

# Alternatives Analysis Report:

California High-Speed Rail vs. Hyperloop



# AGENDA

- **Briefing of Alternatives**
- Alternatives Comparison
- Recommendations

(Image: I-5 Grapevine corridor in Winter 2013)



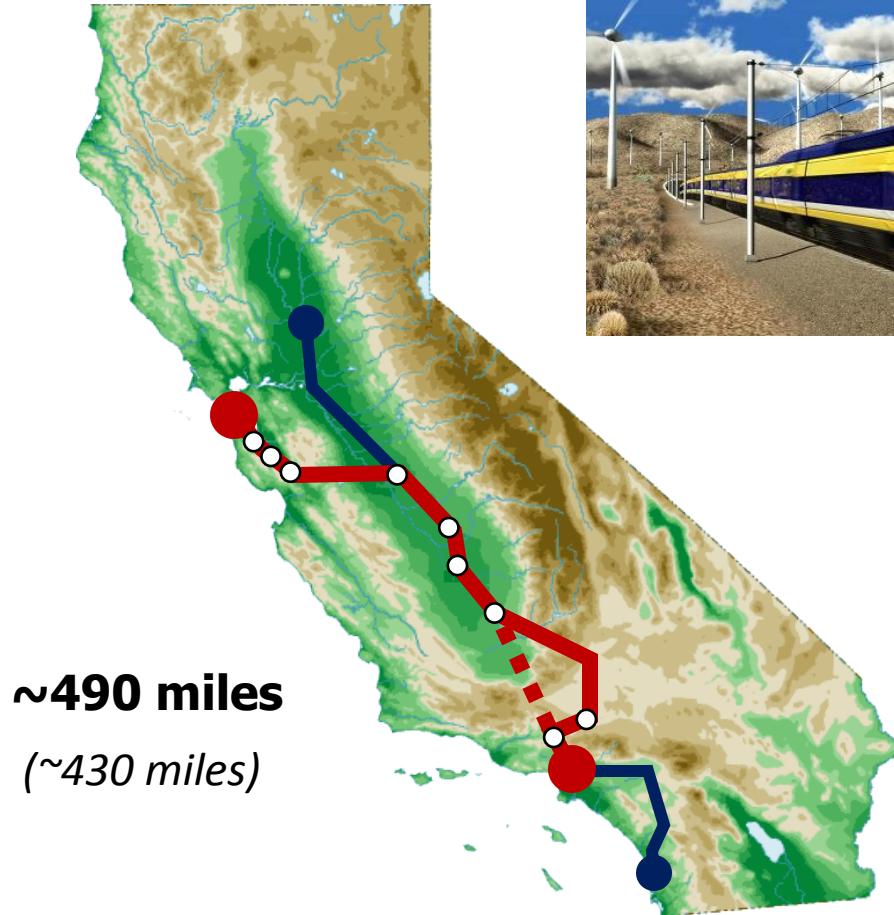
# High-Speed Rail Alternative



- 2008 – Proposition 1A (voters)
  - Provided \$9.95 billion to HSR project
  - Los Angeles to San Francisco in 2h40m
  - Must serve Bakersfield & Fresno
  - Estimated \$45 billion
- California High-Speed Rail Authority
  - 2014 Business Plan: \$67.6 billion in future dollars for Phase I
  - ~\$7.3b funding, state & federal

Image source: CHSRA

# High-Speed Rail Alternative

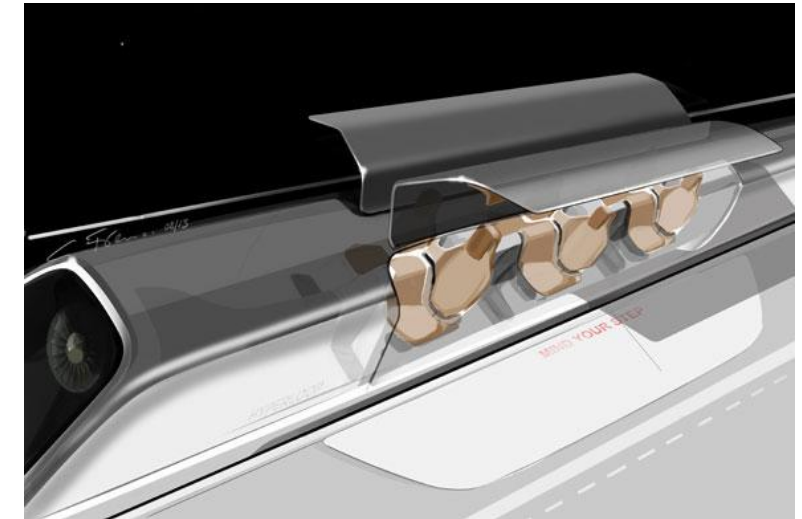


- 2029 – Phase I
- 20?? – Phase II
- 36 miles of tunnels
- Top speed = 220 mph
  - Spain, France, Japan
  - U.S.: 150 mph
- Min. av. speed = 184 mph
  - No international comparison
  - U.S.: 80 mph

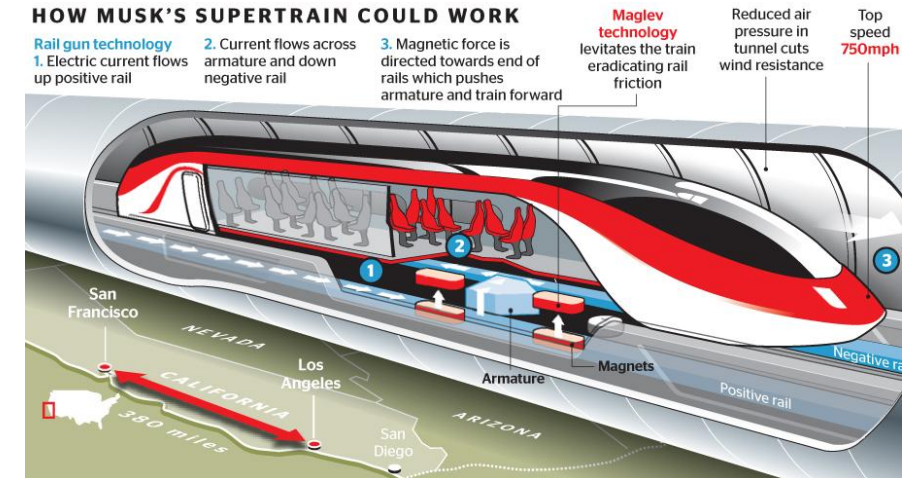
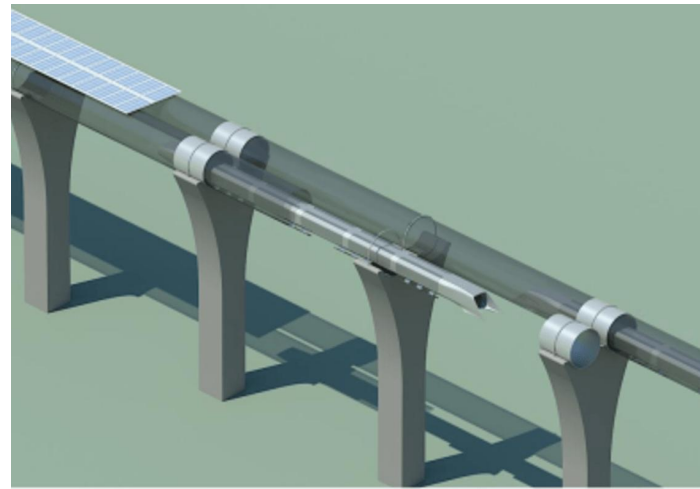
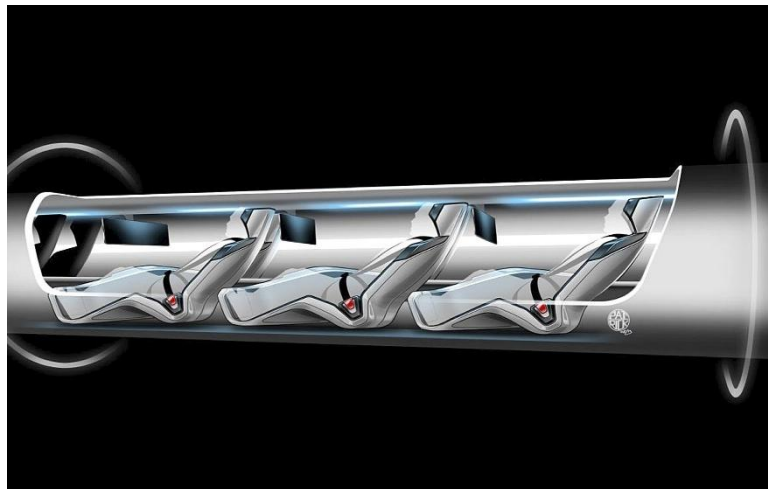
# High-Speed Rail Alternative

- 29 miles (Madera-Fresno) currently under construction
- 82 more miles (Fresno-Bakersfield) ready for construction contracts by February
- Environmental & Engineering in process for all other segments

Image source: LA Streetsblog



## August 2013 - Elon Musk & Tesla Motors: "Hyperloop Alpha"

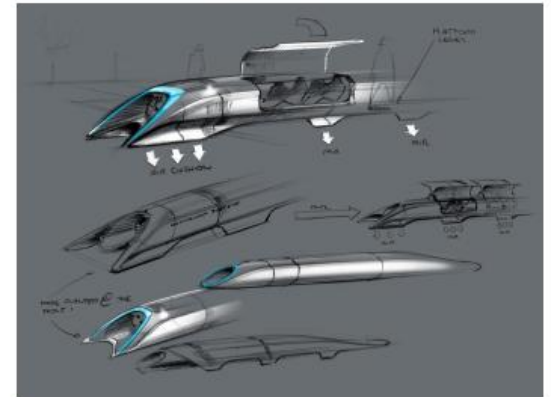


# Hyperloop Alternative

- 10 ft diameter tube
- Internal air pressure: 0.015 psi  $\sim\sim$  1/1000<sup>th</sup> Earth's atmosphere
- "Pods" riding on air cushions
- Turbine mounted on front



## Hyperloop Alpha



## Intro

The first several pages will attempt to describe the design in everyday language, keeping numbers to a minimum and avoiding formulas and jargon. I apologize in advance for my loose use of language and imperfect analogies.

The second section is for those with a technical background. There are no doubt errors of various kinds and superior optimizations for elements of the system. Feedback would be most welcome - please send to [hyperloop@spacex.com](mailto:hyperloop@spacex.com) or [hyperloop@teslamotors.com](mailto:hyperloop@teslamotors.com). I would like to thank my excellent compadres at both companies for their help in putting this together.

## Background

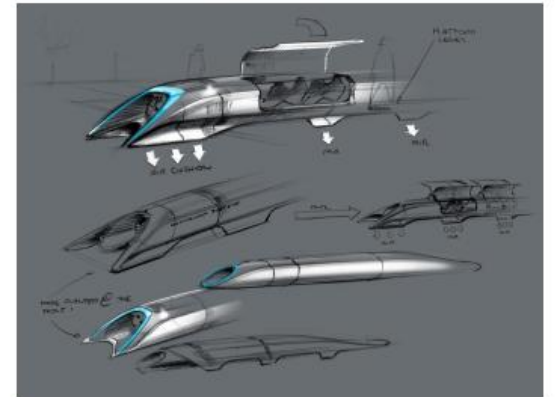
When the California "high speed" rail was approved, I was quite disappointed, as I know many others were too. How could it be that the home of Silicon Valley and JPL - doing incredible things like indexing all the world's knowledge and putting rovers on Mars - would build a bullet train that is both one of the most expensive per mile and one of the slowest in the world? Note, I am

# Hyperloop Alternative

- Top: 760 MPH
- Av: 600 MPH
- Los Angeles – San Francisco: 35 min
- **\$6 billion (???)**



Hyperloop Alpha



## Intro

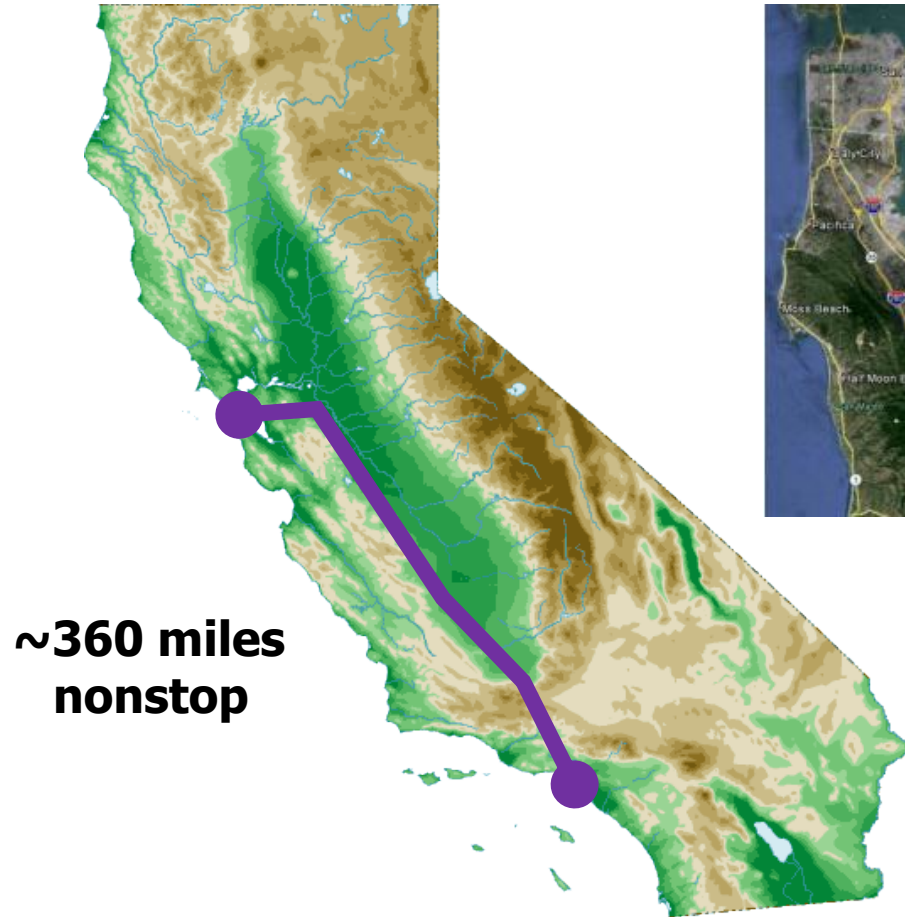
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# Hyperloop Alternative



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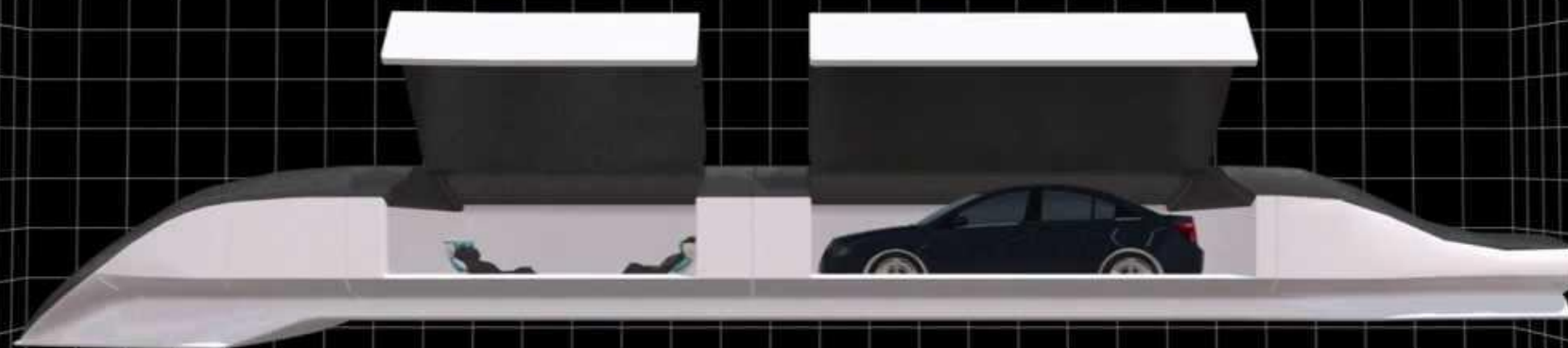
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(Image: I-5 Grapevine corridor in Winter 2013)





\$6 billion



\$10 billion

# True Cost of the Hyperloop

## COSTS IN BILLIONS (2013 \$)

Expense	Hyperloop (Claimed)	Cal High-Speed Rail Phase I	My Assumptions	Hyperloop (True Minimum Cost)
Civil	\$0	\$3.170	x 1/3	\$1.057
Structures	\$3.150	\$19.292	x (15.2 miles of tunnels/ 36 miles of tunnels) + pylons	\$10.696
Track	\$0.650	\$1.967	Equal	\$1.967
Stations, Terminals, Intermodal	\$0.400	\$3.273	Elon Musk's estimate	\$0.400
Support Facilities: yards, shops, buildings	\$0.210	\$0.779	x 1/3	\$0.260
Sitework, ROW, land	\$1.000	\$12.301	x 1/3	\$4.100
Communications & Signaling	\$0	\$0.879	x 1/3	\$0.293
Electric Traction	\$0.140	\$2.879	Equal	\$2.879
Vehicles	\$0.054	\$3.276	Elon Musk's estimate	\$0.054
Professional Services	\$0	\$5.251	Equal	\$5.251
Unallocated contingency (5%)	\$0.536	\$1.825	Same percentage (5%)	\$1.348
<b>Total (in 2013 \$)</b>	<b>\$6.000</b>	<b>\$54.894</b>		<b>\$28.305</b>
<b>Total (in Year of Expenditure \$)</b>	<b>??</b>	<b>\$67.6</b>	Same percentage (123%)	<b>\$34.8 ??</b>

# Cost-Effectiveness Comparison

Alternative	Minimum Cost (2013 \$)	Estimated Annual Ridership	Lifespan	\$ Spent per Rider
<b>Cal High-Speed Rail Phase I</b>	\$54.9 bil	24 million (medium estimate)	50 years	<b>\$45.8/rider</b>
<b>Hyperloop</b>	\$28.3 bil	7.4 million	50 years	<b>\$76.5/rider</b>

- HSR Alternative has higher seating capacity
- HSR Alternative connects more California communities
- Only HSR Alternative can benefit from Prop 1A funds

# What the Hyperloop Offers/What It Doesn't

- ✓ Operational speed
- ✓ Smaller total cost
- ✓ Technological prowess
- ✓ Private sector appeal

When a solution really called for:

- ❑ Accessibility & connectivity
- ❑ Cost-effectiveness (cost per rider)
- ❑ Interoperability with regional passenger & freight networks
- ❑ Service incrementability



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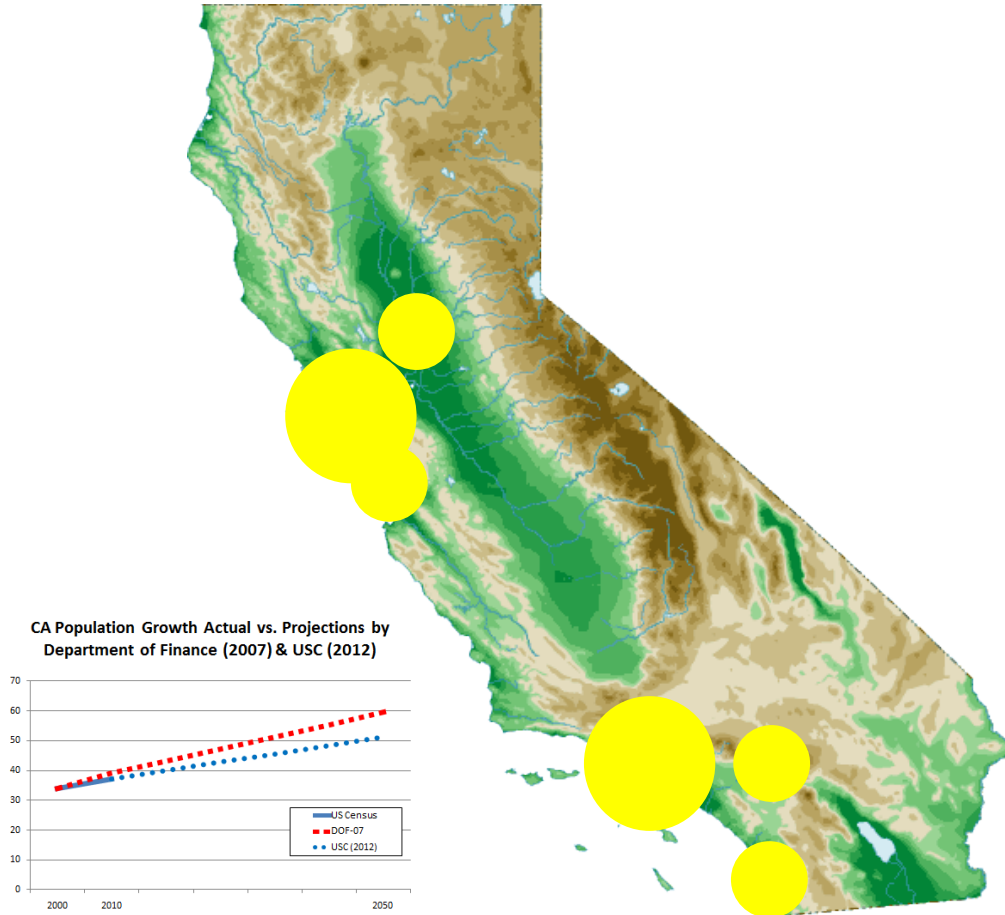
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# Recommendations: Future Conditions

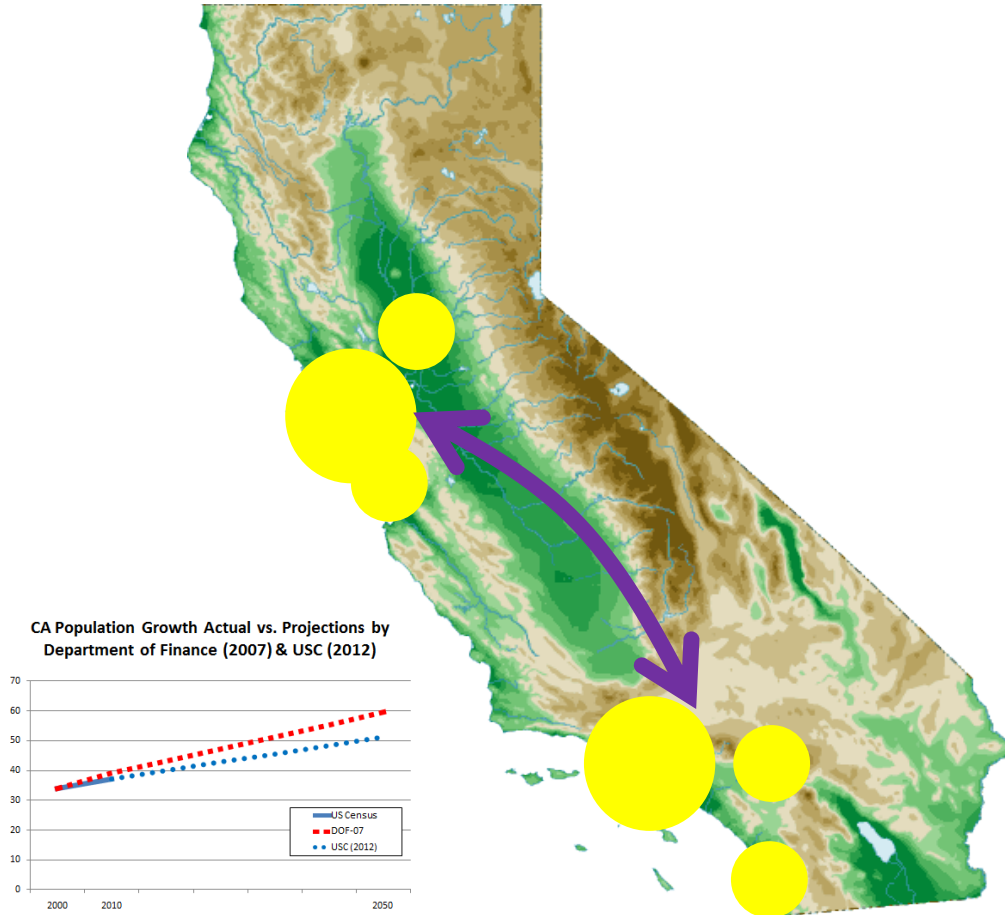
- Infrastructural needs: imminent capacity shortage
  - 2011 - California Transportation Commission:  
\$183 billion by 2020
  - American Society of Civil Engineers:  
\$365 billion *more than currently budgeted*
- Population growth: 39 -> 50 -> 60 mil



# Recommendations: Future Conditions

## What We Need to Assume

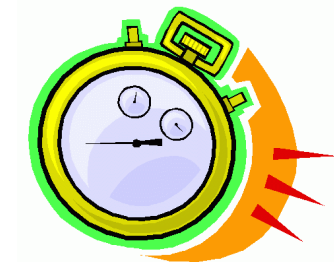
- A multi-billion-dollar mobility solution is necessary.
- Total \$\$ cost is less important than capacity/\$ spent.



# Recommendations: Priorities

## What Needs to Be Prioritized

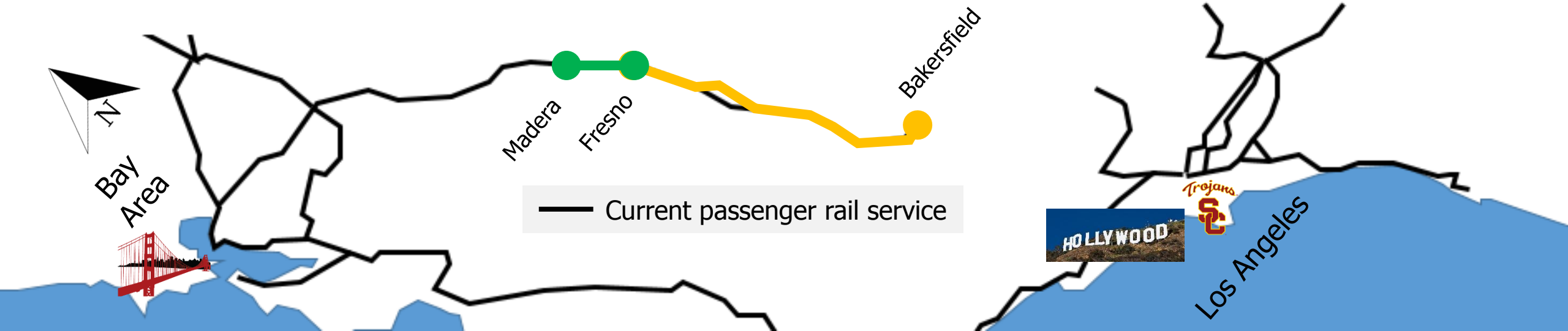
- Thinking about sunk costs
  - ~\$7 billion already apportioned to Cal HSR
- Thinking about connectivity
  - From regional network to regional network
  - From regional network to local network
- Thinking about feasibility
  - Only Cal HSR can benefit from current funding sources
  - Hyperloop technology still ~10 years away



# Recommendations

- (1) Fast-track expenditure of funds already tied to specific segments
  - ✓ Construction Package 1 (Tutor-Perini/Zachry/Parsons)
  - Award Construction Packages 2-5
  - Draw principally from federal + state funds *that expire in 2017*.

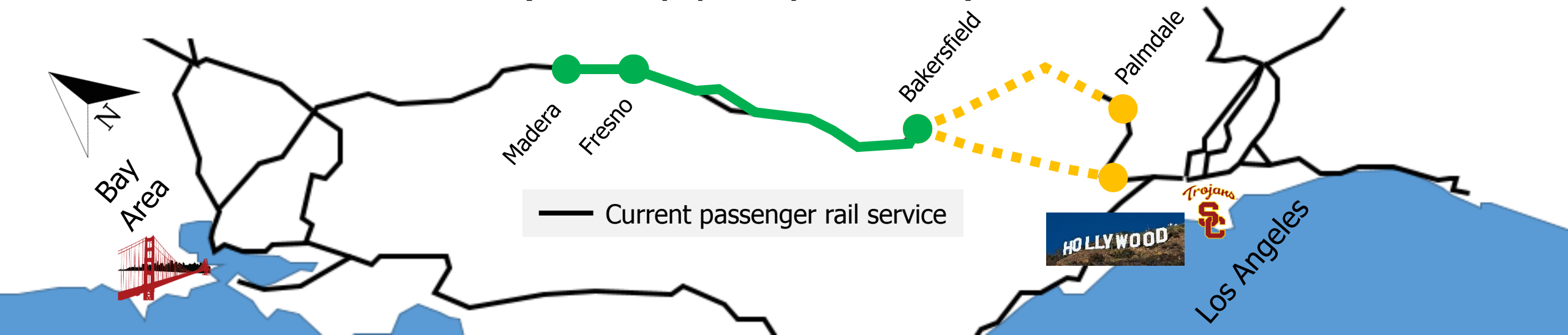
Cost: \$0 (funding already available)



# Recommendations

- (2) Use funds not tied to specific segments to prioritize closure of major gaps in rail system
  - Reopen evaluation of Tejon Pass route (60 miles shorter)
  - Prioritize completion of Draft EIR, Final EIR, and construction contracts
  - Design for immediate operation

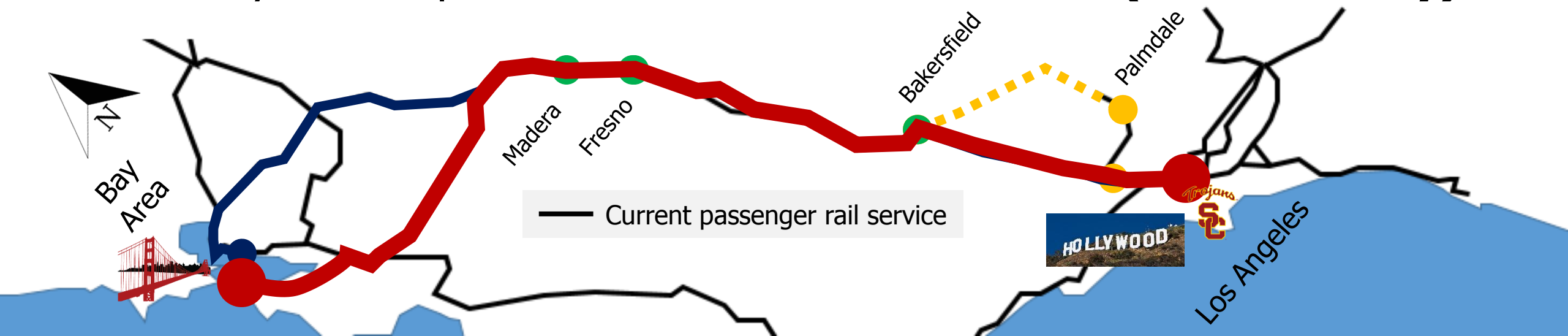
Cost: \$8.4-9.4 billion (already partly funded)



# Recommendations

- (3) Coordinate with regional rail providers (Amtrak/Metrolink) to provide regular-speed passenger rail service *as soon as possible*
  - Establish <7-hour one-seat rail service between Los Angeles and Oakland
  - Reduce trip duration to <3hrs in long term with incremental improvements
  - Stream into long-term Cal HSR Business Plan to satisfy funding req.s

Cost: anywhere up to 41.2 billion over 2+ decades (**discretionary**)





CONCEPT RENDERING  
Grapevine Grade Railway Tunnel - Grapevine, California  
**CALIFORNIA HIGH SPEED**  
**GROUND TRANSPORTATION CORRIDOR**

c. 2003 J. Craig Thorpe,  
Commissioned by Cooper Consulting Co., Kirkland, WA, for the  
Schiller Institute, Los Angeles, CA