

Caltrain Viaduct for Palo Alto:

Summary
Concept
Design and Approach
Costs and Future Savings
Timeframe
Benefits
Notes and References

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2018, 2021, 2023, 2024, 2025



Palo Alto Online, June 14, 2023



Palo Alto architect Joe Bellomo's vision for high-speed rail
<http://www.paloaltoonline.com/news/2009/11/27/architect-calls-for-design-contest-for-high-speed-rail>

Palo Alto Grade Separations – Preface:

Will the cost of grade separations make sense?

Grade separations of any configuration make sense only if a combination of enough of the following apply:

- **CA HSR actually connects from points south to San Jose (an unanswered question).**
- **CA HSR ridership from SJ to SF supports 4 HSR trains per hour both ways.**
 - **It is likely that many perhaps most of CA HSR riders will embark and disembark in SJ from or to destinations around SJ, the East Bay, or along the peninsula using Caltrain – NOT all the way from and to SF.**
- **Caltrain ridership continues to be high enough to support Caltrain itself, without CA HSR.**
 - **Still a question - hence the upcoming ballot measure to support Bay Area transit.**
 - **Shared robotaxis for commuters in the very near future will tend to further reduce Caltrain ridership (as well as VTA, SamTrans, and others).**
- **Over \$200M in future savings for cross-town bike/ped routes adds sufficient justification for a viaduct approach.**
- **Safety considerations (autos on tracks, suicides) are deemed important enough.**

Viaduct Grade Separations – Recommendations

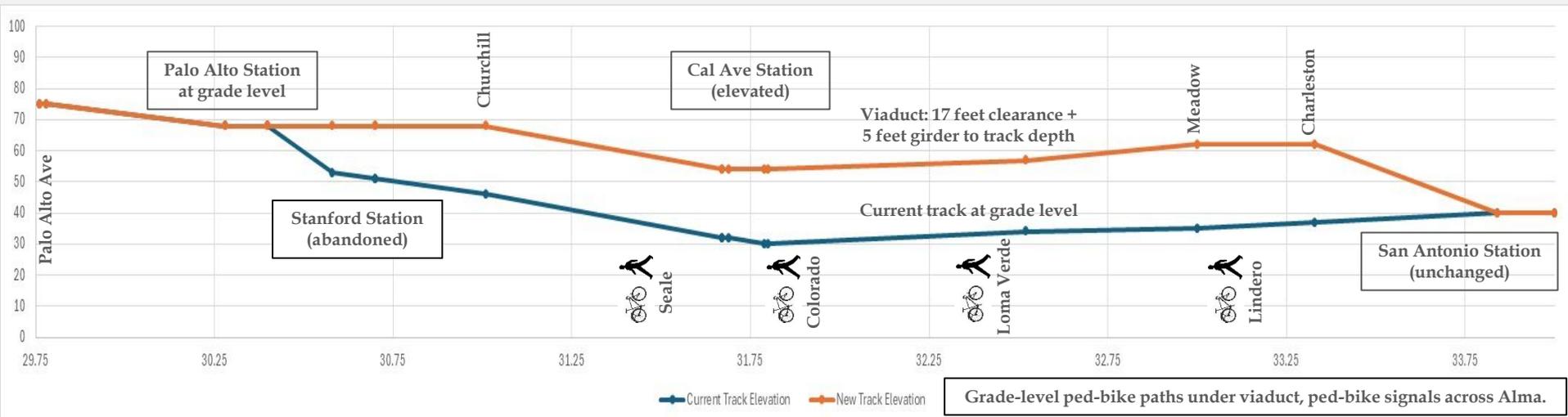
- **Immediately stop further investment of City funds in the next step designs of the currently-selected alternatives.**
- **Determine when sufficient motivations combine to justify restarting such investment.**
 - **Based on the criteria in the Preface in this report.**
- **When restarting such investment is deemed to be justified ...**
 - **Only invest in planning the viaduct approach.**
 - **This report confirms that the viaduct approach using Accelerated Bridge Construction techniques is the far better than other approaches.**

Viaduct Grade Separations – Summary:

Comparable or lower cost, shorter timeframe, less risk, and others

- **The viaduct approach has costs that are comparable to or much lower than the other alternatives.**
- **Cost avoidance from not lowering roadways at all.**
 - Cost for acquisition of private properties for expanded road footprint.
 - Cost to lower the roadways and reconfigure nearby roadways and intersections
 - Cost of changing utilities under the roadways.
 - Cost of pumps to handle sea level rise and groundwater for lowered roadways.
 - Cost of a permanent maintenance and flooding risk issue
- **Risk avoidance due with simpler viaduct approach.**
 - Simplicity reduces risks of surprises, cost and schedule overruns of complex approaches.
- **Reduces assembly timeframe and periods of disruption during construction.**
 - Most or all construction contained with existing Caltrain right-of-way.
- **Avoids personal costs for families of affected homes.**
 - Loss of part or all of a property, driveway length and access, and street parking.
- **Avoids likely legal quagmire.**
 - Avoids likely lawsuits by homeowners over eminent domain.
- **Enables major cost reduction for future cross-town bike-ped underpasses.**

Viaduct Grade Separations: Conceptual Design Avoids Many Issues



Churchill / Meadow / Charleston Avenues roadways unchanged avoids:

- * Private property acquisition
- * Ped/bike tunnel residential parking impacts
- * Odd, complex, convoluted underpasses
- * Traffic congestion from new traffic patterns
- * Under-street utilities impacts
- * Future sea level rise, flood impacts

Viaduct enables new cross-town connections and other options:

- Bike/ped underpasses beneath viaduct with low-cost paving approaches and pedestrian signals across Alma.
- Citywide greenspace, bike/ped path, or other uses under and adjacent to the viaduct.

Viaduct grade separations construction approach: Separate freight line from viaduct Remove eastside tracks, construct viaduct

- **Westside tracks: keep as a permanent grade-level track bed**
 - Keep in place or move slightly westward where necessary, with quad gates.
 - Short-term:
 - Perhaps support the viaduct construction
 - Perhaps support Caltrain alternative operation during construction
 - Long-term:
 - Infrequent freight trains and Caltrain maintenance
 - Avoids adding freight weight requirements to viaduct strength
- **Eastside tracks: remove, replace with two-track viaduct**
 - Remove eastside catenaries and tracks.
 - Construct the dual-track viaduct, catenaries, and elevated Cal Ave station on the eastside close to Alma.
 - Include privacy screens and/or trees on one or both sides in residential sections to shield yards from Caltrain riders.



H St, Union City: Freight rail line and BART

Viaduct grade separations construction approach: Accelerated bridge construction Support Caltrain ridership during construction

- **Viaduct construction approach**
 - Prefabricated piers and spans assembled within Caltrain right-of-way.
 - 3.64 miles / 19,200 feet; 100-foot spans; 192 spans, 191 piers.
 - Likely reduction of Alma to 1 lane each way during construction period, to enable prefab parts delivery and cranes operations in 2 westside lanes.
 - Construction during weekday nights and weekend days.
 - Multiple teams on different segments to minimize overall construction time.
 - Install the Churchill/Meadow/Charleston Caltrain overpass spans over a single weekend each, minimizing cross-town traffic disruption.
- **Transit alternative operations during construction - options:**
 - Caltrain uses westside tracks for single tracking
 - Caltrain uses westside tracks one direction in the morning and the opposite direction in the afternoon,
 - Paired with bus or shared robotaxis for the opposite direction.
 - Bus and shared robotaxis bridges both directions

Viaduct costs

Forest to San Antonio - viaduct to PA Univ Ave station			
Item	Per Mile		Total
	\$M	Miles	\$M
Move 1 track west	3.00	3.64	10.92
Viaduct	180.00	3.64	655.20
Elevated Cal Ave station	46.00		46.00
Upgraded PA station	15.00		15.00
Total			727.12
Future 4 connections at \$1M each			4.00
Total with 4 connections			731.12

- Move 1 set of tracks west; allow room for viaduct near Alma, freight traffic (\$3M/mile)
- Construct viaduct (\$180M/mile)
- Construct elevated Cal Ave station (\$46M, based on comparable projects)
- Upgrade Palo Alto station – extend platforms to 800 feet for CA HSR (\$15M)
- 4 new crosstown bike-ped connections: Seale, Colorado, Loma Verde, Lindero (\$1M each)

Viaduct costs in range or lower to much lower than alternatives

	Combinations >	A	B	C	D	Viaduct
Plans						
	Meadow/Charleston	Hybrids	Hybrids	Underpasses	Underpasses	
	Churchill	Closure, Bike-Ped Underpass	Parial Underpass	Closure, Bike-Ped Underpass	Partial Underpass	
Costs		\$M	\$M	\$M	\$M	\$M
	Meadow/Charleston	477	477	844	844	
	Churchill	115	318	115	318	
	Totals	592	795	959	1,162	727
Future Costs: new crosstown connections at \$62M each						\$1M each
	3 or 4 connections	187	187	248	248	4
Overall Costs including new crosstown connections						
		779	982	1,207	1,410	731
Notes						
	All costs in 2026 dollars.					
	All costs are based on midpoints of sources in Notes and References.					
	Meadow/Charleston Hybrids enable Lindero grade-level crossing, so \$62 x 3 + 1.					

Viaduct enables future cost savings:

Multiple crossing points under viaduct with minimal expense:

Only westside paving to approach Alma and pedestrian beacons at Alma

Base map: Google Earth Project Annotations: Mike Forster



■ New crossing underneath Caltrain viaduct

■ Existing crossing

- **Over \$200M cost savings:**
 - 4 crossings at \$61M savings per crossing
- Constructed under viaduct and with pedestrian beacons for crossing Alma
- \$1M cost per grade-level crossing (\$350K paving, \$750K beacon)
 - Versus \$62M cost per tunnel under Caltrain (latest Menlo Park Willow/Middle project),

Viaduct assembly timeframe

On-site assembly schedule		1	7	14	21	28	35	42	49	56	82
Mike Forster 3/6/26											
53 days (+ Cal Ave station)											
Prefabrication (offsite, starts earlier)	< earlier										
Existing tracks											
Move west, remove east; 21 days											
On-Site Assembly											
Pier footings and caps; 32 days											
Spans; 32 days											
New tracks on spans; 8 days											
New/reused catenaries; 10 days											
Testing: 10 days											
Cal Ave elevated station: 60 days											...
Disruptions											
Caltrain alternative operations; 53 days											
Churh/Mead/Charl - 1 day each											
Alma 2 lanes: piers, spans; 36 days											
Calendar											
June-August; less traffic, no rain											

For parameters, see page:

Notes and References: Assembly Parameters and Durations

Viaduct Grade Separations – Best Solution Matrix

Viaduct is the Best Solution

Combinations Mead/Charl, Churchill	Combination A: Hybrids, Closure	Combination B: Hybrids, Underpass	Combination C: Underpasses, Closure	Combination D: Underpasses, Underpass	Viaduct
Simplicity to avoid risk to cost, construction timeframe	Moderately complex, medium risk	Moderately complex, medium risk	Very complex, high risk	Very complex, high Risk	Simple, low risk
Maintain, Improve All Modes East/West Connectivity	Mixed Results	Mixed Results	Mixed Results	Mixed Results	Maintains
Maintain or Improve Traffic Patterns	Mixed Results	Mixed Results	Inconvenient traffic patterns	Inconvenient traffic patterns	Maintains
Bike-Ped Circulation: Clear, Safe, Separate from Autos	Improves	Improves	Improves	Improves	Improves
Minimizes Caltrain operation disruption	No disruption, shoofly tracks	No disruption, shoofly tracks	No disruption, construction below	No disruption, construction below	Very short-term disruption
Reduce Rail Noise and Vibration (Study, July 2020)	Best	Best	Significant (with barrier)	Significant (with barrier)	Significant
Construction Noise and Vibration (Study, July 2020)	Severe	Severe	Severe	Severe	Moderate
Timeframe of Construction	4 years, 2 years	4 years, 2.5 years	4 years, 2 years	4 years, 2.5 years	2 months (plus Cal Ave station)
Minimize Visual Changes	Significant	Significant	None	None	Significant
Minimize Property Acquisition	No property acquisitions	Some property acquisitions	Significant property acquisitions	Significant property acquisitions	No property acquisitions
Minimize impacts on driveway access, parking, street safety	Driveways affected	Loss of street parking	TBD	Loss of street parking	No impacts
Minimize Disruption and Duration of Construction	Major disruptions	Major disruptions	Major disruptions	Major disruptions	Minimal disruptions (Alma moderate)
Avoid Sea Level, Groundwater Issues (Study, January 2024)	Need pump, long-term maintenance, risk of flooding	No risk			
Avoid utilities relocation	Utilities relocation required	Utilities relocation required	Utilities relocation required	Utilities relocation required	No relocation required
Minimize Trees Removal or Trimming	TBD	TBD	TBD	TBD	TBD
Grade Separations Cost	\$592M	\$795M	\$959M	\$1,162M	\$727M
Include 4 New Connections Cost	\$779M	\$982M	\$1,207M	\$1,410M	\$731m

See Notes and References for Noise and Vibration (2020), and water impacts (2024), studies.

Viaduct Grade Separations – Conclusion

- A viaduct is the best solution for Palo Alto
 - As shown by this report
- Construction and disruption timeframes for the non-viaduct approaches could be much longer than 2 and 4 years
 - And these might be additive:
 - We could not close any 2 of the 3 crossings concurrently: Crosstown traffic would come to a halt
- If this report's budget and timeframe are a little optimistic and would be increased ... the viaduct option will still:
 - Have comparable or lower cost
 - A shorter assembly timeframe
 - Less risk for cost and schedule than the other complicated approaches
 - Enable future savings on east-to-west crossings
 - Satisfy all of the qualitative criteria:
 - Much less disruption
 - No property acquisitions
 - No impacts on parking or driveways
 - Better traffic patterns
 - Avoids long-term water mitigation maintenance (including pumps)
 - Avoids utilities relocations

Viaduct Grade Separations – Notes and References: Costs

- Palo Alto Churchill Closure with Mitigations: \$115M midpoint, \$104M to \$126M, tracks at grade level, Churchill vehicle traffic closed / bike-ped underpass and upgrades at Embarcadero and Page Mill, night and weekend traffic limitations, 2 years
 - https://www.paloalto.gov/files/assets/public/v/1/transportation/rail/connecting-palo-alto/fact-sheet/churchill-closure_factsheet_pa_june_7_2024.pdf
- Palo Alto Churchill Partial Underpass: \$318M midpoint, \$285M to \$351M, tracks at grade level, Churchill/Alma vehicle/bike/ped traffic access limited, loss of street parking, property acquisitions, 2.5 to 3 years
 - https://www.paloalto.gov/files/assets/public/v/1/transportation/rail/connecting-palo-alto/fact-sheet/churchill-partial-underpass_factsheet_pa_june-3_2024.pdf
- Palo Alto Meadow-Charleston Hybrids: \$477M midpoint, \$428M to \$526M, tracks raised 15 feet, Meadow-Charleston traffic access limited, no property acquisitions but driveways affected, 4 years
 - https://www.paloalto.gov/files/assets/public/v/1/transportation/rail/connecting-palo-alto/fact-sheet/meadow-charleston-hybrid_factsheet_pa_june-6_2024.pdf
- Palo Alto Meadow-Charleston Underpasses: \$844M midpoint, \$756M to \$932M, tracks at grade level, Meadow-Charleston traffic closed/Alma traffic limited during construction, property acquisitions, 4 years
 - https://www.paloalto.gov/files/assets/public/v/1/transportation/rail/connecting-palo-alto/fact-sheet/meadow-charleston-underpass_factsheet_pa_june-3_2024.pdf
- All share these characteristics: pump station/long term maintenance and risk of flooding, utilities relocation, construction 2 to 4 years; 2026 dollars.
- Viaduct: cost per mile for CA HSR: \$180M, 2026 dollars; \$9.8B / 113 miles, \$90M midpoint estimate, 2011 dollars
 - https://hsr.ca.gov/wp-content/uploads/2025/06/BPlan_2012CostChanges09_12.pdf page 10
- Viaduct: cost per station for heavy rail transit (HRT): \$45.9M (adjusted 2026 dollars; 6 HRT projects)
 - <https://projectdelivery.enotrans.org/fta-capital-costs-database/>
- Grade-level east track moved/new cost per mile: \$3.0M, 2026 dollars; \$2.6M for new HSR single track; + for catenaries, - for reuse.
 - <https://www.scribd.com/document/428116190/2017-RailRoadEngineering>
- Underpass costs, Menlo Park / Middle Avenue: \$62M
 - <https://nationaltoday.com/us/ca/menlo-park/news/2026/02/04/menlo-park-struggles-to-fund-costly-rail-crossing-project/>
- Underpass costs, Palo Alto / Homer Avenue: \$13.6M (\$5.2M 2005, 2.6 inflation 2026 February); likely no longer allowed by Caltrain
 - <https://www.paloaltoonline.com/news/2005/05/05/homer-tunnel-officially-opens>

Viaduct Grade Separations – Notes and References: Timeframe parameters

- Viaduct span lengths: 100 feet applied here (98 to 145 feet in practice); 19,200 feet means 192 spans, 191 piers
 - https://www.pci.org/PCI_Docs/Publications/PCI%20Journal/2014/Spring/Full-span%20precasting%20for%20light-rail%20transit%20and%20high-speed%20railway%20bridges.pdf
- Viaduct spans installed per shift or day
 - 1 span per day: https://www.idc-online.com/technical_references/pdfs/civil_engineering/Longer_and_Longer_Concrete_Viaducts_for_Transportation_Growing_Needs.pdf
 - 2 spans per day https://www.pci.org/PCI_Docs/Publications/PCI%20Journal/2014/Spring/Full-span%20precasting%20for%20light-rail%20transit%20and%20high-speed%20railway%20bridges.pdf
- Drilled piers: 2 piers per day for piers greater than 60 inches in diameter
 - <https://connect.ncdot.gov/resources/Structures/StructureResources/NCDOT%20Working%20Days%20Guidelines%20for%20Structure%20Construction,%2001-05-2016.pdf>
- New track per day: 0.5 miles per day (8-hour shift)
 - “replace 10,000 ties or several thousand feet of rail in a concentrated work window (often 48 hours)” (Google AI response)
 - 3250 ties per mile, for 10,000 ties (above), 3 miles over 48 hours, 1.5 miles per 24 hours
 - <https://www.trainorders.com/discussion/read.php?1,774445>
- Catenary renewal: 0.4 miles per day; up to 150 miles (250km) per year / 365.
 - <https://uic.org/com/enews/article/at-uic-the-world-s-rail-platform-french-innovation-in-catenary-renewal-for-the>

Viaduct grade separations - Notes and References: Assembly Parameters and Durations

Item	Action	Parameters	Days
Existing tracks	Move/replace west, remove east	3.7 miles	21
On-Site Assembly		19,200 feet; 100-foot spans; 192 spans, 191 piers	
	Pier footings and caps	191; 3 teams, 2 per day	32
	Spans	192; 3 teams, 2 per day	32
	New tracks on spans	3.7 miles; 0.5 miles/day	8
	New/reused catenaries	3.7 miles; 0.4 miles/day	10
	Testing	inspection, trial runs	10
	Cal Ave elevated station	after nearby spans done	60
Disruptions			
	Caltrain alternative operations	single track or bus bridge	53
	Churchill/Meadow/Charleston	1 weekend day each	3
	Alma 2 lanes: piers, spans	2 lanes used for cranes	36

Viaduct Grade Separations – Notes and References: General Information

General Configuration Parameters

- CA HSR platform length: 800 feet
 - <https://www.railjournal.com/passenger/high-speed/shorter-platforms-for-california-high-speed-rail/>
- Clearance above roadways: 17 feet (16.6 feet) for California
 - <https://dot.ca.gov/-/media/dot-media/programs/traffic-operations/documents/hov/hov-guidelines-2020-a11y.pdf>
- Inflation calculator, non-residential construction: 4.7% average per year; 2.6 factor 2005 to 2026
 - <https://edzarenski.com/category/inflation-indexing/>
- Pedestrian crossing candidate locations in Palo Alto
 - https://www.cityofpaloalto.org/files/assets/public/v/1/transportation/projects/southern-palo-alto-bikeped-railroad-crossings/spa-ped-bike-connectivity_existing-conditions-report_final.pdf
- Pedestrian hybrid beacon costs (Caltrans): \$300K to \$1.5M; used \$750K plus \$350 for paving and other costs
 - <https://dot.ca.gov/-/media/dot-media/programs/safety-programs/documents/policy/202505-tsb-25-01-phb-guidelines-a11y.pdf>
- Rail height above clearance: 5 feet (4 to 5.5 feet)
 - <https://meadhunt.com/designing-steel-plate-girder-bridges/>

Best Solution Matrix References

- Criteria based on Appendix E, City Council Staff Report, Meeting Date 9/5/17. Expanded criteria and evaluations by Mike Forster.
- Vibration/Noise Study, July 2020: <https://connectingpaloalto.com/wp-content/uploads/2020/08/Noise-Vibration-Comparative-Analysis-Report.pdf> Page 24
- Sea Level Rise Study, January 2024: <https://connectingpaloalto.com/wp-content/uploads/2024/03/Attachment-C-Sea-Level-Rise-Assessment-1.pdf>

Viaduct Grade Separations

Notes and References: Peninsula Examples

- **Burlingame: Chose a viaduct approach: fully elevates tracks, does not lower roads**

- <https://burlingame.org/DocumentCenter/View/2932/Presentation-Slides---Virtual-Community-Meeting-July-13-2022-PDF>
- <https://www.caltrain.com/media/33194/download>

Broadway
(proposed)



Cadillac Way underpass (proposed)
Similar to future
Palo Alto Bike-Ped crossings

- **San Bruno: Viaduct-like - as built:**

- Minimal road lowering at San Bruno Ave
- Minimal or no road lowering at San Mateo Ave
- Little or no impact on nearby properties

San Bruno
Avenue



San Mateo Ave

- **Redwood City: Favoring a viaduct approach, plan 1A, north of Highway 84**

- [Caltrain grade separation plans take shape in Redwood City | Local News | smdailyjournal.com](https://www.smdailyjournal.com/news/caltrain-grade-separation-plans-take-shape-in-redwood-city-1.1000000)

The End: Visually Attractive Examples of Viaduct Grade Separations

- Elevated tracks do not have to be berms that might divide cities.

(Images from Google Earth / Streetview)



Montessoro, Italy



Paris, France - Bercy



Sunnyside, NY



Paris, France - Blvd. St. Jacques



Berlin, Germany - SPUR 2017



Union City, CA - Kennedy Park - BART