high marks for reasonable estimates, compliance with laws and good accounting methods and they could find no recommendations for things CHSRA should change **Z**
Dispelling some myths, cont.

Claim: “The $98 billion price tag is ridiculous and the state cannot afford it”
- This value is not an annual cost but is a total for the entirety of the project, which may not be fully completed for two decades and it is in final dollar values, making it seem larger than it is
- On an annual basis, the price tag becomes a more manageable $3 billion
  - This still sounds like a huge sum but remember that California’s population represents 1/8 of the entire country
  - This amount is only equal to 23% of the total amount of money Caltrans plans to spend this year anyway
    - To have 23% of what is already planned to be spent on something other than highways doesn’t seem risky, it seems sensible
- It’s not all just the states money
  - Almost 50% is now being provided by the Fed’s; hard to pass up free money, even for the state
A review of previous endeavors and lessons learned
Key elements to look for using Case Studies methodology

Goal: Try to find a good historical case example of each type of the 9 key elements

Level of detail of publicly released documents may limit the ability to do this in certain areas or to a desired level of detail

- A) Requirements definition and management
- B) Systems Architecting and Conceptual Design
- C) System and Subsystem Detailed Design and Implementation
- D) Systems and Interface Integration
- E) Validation and Verification
- F) Deployment and Post Deployment (in service)
- G) Life Cycle Support
- H) Risk Assessment and Management
- I) Systems and Program Management
Case study examples and lessons learned

- **G) Life Cycle Support**
  
  Japan has continuously improved and refined their HSR system since initial opening in 1964
  
  - Operating speeds from the start were 130 mph
  - Maximum commercial speed are now up to 186 mph
  - Test runs performed up to 275 mph
  - Network has been continuously expanded to consist of 1484 miles of lines now
  - World’s busiest HSR line
    - Carried it’s 1 millionth customer within first 3 years
    - Carried it’s 5 billionth passenger in 2000
    - Carried over 150 million passengers per year starting in 2008
    - Tokyo to Osaka line now has up to 13 trains per hour with 16 cars each, 1323 seats total
    - Minimum of 3 minutes between trains for safety but average is just 4 ½ minutes apart
      - That’s 17640 people every hour
High speed rail in Europe
Make it safe and useable by everyone

TGV “Train a Grande Vitesse,” high speed train; or originally “tre’s grande vitesse,” very high speed

Case study examples and lessons learned
• A) Requirements definition and management
• E) Validation and Verification
  – Gas turbine electric locomotives were originally chosen due to their good power to weight ratio
    • It worked and still holds the land gas turbine speed record
    • France switched to overhead electric lines due to the 1973 energy crisis and it’s fuel price concerns
  – During speed trials of this new system, they discovered the overhead catenary wires could sag due to drag and create standing waves - this required redefinition and tightening of the catenary wire system
High speed rail in Europe, cont.

- B) Systems Architecting and Conceptual Design
  - Some French station locations were chosen with the idea to serve the outskirts between two different communities, and thus save costs and reduce the number of stops
    - Many passengers found these inconvenient for either community and derisively dubbed them “beet” stations for the farmers fields they served
    - “Beet station” has now apparently become a common term for any small station and the term may be used affectionately by the few locals for the level of convenience and service they provide
    - This is a lesson learned that trying to save costs too much may provide a solution that pleases hardly anyone
  - Poland had invested primarily in their road network for public transportation but is transitioning in 2012 onward to focusing on improving it’s rail network *
    - They have almost 800 km of existing HSR
    - Plan to expand to 1500 km by 2015
    - Plan to link their 12 largest cities by HSR by 2020
High speed rail in Europe, cont.

- **C) System and Subsystem Detailed Design and Implementation**
  - The English developed a central car design with no high power transmission running through the passenger cars for safety; an interesting idea that didn’t pan out and was dropped
  - Didn’t allow passengers to move freely from “front” cars to “rear” cars
  - Made adding additional power locomotives difficult as well as removing them for maintenance
  - In nearly three decades of high-speed operation, the TGV has not recorded a single fatality due to an accident while running at high speed
    - There have been 3 derailments at or above 170 mph but there were no carriages overturned or fatalities
    - There have been fatal accidents but all occurred at places where the HSR experienced the same risks as normal trains and mostly have to due with level crossings with street traffic

- **D) Systems and Interface Integration**
  - It is convenient to have certain trains cross over international boundaries into neighboring countries cities rather than stopping at borders
  - This creates new problems though as the EU has numerous different voltage supply requirements
  - In the worst case example French trains which can travel to Germany, Switzerland or Belgium are required to have no less than tri-current motors, able to run on 25KV, 50 Hz; 1.5 KV DC; or 15 KV, 16 2/3 Hz and two sets of pantographs for AC or DC connections
  - The system is designed so the trains coast across the border until the new supply is detected and hooked into
High speed rail in Europe, cont.

• **E) Validation and Verification**
  - The French performed extensive locomotive power and speed testing
  - A TGV test train set the record for fastest wheeled train reaching 357 mph in 2007 *\(^A\)
  - Regular service speeds reach 200 mph
  - Testing showed the need for an unexpected requirement change to increase initial tunnel diameters and to taper them due to uncomfortable air pressure changes when trains entered them at speed

• **G) Life Cycle Support**
  - To counteract a popular misconception that the TGV would be another premium service for business travelers, TGV service was run for all types of passengers with the same ticket price as for trains running on parallel conventional tracks
  - This commitment to democratized TGV service was further enhanced in the Mitterrand era with the promotional phrase “Progress means nothing unless it is shared by all”
  - The TGV has proven considerably faster than normal trains, cars, and even airplanes (for commuter hops) and has become hugely popular

• **H) Risk Assessment and Management**
  - The EU has exemplary crash history – crashes that do happen are often on the shared, un-separated part of the line
  - Passing freight trains at high speed was discovered to pose a risk as cargo could become destabilized by the air turbulence
High speed rail in the US
Minimize the Cost

Case study examples and lessons learned

C) System and Subsystem Detailed Design and Implementation

F) Deployment and Post Deployment (in service)

- Acela Express Line
  - Average trip speed is 84 mph with brief segments reaching 150 mph
  - Was profitable from the first year of operation
  - This single line creates 25% of all of Amtrak nation-wide profits *H
  - Initial implementation relied heavily on shared existing track to minimize costs
  - Line continues to plan and make small incremental improvements in speed and service

F) Deployment and Post Deployment (in service)

- Chicago to St. Louis line upgraded from 79 to 110 mph over a 15 mile stretch
- Planned to make 75% of the route at 110 mph by 2015
- The number of people you can carry improves dramatically at 110 mph
  - It really begins to compete with short hop air travel *W
High Speed Rail in China
Ambitious plans and Gung-ho schedule

China has been making rapid progress in establishing a nation-wide HSR system

- China has built 5800 miles of dedicated HSR in only 6 years *
- $1 Trillion in total is allocated *
- Long term plan is to crisscross the country with 4 East-West and 3 North-South lines that will connect virtually every large Chinese city
  - ECD is 2015! Nearly half is already completed! **
- Surpassed Japan with highest annual passenger ridership of 370 million passengers in 2011
- Opened the world’s longest HSR line in December 2012
  - Beijing-Guangzhou-Shenzhen-Hong-Kong, 1428 miles *
  - Further than the distance from NY to Miami, a nearly 30 hour Amtrak ride
  - A 21 hour trip now cut to just 8 hours, making it a day trip
  - 150 pairs of trains make the run daily
High speed rail in China, cont.

Case study examples and lessons learned

• F) Deployment and Post Deployment (in service)

• I) Systems and Program Management
  – The Wenzhou disaster: In July 2011, a CRH2 train traveling at 100 km/h collided with a CRH1 which was stopped on a viaduct in the suburbs of Wenzhou, China *
  – The two trains derailed, and four cars fell off the viaduct
  – 40 people were killed, at least 192 were injured
  – The disaster led to a number of changes in management and use of high-speed rail in China, including the lowering by 50 km/h of all maximum speeds; a 350 km/h limit becoming 300 km/h, etc. (217 mph to 186 mph)
  – China is already testing the next generation of trains which it hopes can reach 500 km/h (310 mph), this would again almost cut the travel times in half!

  – The suddenly expensive land near rail stations can result in a lack of stores springing up near stations even though they are frequented by tens of thousands of travelers every day
Lessons Learned from another large scale construction effort

Lessons Learned from The Big Dig

• Minimize imminent domain usage
  – A HSR system should use less land than other options
  – Most new land taken lays outside expensive city center areas

• Get federal funding, don’t make the locals pay for it all
  – On July 6 2012, California legislature approved construction financing for $4.5 billion (previously approved by voters on Nov 2008) which in turn freed up $3.2 billion in federal funds (that would have expired July 6!)
  – Not as good as the dollars for dimes Bostonians hoped for but still pretty good at 42% of total funding
  – Ohio, Wisconsin & Florida passed on potential HSR lines to California’s benefit - Total federal government's funding commitment to high-speed rail projects in California now at $4.3 billion *O

• Put cost into final year of expenditure numbers
  – Current estimate is for $68 billion at final year of expenditure for phase 1 end date of 2017
Development of definitions and top level goals and requirements for a HSR system in California

- The California High-speed Rail Authority (CHSRA) should service several of California’s major cities
  - Current plans will service all 6 of the largest cities
  - 12 of the largest 18 cities are directly serviced
  - All 18 of the largest cities are directly served or are within ½ hour of a station
- Can be accomplished with a single line with two relatively short side branches (106 miles and 41 miles) at each end

<table>
<thead>
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<th>City</th>
<th>Population</th>
<th>Serviced by HSR?</th>
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<tbody>
<tr>
<td>1</td>
<td>Los Angeles</td>
<td>3,792,621</td>
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<tr>
<td>2</td>
<td>San Diego</td>
<td>1,307,402</td>
<td>Yes</td>
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<tr>
<td>3</td>
<td>San Jose</td>
<td>945,942</td>
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</tr>
<tr>
<td>4</td>
<td>San Francisco</td>
<td>805,235</td>
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</tr>
<tr>
<td>5</td>
<td>Fresno</td>
<td>494,665</td>
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</tr>
<tr>
<td>6</td>
<td>Sacramento</td>
<td>466,488</td>
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<tr>
<td>7</td>
<td>Long Beach</td>
<td>462,257</td>
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<td>8</td>
<td>Oakland</td>
<td>390,724</td>
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<td>9</td>
<td>Bakersfield</td>
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<td>Anaheim</td>
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<td>Santa Ana</td>
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<td>13</td>
<td>Stockton</td>
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<tr>
<td>18</td>
<td>Modesto</td>
<td>201,165</td>
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Development of definitions and top level goals and requirements for a HSR system in California, cont.

- CHSRA should be able to listen to new ideas and implement them*
  - Cost and schedule concerns led to the development of the Revised 2012 Business Plan which incorporated the blended and phased approaches
  - "Blending" provides for the integration, or blending, of high-speed rail improvements with existing and upgraded rail systems
  - Passengers will have more options, faster travel times, and greater reliability and safety
  - By leveraging new infrastructure and systems with existing and upgraded systems, taxpayers will benefit from greater cost efficiency and more effective use of state investments dollars
  - Phased approach allows valuable segments to be completed and become operational without needing to complete the entire project to see benefits
- CHSRA should minimize risk through appropriate actions
  - The phased approach allows risk to be reduced for each subsequent section because of the successful performance and lessons learned from the completed HSR sections
  - In this way, success feeds on success and enhances the ability to attract private capital and operating expertise

*Shows good Systems and Program Management, section 1)
Development of definitions and top level goals and requirements for a HSR system in California, cont.

- Tickets should be reasonably priced
  - Expected price San Francisco to Los Angeles is $81 in 2010 dollars
- The system should be available soon to a large number of people
  - The first phase will connect the fastest-growing part of California, the Central Valley, with the most heavily populated area, greater Los Angeles
  - The central valley, with a population approaching 7 million, is larger than 38 states
  - Ridership on existing Amtrak lines in central valley have already been increasing 6% per year
  - Total number of people who will be able to reach the completed California HSR system will be about 10 times greater than served by the successful Acela Express Line

<table>
<thead>
<tr>
<th>Exhibit 5-7. Example of HSR fares (2010$ one-way)</th>
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<tbody>
<tr>
<td>Station-to-Station</td>
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<tr>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>San Francisco-Los Angeles</td>
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<tr>
<td>San Jose-Anaheim</td>
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<tr>
<td>Fresno-Millbrae</td>
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<tr>
<td>Sacramento-Fresno</td>
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<tr>
<td>Los Angeles-Kings/Tulare</td>
</tr>
<tr>
<td>Bakersfield-Merced</td>
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<tr>
<td>Palmdale-San Diego</td>
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</table>
Development of definitions and top level goals and requirements for a HSR system in California, cont.

- The service should be reasonably quick between destinations

## Estimated Travel Times for Various Destinations

Much improved on current conditions, especially for the corridor from Bakersfield to Los Angeles

<table>
<thead>
<tr>
<th>Segment</th>
<th>Distance</th>
<th>Travel Time</th>
<th>Average Speed</th>
</tr>
</thead>
<tbody>
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<td>San Francisco to San Jose</td>
<td>48 miles (77 km)</td>
<td>30 minutes</td>
<td>96 mph (154 km/h)</td>
</tr>
<tr>
<td>San Jose to Los Angeles</td>
<td>400 miles (644 km)</td>
<td>2 hours 21 minutes</td>
<td>170 mph (274 km/h)</td>
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<tr>
<td>San Francisco to Los Angeles</td>
<td>432 miles (695 km)</td>
<td>2 hours 38 minutes</td>
<td>164 mph (264 km/h)</td>
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<tr>
<td>Sacramento to Los Angeles</td>
<td>412 miles (663 km)</td>
<td>2 hours 17 minutes</td>
<td>180 mph (290 km/h)</td>
</tr>
<tr>
<td>San Francisco Airport to Fresno</td>
<td>174 miles (280 km)</td>
<td>just over an hour</td>
<td>161 mph (259 km/h)</td>
</tr>
<tr>
<td>Bakersfield to Los Angeles</td>
<td>142 miles (229 km)</td>
<td>less than 1 hour</td>
<td>155 mph (249 km/h)</td>
</tr>
<tr>
<td>Los Angeles to Riverside</td>
<td>68 miles (109 km)</td>
<td>33 minutes</td>
<td>124 mph (200 km/h)</td>
</tr>
<tr>
<td>Los Angeles to San Diego</td>
<td>167 miles (269 km)</td>
<td>1 hour 18 minutes</td>
<td>129 mph (208 km/h)</td>
</tr>
<tr>
<td>Ontario to San Diego</td>
<td>125 miles (201 km)</td>
<td>less than 1 hour</td>
<td>136 mph (219 km/h)</td>
</tr>
</tbody>
</table>
Development of Architectural views of a HSR system in California based on definitions, goals, requirements and lessons learned

Based on the lessons learned and the prescribed goals, develop a set of architectural views for the system
OV-1
High Level Operational Concept Graphic

Advertising
- Routes & Scheduling

Accounting

Ticketing
- Online
- At Point of Use
- From smart phone

CHSRA

Customers

STATIONS

CALTRANS

DOT (Federal)

TRAINS

ACCESS TO

ACCESS TO
Top Level Schedule

- 1st leg, Merced to San Fernando Valley, service in 2022
  - Closes the North-South intercity rail gap, connecting Bakersfield and Palmdale
- Bay to Basin, San Jose to Palmdale, service in 2026
- Phase 1 blended, San Francisco to Anaheim, service in 2029

![Timeline Diagram]

- IOS 2013-2021
- Bay to Basin 2021-2026
- Phase 1 Blended 2014-2028

- Northern California Unified Service
- IOS HSR Operational
- Bay to Basin Operational
- Phase 1 Blended Operational
1) Published schedules & routes and timetables, commercials, posters, signs
2) Online printable/scan-able confirmation numbers, paper tickets and scan-able “App” tickets
3) Live feedback of ticket sales, ridership levels & payment information
4) Video feeds & telemetry of station, customers and track conditions
5) Real time Rail line “block” information, schedules & feedback from drivers and security on conditions
6) Access through public transportation, taxis, park & ride locations and drop-off points
7) Access through automatic ticket reader turnstiles
8) Ridership predictions & actuals, advice & problem resolution, receipts and costs
# OV-3

## Operational Exchange Information Matrix

<table>
<thead>
<tr>
<th>Information Description</th>
<th>Producer</th>
<th>Consumer</th>
<th>Nature of transaction</th>
<th>Performance attributes</th>
<th>Information assurance</th>
<th>Security</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAHSRA Design requirements, routes, ticket prices, bid winners</td>
<td>CAHSRA</td>
<td>Customers, contractors</td>
<td>Design requirements, answers to contractors questions sent to every contractor bidding on that part, information for advertising and ticketing areas and for external stakeholders such as CALTRANS and the DOT</td>
<td>Clear consistent requirements, rapid response to questions. Clear &amp; consistent information for the public. High quality service and safety for customers.</td>
<td>Adequate and cross functional review of requirements and information before issuing.</td>
<td>Outgoing public information and requirements should not need any special security. Design features having to do with security features and certain information for the DOT and CALTRANS may require encryption</td>
</tr>
<tr>
<td>Advertising Route maps, timetables, public information</td>
<td>Advertising &amp; information dept of CAHSRA</td>
<td>Customers</td>
<td>Public advertising and information, special events and information booths</td>
<td>Clear, timely &amp; consistent information for the public.</td>
<td>Adequate and cross functional review of requirements and information before issuing.</td>
<td>Outgoing public information should not need any special security</td>
</tr>
<tr>
<td>Ticketing Tickets with scannable confirmation numbers to prove authenticity.</td>
<td>Ticketing dept of CAHSRA</td>
<td>Customers</td>
<td>Sale of paper and electronic tickets</td>
<td>Timely scannable tickets</td>
<td>Review between ToC, ToJ and government verifiers on the factory floor</td>
<td>Ticket confirmation codes and billing information will require encryption. See TV-1 for pre-planned upgrade reviews.</td>
</tr>
<tr>
<td>CALTRANS, DOT Information and lessons learned on other public transportation efforts</td>
<td>CALTRANS, DOT</td>
<td>CAHSRA</td>
<td>open and encrypted emails, phone calls, faxes</td>
<td>Ridership, security and other lessons learned issues</td>
<td>Adequate and cross functional review of requirements and information before issuing. Encryption may be needed for many aspects, especially related to security issues.</td>
<td>Encryption requirements. See TV-1 for pre-planned upgrade reviews.</td>
</tr>
<tr>
<td>Contractors Questions about requirements, final bids for construction or delivery</td>
<td>Contractors</td>
<td>CAHSRA</td>
<td>open and encrypted emails, phone calls, faxes</td>
<td>Clear consistent descriptions, drawings, and rapid response to questions. Clear &amp; consistent information. High quality service and safety for CAHSRA.</td>
<td>Adequate and cross functional review of requirements and information before issuing. Encryption may be needed for many aspects, especially related to security issues.</td>
<td>Encryption requirements. See TV-1 for pre-planned upgrade reviews.</td>
</tr>
</tbody>
</table>
OV-4
Organizational Relationship Chart

1st tier

2nd tier

3rd tier

Customers

CHSRA  Ticketing  Advertising  TRAINS  STATIONS

CALTRANS  DOT (Federal)
OV-5
Operational Activity Model

Design & acquire HSR system

Spread knowledge and demand for HSR

Customers ride HSR

DOT (Federal)

CALTRANS

CHSRA

Advertising

Ticketing

CONTRACTORS

STATIONS

TRAINS

CHSRA outgoing funds: $

CHSRA incoming funds: $

Happy Customers Arrive at their destination
## TV-1
### Technical Standards Profile

<table>
<thead>
<tr>
<th>Service Area</th>
<th>Service</th>
<th>Standard</th>
<th>Responsible Departments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stations</td>
<td>Comfortable safe waiting areas. Food drinks and retail services. Cell phone Wi-Fi and Fax services. Ticketing options.</td>
<td>Crime levels at or below surrounding community. Adequate bandwidth available to prevent loss of transmission on busiest days.</td>
<td>CAHSRA for maintenance levels and contractors for design. Private, state or local security support likely such as Sherriff or CHP.</td>
</tr>
<tr>
<td>Trains</td>
<td>Comfortable safe seats. Food drinks and limited travel-related retail services. Cell phone W-Fi and Fax services.</td>
<td>Crime levels at or below surrounding community. Adequate bandwidth available to prevent loss of transmission on busiest days.</td>
<td>CAHSRA for maintenance levels and contractors for design. Private, state or local security support likely similar to &quot;Sky Marshalls&quot;.</td>
</tr>
<tr>
<td>CAHSRA website</td>
<td>HSR routes and timetables and prices. Link to ticketing. Information on linking to other modes of public transportation. Interesting facts about HSR.</td>
<td>Updated continuously as needed concerning any accidents or route closures or for maintenance or security concerns. There should be none &gt;98% of the time.</td>
<td>CAHSRA</td>
</tr>
<tr>
<td>Ticketing</td>
<td>Ticketing via on-site paper printout or on-line paper printout or smart phone app.</td>
<td>Payment services would use 265 bit encryption. Tickets would have a scannable verifiable confirmation number to prove authenticity.</td>
<td>CAHSRA</td>
</tr>
<tr>
<td>Dining cars</td>
<td>Food drinks and limited travel-related retail services. Cell phone W-Fi and Fax services.</td>
<td>A range of hot and cold food and drinks offered. Adequate bandwidth available to prevent loss of personal transmission services on busiest days.</td>
<td>CAHSRA</td>
</tr>
</tbody>
</table>
TV-2
Technical Standards Forecast

Possible future growth plans

• Explore options & needs every 6 months
  – Pre-planned periodic review of encryption systems for ticketing, bill payments and contractor bids and for communication systems upgrades for stations and trains such as cell phone and Wi-Fi traffic

• Re-visit system options after completion of initial system as funding allows
  – Link to Tijuana to capitalize on the international economic opportunities *L
  – Build an extension, XpressWest, to link the system from Palmdale to Las Vegas *M

• Explore options & needs every year
  – Explore upgrades to the locomotive system which is still evolving and improving
  – A study by the Stockholm Royal Institute of Technology showed that they could upgrade their 1994 system to newer tilting HSR locomotives after just ten years in operation (in 2004)
    • this would reduce their energy consumption by 29%
    • increase the average speed by 44%
    • reduce the travel time by 30% **Y
    • This was all due to faster acceleration times and to being able to safely take turns at higher speeds
SV-1
Systems Interface Description

*1 Open email
  Smart phone apps

*2 Open email
  Encrypted email
  Smart phone apps

*3 Rail line "Block"
  instant communication
  (encrypted)
SV-2
Services Resource flow description

ADVERTISING

INFORMATION &
CUSTOMER FEEDBACK

TICKETING

INFORMATION &
CUSTOMER FEEDBACK

CONTRACTORS

INFORMATION & BILLING

TRAINS

DESIGN REQUIREMENTS
& INFORMATION

STATIONS

*1 Comfortable & safe rides; food, drink, and retail services
*2 Comfortable & safe lobbies; food, drink, and retail services
*3 Comfortable & safe areas; food, drink, and retail services
## SV-3

### Systems-Systems Matrix

<table>
<thead>
<tr>
<th>Customers</th>
<th>DOT</th>
<th>Caltrans</th>
<th>CAHSR</th>
<th>Advertising</th>
<th>Ticketing</th>
<th>Trains (Drivers)</th>
<th>Outside contractors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>*1</td>
<td>*1</td>
<td>*1</td>
<td>be informed and energized by</td>
<td>Buy tickets from</td>
<td>*1</td>
<td>*1</td>
</tr>
<tr>
<td>DOT</td>
<td>*1</td>
<td>*1</td>
<td></td>
<td>Review of procedures, advice, resolution of issues</td>
<td>*1</td>
<td>*1</td>
<td>*1</td>
</tr>
<tr>
<td>Caltrans</td>
<td>*1</td>
<td>*1</td>
<td></td>
<td>Advise, coordinate, help resolve issues</td>
<td>*1</td>
<td>*1</td>
<td>*1</td>
</tr>
<tr>
<td>CAHSR</td>
<td>*1</td>
<td>*1</td>
<td></td>
<td>Advise, coordinate, help resolve issues</td>
<td>Provide schedules &amp; goals</td>
<td>Receive payments and ridership expectations, provide pricing</td>
<td>Provide schedules and updates, receive local condition updates</td>
</tr>
<tr>
<td>Advertising</td>
<td>Provide schedules and information, create interest, get feedback</td>
<td>*1</td>
<td>*1</td>
<td>Provide advertising for and give customer feedback</td>
<td>Creates demand &amp; provides information through CAHSR</td>
<td>*1</td>
<td>*1</td>
</tr>
<tr>
<td>Ticketing</td>
<td>Sell tickets, collect fees</td>
<td>*1</td>
<td>*1</td>
<td>Advise of sales, deposit payments, receive pricing rates</td>
<td>Provides ticketing feedback through CAHSR, receives demand</td>
<td>*1</td>
<td>*1</td>
</tr>
<tr>
<td>Trains (Drivers)</td>
<td>Transport them, verify proper ticketing</td>
<td>*1</td>
<td>*1</td>
<td>Advise of conditions</td>
<td>*1</td>
<td>*1</td>
<td>*1</td>
</tr>
<tr>
<td>Outside contractors, vendors</td>
<td>NA</td>
<td>*1</td>
<td>*1</td>
<td>Clarify issues, collect payments, pay fees</td>
<td>*1</td>
<td>*1</td>
<td>*1</td>
</tr>
</tbody>
</table>

*1 No direct contact normally, feedback possible if allowed
SV-5
Operational Activity to System Function Traceability Matrix

<table>
<thead>
<tr>
<th></th>
<th>Advertising</th>
<th>Ticketing</th>
<th>Train rides</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>I</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>DOT</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Caltrans</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>CAHSR</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Advertising</td>
<td>D</td>
<td>I</td>
<td>S</td>
</tr>
<tr>
<td>Ticketing</td>
<td>S</td>
<td>S</td>
<td>I</td>
</tr>
</tbody>
</table>

I = Capability Implements the System
S = Capability Supports the System
D = Capability Drives the System
SV-7
Systems Performance Parameters Matrix

Create and track a house of Quality for each major stakeholder
Have weekly updates and reviews of weighted results and make suggestions for improvements
Goal to keep all stakeholders above 90% satisfaction

House of Quality based on Customer view
- 20% Safety
- 20% Accessibility
- 20% Cost to ride
- 15% Reliability
- 10% Security
- 10% Comfort
- 5% Amenities

House of Quality based on tax-payer view
- 20% Cost of system
- 20% Payback rate due to profits
- 20% Minimum negative impact
- 15% Safety
- 15% Accessibility
- 10% Security

House of Quality based on CAHSRA view
- 20% System design meeting goals
- 20% Customers happy
- 20% Employees happy
- 15% Safety
- 15% Security
- 10% Payback rate due to profits
Identification of major risk areas and possible mitigation efforts

- **Safety issues, HSR specific answers**
  - The trains will be completely grade-separated, so there is no threat of interference with automobile and pedestrian traffic
  - The project also involves grade-separation for existing rail lines with which it will share rights-of-way along part of its length, further improving safety on these lines and eliminating traffic delays
  - Use appropriate minimum train spacing for projected train speeds
- **General good practices**
  - Hold design reviews with outside industry experts
  - Develop an independent Safety Review Team with the power to stop un-safe acts
  - Establish a Failure Review Board process with the intent of finding a positive resolution action for every concern
  - Consult with other earlier project leads and experts to gather a lessons learned database
  - Make efforts to retain your own knowledgeable staff and recruit some staff from previous endeavors
  - Develop checklists to ensure all actions completed correctly, during construction and operation
Identification of major risk areas and their possible mitigation efforts, cont.

- **Schedule delays**
  - Develop fluid timelines that depend on previous actions, not dates
    - Then take immediate advantage of any improvement to schedule
  - Establish good, clear lines of communication
    - Have daily standup meetings for shift handoffs
    - Have visual boards posted and web-sites showing status, next actions and contact points

![Train Station Image](image-url)
Identification of major risk areas and their possible mitigation efforts, cont.

- **Cost over-runs**
  - Hire experienced project managers and provide further training as needed
  - Follow LEAN practices to maintain quality, prevent rework, reduce clutter, accidents, and mistakes
  - Express costs in final year values
  - Provide adequate review of parts and materials going into the project and proper training to use them
    - Prevent problems like the Big Dig’s incorrect use of tunnel roofing bonding material
    - Motorola made good use of requirements verification in their shortened final assembly of Iridium satellites with minimal mistakes
Identification of major risk areas and their possible mitigation efforts, cont.

Ridership concerns - Build it and they will come?

• An important aspect of the performance of public transportation systems is the actual ridership compared to forecasts
• Various studies have been conducted on toll roads & high-speed rail systems to refine the estimates
• One of the most widely cited is a 2003 Cambridge University report "Megaprojects and Risk" by Flyvbjerg, et al.
• This report found that a common element in projects that failed to reach forecast results was an optimistic assumption of a particular event that would lead to higher ridership, such as spiking fuel costs
Ridership concerns, cont.

- This and other lessons were considered in developing the ridership and revenue modeling for the system so there is no such reliance on singular and unsubstantiated factors
- Key inputs that are drivers of ridership, such as fuel prices, airline ticket prices, and the population, are all conservative and based on external sources
- The Risk Analysis portion of the revised plan shows that gas prices would have to drop to $2.60 per gallon before CHSRA would dip below its breakeven point

The Los Angeles and San Francisco metropolitan areas have hundreds of daily flights and more than 5 million passengers annually
  - This is larger than the New York-to-Washington, D.C. market so CHSRA should have ridership & profits better than the Acela line has
Identification of major ethical issues and mitigation efforts

- Noise issues and noise mitigation efforts
  - International freeway and metro line noise mitigation have given California pretty good, standard, if somewhat expensive response to the noise problem
  - HSR, while noisier than conventional trains or cars, are quieter than diesel trucks or airplanes

![Image of noise levels comparison]

**HOW DOES THE SOUND FROM HIGH-SPEED TRAINS MEASURE UP?**

| Sound Source                  | Maximum Level (dB)
|------------------------------|--------------------
| Automobile 70 mph at 50 ft   | 84                 |
| Commuter Train 79 mph at 100 ft | 82             |
| High-Speed Train 120 mph at 100 ft | 96             |
| Diesel Truck (red吼red) at 60 ft | 95             |
| Power Lawn Mower at 3 ft     | 80                 |
| Commuter Train with Horns at 100 ft | 85             |
| Chain saw at 3 ft            | 85                 |
| Jet aircraft at 500 ft        | 120                |
Identification of major ethical issues and mitigation efforts, cont.

Land acquisition concerns and mitigation efforts

• Central Valley opposition due to “Harassment of land owners” *V
  – Demonstrate that actions are being taken to minimize land usage
    • Demonstrate that HSR compares favorably to new freeways or airports
  – Demonstrate that prices being paid are fair for the market through transparency
    • compare commercial market prices per acre to offered prices per acre
  – Use meetings, town councils & advertising to educate the public on the issues
  – Highlight the improvements that greater freedom of movement, improved business and transportation options and reduced costs should have for surrounding businesses and homes
  – Highlight that improved passenger service will also benefit freight lines by freeing up existing tracks, increasing freight services and lowering freight prices as was seen in France and China

• Create special pricing programs for stores to move into the new train stations so that they can phase in the rents as the ridership levels phase in and customer levels increase
  – Avoid the Chinese problem of crowded stations devoid of stores due to prohibitively expensive rents that store owners can’t afford to initially pay
Cost vs. Value

A new HSR system is expensive but there are paybacks

- TGV generated a profit of $1.75B in 2007 *A
- Within the first month of operation, the Rhin-Rhone line carried more than 1,000,000 passengers
- HSR stations can link with existing airport and commuter stations making them more efficient
- Train terminals can themselves become focal points for commercial redevelopment and promote substantial new development in the area as was seen in Washington D.C. and Kalamazoo
- It’s estimated that:
  - A single railroad track with occasional sidings can carry as many people as a ten-lane freeway at less cost and in less space *Q
  - Having a HSR station in a city center is the equivalent to building a new medium-sized airport without ripping out hundreds of acres of buildings to make it
- Trains have amenities not seen on buses or planes
  - Wider seats, fax machines, places to plug in your laptop or cell phone, hot food or cold drinks on demand, there are no electronic blackouts during take-offs and landings, and there is more freedom to get up and walk around safely
US population will grow from 300 million to 400 million over the next 35 years *C
California, already the most populous state, will have its population grow 39% by 2060, from 38 million to 53 million *F
Current highway and transportation systems already operating at capacity for much of the day
Driving population is growing even faster than general population
Construction of major new Highways has virtually ceased
Clogged roads cost Americans $121B in 2011 *E
The Cost of Inaction, cont.

- Los Angeles and San Francisco are the 2nd and 3rd worst congested cities in America
- Congestion actually peaked in 2005 and then improved due to the economic downturn – as the economy recovers congestion will quickly return
- Our biggest cities are also our biggest wealth creators
  - We shouldn’t let them stagnate
- The interstate highway system promotes sprawling
  - Outsources a major costs (fuel, vehicle purchase and maintenance, insurance) to the consumer
  - HSR encourages a return to city centers and reduces sprawl
  - HSR pools more people together and thus further reduces total costs & impacts
- CHSRA projects that the system will "alleviate the need to spend more than $100 billion to build 3,000 miles of new freeway, five new airport runways, and 90 departure gates” *N
Adding HSR to our transportation mix is the most logical, next best step to take.

Distance vs. Efficiency

Approximate efficiency vs. Distance based on expected ridership choices for the distance to travel (author’s estimates).
Review summary and recommendations

- The addition of high-speed rail service between California’s major city’s would be the best new addition to California’s transportation networks and a good boost to overall state business and economy.
- Further delays will only accrue further costs and make the final solution more costly.
- From the governments viewpoint this is an advantageous time to build the system:
  - Unemployment rates within California are still relatively high at 9.8%, above the national average, which should make it easy to attract needed employees.
  - Interest rates are still near record lows, making the state issued bonds to fund the project cheap.
- Let’s learn the lessons from the past and proceed into the future!
List of sources

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* G High Speed Rail, Wikipedia, as of Jan 23, 2013
* H “Amtrak Sets New Ridership Record, Thanks Passengers For Taking The Train“, Amtrak, October 11, 2012
* J “Vision for High-speed rail in America”, Federal Railroad Administration, February 5, 2010
* K China’s operating high-speed railway exceeds 7,000 km“, xinhuanet.com, November 27, 2012
* M "California Corridor”, Federal Railroad Administration, U.S. Department of Transportation,
* N "December 2009 Business Plan Report to the Legislature", California High-Speed Rail Authority, December 14, 2009
* O California High-Speed Rail Awarded $715 Million”, California High-Speed Rail Authority, October 28, 2010
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* T “California High-Speed Rail Program Revised 2012 Business Plan”, April 2012
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* W “High-speed rail efforts gain momentum across the country”, NBCnews.com/travel, 10/25/2012
* X “High-speed rail in Poland”, Wikipedia article citing "Super pociągi zamiast autostrad", TVN24, December 23, 2009
* Z “GAO gives California High-speed rail high marks in audit”, CHSRA website, 3/29/2013