



City of Palo Alto

City Council Staff Report

(ID # 9993)

Report Type: Action Items

Meeting Date: 1/22/2019

Summary Title: Project Update and Possible Action on Rail Grade Separation Alternatives

Title: Discussion and Project Update on Connecting Palo Alto and Consideration of the Following Actions: A) Separate From Study all Alternatives for the Palo Alto Avenue Crossing (Closure and Hybrid) and Include Palo Alto Avenue in a Separate Comprehensive Planning Effort; B) Separate From Study the Bicycle and Pedestrian Crossing of the Caltrain Corridor in the Vicinity of Loma Verde Avenue and Assess Feasibility in a Future Study; C) Address the Rail Committee's Recommendation Regarding a Tunnel by Modifying the Alternative to be South of Oregon Expressway Only and Further Explore the Scope and Budget for an Alternative With Freight Trains on the Surface and Passenger Trains Underground for the Meadow and Charleston Crossings; and D) Adopt a Modified List of Grade Separation Alternatives (Continued From December 17, 2018)

From: City Manager

Lead Department: City Manager

Recommendation

Staff recommends that Council receive a project update on Connecting Palo Alto and consider the following actions:

- a) Separate from study all alternatives for the Palo Alto Avenue crossing (closure and hybrid) and include Palo Alto Avenue in a separate comprehensive planning effort;
- b) Separate from study the bicycle and pedestrian crossing of the Caltrain corridor in the vicinity of Loma Verde Avenue and assess feasibility in a future study;
- c) Address the Rail Committee's recommendation regarding a tunnel by modifying the alternative to be south of Oregon Expressway only and further explore [the Scope and Budget] for an alternative with freight trains on the surface and passenger trains underground [for the Meadow and Charleston crossings].

d) Adopt a Modified List of Grade Separation Alternatives:

- SOUTH PALO ALTO | Rail Tunnel
- CHURCHILL AVE. | Full or Partial Closure & Add Improvements (CAX)
- MEADOW DR. & CHARLESTON RD. | Hybrid (MCL)
- MEADOW DR. & CHARLESTON RD. | Rail Trench (MCT)
- MEADOW DR. & CHARLESTON RD. | Viaduct (MCV)

Executive Summary

This report and recommendation (with the exceptions noted below), was provided to Council and the public at the December 17, 2018 Council meeting. At the December 17, 2018 Council meeting public comments were heard on this item, and Council discussion and action were continued. Additional public comments and recommendations for Council consideration are being taken up at the January 22, 2019 Council meeting.

Two revisions have been made to the December 17th recommendation:

- Recommendation c) has been revised from “south of California Avenue” to “south of Oregon Expressway.” This recognizes the short distance between the two streets and avoids necessarily requiring reconstruction of the Oregon Expressway undercrossing.
- The reference to “Trench or Tunnel” for alternative MCT has been reduced to “Trench” only. This clarifies the distinction between this alternative and the new South Palo Alto Rail Tunnel alternative.

Connecting Palo Alto, the City’s rail corridor grade separation planning effort, is approaching the goal of selecting a preferred solution by February 2019. The current stage of the process focuses on narrowing the remaining grade separation alternatives based on Rail Committee recommendations, Community Advisory Panel (CAP) suggestions, public feedback, technical design development, and ultimately City Council direction.

For the City’s four at-grade crossings, the City Council voted and gave staff direction at the May 29, 2018 City Council meeting to narrow the alternatives down to ten grade separation alternatives. The ten alternatives were further narrowed to eight at the June 19, 2018 City Council meeting, due to the elimination and modification of alternatives at Churchill Avenue. At the January 22, 2019 meeting, the City Council has an opportunity to further narrow the list of remaining alternatives before the February City Council meeting which, based on the current schedule, is the target meeting for selecting a preferred solution. The current alternatives still in consideration based on the City Council direction in June 2018 are listed here. In addition to these alternatives, at the November 27th Rail Committee meeting, the Committee recommended that staff and the consultant further explore [the scope and budget for] an alternative with freight trains on the surface and passenger trains underground. Members of the public advocated for this additional alternative with the intention for it to be specific to the Meadow and Charleston crossings as opposed to citywide though that specificity was not provided in the Rail Committee’s recommended motion.

Rail Alternatives Still in Consideration as of June 19, 2018 Council Action:

- a. **WBP** CITYWIDE | **Deep-Bore Rail Tunnel**
City-wide deep-bore railroad under roadway tunnel within Palo Alto city limits with two new underground rail stations;
- b. **PAH** PALO ALTO AVE. | **Hybrid**
Continue proposed Menlo Park railroad over roadway hybrid and/or viaduct across San Francisquito Creek and Palo Alto Avenue;
- c. **PCX** PALO ALTO AVE. | **Full Closure**
Palo Alto Avenue Crossing Closed; improvement options include: build an Everett Avenue bike/pedestrian undercrossing and widen University Avenue;
- d. **CAX** CHURCHILL AVE. | **Full or Partial Closure & Add Improvements**
Study additional options for addressing traffic in the Embarcadero Road underpass area including actions to minimize redirected traffic onto residential streets in adjacent neighborhoods and commit to adopting appropriate mitigations to address the impacts;
- c. **MCL** MEADOW DR. & CHARLESTON RD. | **Hybrid**
Meadow Drive and Charleston Road railroad over roadway hybrid and build Loma Verde Avenue bike/pedestrian crossing to connect to Margarita Avenue bicycle boulevard;
- d. **MCT** MEADOW DR. & CHARLESTON RD. | **Rail Trench or Tunnel**
Meadow Drive and Charleston Road roadway over railroad trench or tunnel Alma street would not be within trench or tunnel (maintains Alma Street connections to Meadow Drive and Charleston Road) with Alma Street in its existing alignment or a new alignment;
- e. **MCV** MEADOW DR. & CHARLESTON RD. | **Viaduct**
Meadow Drive and Charleston Road railroad over roadway viaduct.
- f. **MCR** MEADOW DR. & CHARLESTON RD. | **Reverse Hybrid**
Meadow Drive & Charleston Road roadway over railroad reverse hybrid and build Loma Verde Avenue bike/pedestrian crossing to connect to Margarita Avenue bicycle boulevard. *On August 15, 2018 Rail Committee recommended merging this alternative with MCT.*

Since the June 19, 2018 City Council meeting, the Rail Committee and CAP discussed potential policy considerations for the Palo Alto Avenue crossing given its unique context near Downtown and the Transit Center, and potential land use coordination opportunities. Staff recommends that the City Council at the January 22, 2019 meeting consider putting the Palo Alto Ave grade crossing alternatives analysis on a separate but parallel planning track as part of a Downtown Coordinated Area Planning effort. If Council agrees, this would remove the PAH and PCX alternatives above from study.

In addition to the action related to the Palo Alto Avenue crossing, staff is also recommending that the City Council at the January 22, 2019 meeting consider removing from study the bicycle and pedestrian crossing of the Caltrain corridor in the vicinity of Loma Verde Avenue and assess feasibility in a future study. This study was included in the June 19, 2018 City Council motion for the Meadow Drive and

Charleston Road hybrid alternative (MCL). Due to the need to coordinate bicycle access with crosstown circulation, staff recommends that this be removed from study with the grade separation alternatives.

Further technical analysis, conceptual engineering, and interagency communication related to the Meadow Drive and Charleston Road alternatives illuminated key differences between the three options for these two crossings. In addition to the greatest construction cost and disruption, the trench option (MCT) has substantial engineering and regulatory challenges related to drainage, groundwater, and creek diversion. The viaduct (MCV) and hybrid (MCL) are expected to have relatively lower capital construction cost but would introduce visual changes along the affected areas of the corridor and potentially new noise impacts. A detailed comparison of the alternatives is presented in the Discussion section of this report.

Background and Project Update

The following is a summary of the eight grade separation design alternatives presently under consideration as part of *Connecting Palo Alto*, and direction received at two City Council meetings which informed the scope and extent of these alternatives. While Council has discussed grade separation at many past City Council meetings, this report highlights Council decisions which concern selection of the narrowed ten design alternatives and subsequent action to narrow the range of alternatives in pursuit of a preferred solution by early 2019. This section of the report will primarily summarize City Council action, key Rail Committee recommendations, CAP suggestions, and interagency feedback as it relates to the remaining alternatives. Full summaries and minutes of CAP and Rail Committee meetings are available via the project website: connectingpaloalto.org. **Attachment A** also contains a list of meetings held related to this project.

City Council Action on Grade Separation Alternatives

Initially narrowed by City Council: May 29, 2018

Revised by City Council: June 19, 2018

MAY 29, 2018 CITY COUNCIL MEETING – TEN ALTERNATIVES

City Council selected ten discrete grade separation alternatives for further study at the May 29, 2018 Council meeting, representing a significant milestone in the *Connecting Palo Alto* planning process. In project nomenclature, this decision constituted a transition from a vast constellation of design “ideas,” to ten design “alternatives.” Design “ideas” are general in nature and “alternatives” are more distinctly defined to allow for more detailed study and community discussion. This action initiated the current stage of the *Connecting Palo Alto* planning process, which involves continual refinement and narrowing of alternatives until a preferred solution is reached.

JUNE 19, 2018 CITY COUNCIL MEETING – CHURCHILL AVENUE

To date since the May 29, 2018 Council meeting, City Council met once to discuss and act upon rail design alternatives (on June 19, 2018). As a result of City Council direction received at this meeting, the Churchill Avenue Hybrid and Reverse Hybrid were removed from further consideration and the Churchill Avenue closure alternative was modified to remove the widening of the Embarcadero Road underpass from the description of the closure option. Instead, traffic impacts of the closure would be evaluated through a comprehensive traffic study. Finally, a “partial closure” alternative at Churchill Avenue was added as part of the closure option. Following City Council’s direction at this meeting,

the number of alternatives under study reduced from ten to eight and one alternative was modified. The outcome of this decision is reflected in the list of alternatives shown in the Executive Summary. .

Summer & Fall Developments

In the months following the June 19, 2018 Council meeting, several Rail Committee and CAP meetings centered on technical issues related to the Meadow Drive and Charleston Road crossings. Also discussed were the policy, planning, and coordination opportunities around the Palo Alto Avenue crossing and its relationship to Downtown and the Transit Center and land use issues. City staff and the consultant team conducted interagency meetings with Caltrain and the Santa Clara Valley Water District (SCVWD) to augment project design criteria and identify areas of risk or where deviation from standard practices would be necessary.

AUGUST 15, 2018 RAIL COMMITTEE – MEADOW DR & CHARLESTON RD. REVERSE HYBRID MERGER

As a result of the property impacts projected as part of the Churchill Avenue hybrid alternative, staff and the consultant team accelerated design development of the four alternatives at Meadow Drive and Charleston Road to ascertain the degree of potential property impacts. The design progression revealed two key findings for Meadow Drive and Charleston Road: no full property acquisition was required and few geometric differences existed between the reverse hybrid and full trench alternatives to warrant further study as separate alternatives.

Based on conceptual designs, permanent property impacts for the Meadow and Charleston hybrid consisted of modifications to existing driveways. The trench alternative was found to require minimal property acquisition above ground (Note: analysis conducted later in the fall revealed a need for underground easements for a structural anchor system to support the trench). The viaduct requires no property acquisition. The second outcome of this process revealed the design of the reverse hybrid (Alternative MCR) had few benefits as a discrete alternative relative to the full trench alternative (Alternative MCT). Accordingly, the Rail Committee recommended that variations in the vertical alignment of the rail trench be considered as part of Alternative MCT, the full trench alternative. Due to this recommendation, staff focused analysis effort on Alternative MCT and presented results to the CAP, Rail Committee, and at the November 28 Community Meeting.

OCTOBER 2018 – CALTRAIN & SANTA CLARA VALLEY WATER DISTRICT INTERAGENCY MEETINGS

During October, City staff and the AECOM consultant team met with counterparts at Caltrain and the Santa Clara Valley Water District (SCVWD) to discuss technical engineering issues related to the grade separation design alternatives.

Discussion topics included approval processes and criteria for designs with railroad grades steeper than one percent; maintenance responsibilities for grade separation structures during their lifespan; and drainage design criteria related to below-grade alternatives. Caltrain engineering indicated that grades steeper than one percent were permitted at the recently-completed San Bruno grade separation project, but that such exceptions are granted on a case-by-case basis. The City sent a letter to Caltrain seeking additional clarity on these matters and are awaiting a response. A copy of the letter is attached to this report as **Attachment B**.

One meeting and subsequent correspondence with SCVWD concentrated on issues related to the four locations where creeks cross the rail corridor within the city. Of concern were scenarios where below-

grade alternatives obstruct existing creek beds, necessitating an engineering method to divert creek outflow around the below-ground rail structures. Comments from SCVWD staff (**Attachment C**) regarding the design alternatives and their relationship to waterways are discussed in greater detail in following sections.

NOVEMBER 27, 2018 RAIL COMMITTEE – MODIFIED TUNNEL WITH FREIGHT ON SURFACE

At the November 27, 2018 Rail Committee meeting they recommended the City Council direct staff and the consultant team to further explore [the scope and budget for] an alternative with freight trains on the surface and passenger trains underground. Members of the public advocated for this additional alternative with the intention for it to be specific to the Meadow and Charleston crossings as opposed to citywide though that specificity was not provided in the Rail Committee’s recommended motion.

Based on very preliminary estimates, the technical analysis, 3-D rendering, conceptual schematics and costing for the tunnel alternative currently assumes that both the passenger and freight trains are in the deep bore tunnel for the citywide tunnel. To conduct the same level of study for a passenger train only in the tunnel and freight train on the surface for the Meadow and Charleston crossings, additional budget and time will be needed. Depending on the analysis scope, the increased costs to conduct the analysis is expected to be at least \$100,000. Beyond the cost and schedule needed, the AECOM consultants have indicated that the construction cost savings for a passenger only tunnel are unlikely to yield significant savings compared to a tunnel that includes freight. In addition, the land value capture of a tunnel is lost if freight remains on the surface, which is also something to consider. However, the issues raised could be evaluated by refocusing the current citywide tunnel to South Palo Alto only. If the City Council directs staff to proceed with the additional study, staff will return to the City Council with a budget change order request.

NOVEMBER 28, 2018 COMMUNITY MEETING – MEADOW DR. & CHARLESTON RD. FOCUS

A summary of the main feedback received at the community meeting will be provided at the City Council meeting. A meeting summary will also be available online on the connectingpaloalto project website.

Discussion and Key Findings

As noted above, the focus of staff and the consultant team centered on the three active grade separation alternatives at Meadow Drive and Charleston Road. The Citywide Rail Tunnel and Churchill Avenue alternatives are under development with results scheduled for distribution and feedback at the CAP, City Council, and public in early 2019. The following section highlights key aspects of the Meadow Drive and Charleston Road alternatives based on the City Council adopted screening criteria; recommendations regarding Palo Alto Avenue alternatives; and developing information around creeks, groundwater, and drainage.

Drainage, Creek Crossings, & Groundwater

Presently, conceptual designs for the two below-ground alternatives, the Citywide Deep-Bore Rail Tunnel (WBP) and the Meadow Drive and Charleston Road trench (MCT), obstruct existing creek corridors, are within areas of shallow groundwater, and would require extensive stormwater drainage systems. Groundwater and stormwater can be managed with pump systems, but the creek crossings are of greatest concern from an engineering feasibility, regulatory, and maintenance cost standpoint. Presently, staff is not recommending the below-grade options be removed from consideration as further engineering analysis is required and underway. However, staff wanted to share the following

preliminary findings as they will figure prominently in forthcoming feasibility evaluations.

Alternative WBP would obstruct Adobe Creek and Alternative MCT would obstruct Adobe and Barron Creeks. This occurs due to the physical geometry requirements and project limits defined in the alternative descriptions. Based on preliminary analysis, a pump system, known as a lift station, appears to be the only solution potentially capable of managing the water flow rates within the affected creeks, but further engineering feasibility of this pump system is necessary and is underway. Should an engineering solution be technically possible, the City would need to obtain approval from various state, regional, and federal agencies with regulatory authority and meet strict environmental regulations. The following are a summary of preliminary standards and criteria from the Santa Clara Valley Water District (SCVWD) for engineering solutions to the creek obstructions introduced by the below-ground alternatives:

- Provide the same conveyance capacity as existing conditions;
- Provide equivalent SCVWD maintenance requirements as the existing condition and not increase District maintenance costs;
- Be functional during all flow events with sediment and debris loading;
- Allow fish passage;
- Be designed to not increase the potential for flooding or adversely impact existing flooding conditions;
- Be permitted by various regulatory agencies, potentially including but not limited to: California State Department of Fish and Wildlife, San Francisco Bay Regional Water Quality Control Board, and the U.S. Army Corps of Engineers; and
- Waterways within or related to a FEMA floodplain must also be examined by the City's Floodplain administrator to demonstrate the project will not adversely affect the risk of flooding or follow the process to modify floodplain boundaries.

If all engineering and environmental criteria are satisfied, the pump and lift stations will require ongoing maintenance to ensure reliable operation during storms.

Meadow Drive & Charleston Road

Exclusive of the citywide tunnel, three grade separation options for the Meadow Drive and Charleston Road crossings have been analyzed and developed to a greater degree: MCT, MCL, and MCV. This approach was based on a CAP suggestion that it would be beneficial to center on Meadow Drive and Charleston Road at the November 28 Community Meeting, culminating with the citywide tunnel, Churchill Avenue, and Palo Alto Avenue at the next Community Meeting.

Development of the reverse hybrid alternative (MCR), and an ancillary feature of the hybrid alternative, the Loma Verde bicycle and pedestrian undercrossing, was not advanced. The former was not advanced based on Rail Committee recommendations and staff finding there were few practical differences between the reverse hybrid (MCR) and trench (MCT) as discrete alternatives. Staff is recommending City Council merge MCR with MCT due to the previous findings and Rail Committee recommendation.

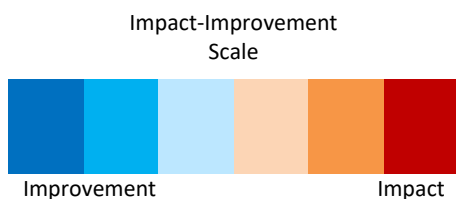
The general location of the Loma Verde bicycle and pedestrian undercrossing, which is presently included as part of the hybrid (Alternative MCL), was ultimately found to be outside the construction

limits for Alternative MCL and introduces design challenges which would benefit from analysis in a future study. This finding was based on a preliminary feasibility analysis of the crossing, conducted as part of the City’s 2016 *Midtown Connector Feasibility Study*. Challenges noted in the study include obtaining right-of-way to complete the connection on the west side of the rail corridor to Park Boulevard. On the east side of Alma, utility relocation would be necessary to construct the undercrossing tunnel portal. Accordingly, staff is recommending City Council remove the Loma Verde bicycle and pedestrian crossing from further study within *Connecting Palo Alto* and resume detailed analysis in a future effort.

For the remaining three alternatives, as described in the **Attachment D** engineering memos, the Council-adopted screening criteria are a critical tool for evaluating the differences between the three alternatives at Meadow Drive and Charleston Road. The consultant team, in collaboration with staff and the CAP worked to assign values on an “impact-improvement” scale for each criterion. Of the ten screening criteria, the discussion will focus on the six where key differences exist between the design options. Criteria A, B, C, and H will not be further discussed at this time since each option offers a similar degree of improvement toward meeting that goal. While the Council Criteria were initially broken down into Tier 1 and Tier 2 criteria, staff is working under the assumption that there is less need for the tiers and instead only the need to use one set of criteria to be more consistent with Council direction. The chart below is the matrix which applies the Council Criteria to the Meadow and Charleston alternatives.

Council Adopted Evaluation Criteria Applied to the Meadow and Charleston Alternatives:

Criteria		Trench (MCT)	Hybrid (MCL)	Viaduct (MCV)
A	Improve east-west connectivity	Blue	Blue	Blue
B	Reduce traffic congestion and delays	Blue	Blue	Blue
C	Provide clear, safe routes for pedestrians and bikes	Blue	Blue	Blue
D	Support continued rail operations	Orange	Light Blue	Light Blue
E	Finance with feasible funding sources	Red	Light Orange	Light Orange
F	Minimize right-of-way acquisition	Orange	Light Orange	Blue
G	Reduce rail noise and vibration	Light Orange	Light Orange	Light Orange
H	Maintain or improve local access	Blue	Blue	Blue
I	Minimize visual changes along the corridor	Orange	Light Orange	Light Orange
J	Minimize disruption and duration of construction	5 years	4 years	2 years
K	Order of magnitude cost	\$600M-\$800M*	\$200M-\$250M*	\$400M-\$450M*



**Total preliminary construction costs in 2018 dollars (subject to change)*

CRITERIA D | SUPPORT CONTINUED RAIL OPERATIONS

The viaduct was ranked with the highest color tile since it has the least impact to rail operations both during and after construction. During construction, both the hybrid and trench alternatives require temporary railroad detour tracks, known as a “shoofly,” whereas the viaduct can be constructed without the shoofly track. Following completion, the trench option will have greater maintenance costs due to the required pump systems for groundwater storm water, and at the Barron and Adobe Creek crossings.

CRITERIA E | FINANCE WITH FEASIBLE FUNDING SOURCES

Further financial analysis is underway. More detailed analysis will be presented in February. The current information is available on the connectingpaloalto website in the Community Meeting Presentation materials.

CRITERIA F | MINIMIZE RIGHT OF WAY ACQUISITION

Based on results from this stage of the design process, full property acquisition is not necessary for any of the three alternatives. The trench alternative requires the most property acquisition, but primarily in the form of underground easements to permit construction and protection of a permanent structural anchor system. These anchors would radiate horizontally away from the trench walls and function as structural support to the wall system. Building and landscaping would be restricted within the easements to protect the integrity of the anchor system. The extent of the easement is contingent on the number of anchors required based on soil conditions and the project team are presently conducting further analysis on this factor. A secondary potential property need for the trench is for the pump stations which are necessary at the creek crossings and at one or more locations along the trench to remove stormwater and groundwater.

The hybrid will require some modifications to existing driveways where the roadways approaching the undercrossing are lowered from their existing height to go beneath the railroad. The viaduct is currently shown to require no property acquisition.

CRITERIA G | REDUCE RAIL NOISE AND VIBRATION

All alternatives eliminate train horn noise and warning bells and have some degree of noise impact or improvement. In a trench, noise could reflect off walls and impact properties farther away, but noise levels adjacent to the rail corridor could be reduced. The viaduct and hybrid alternatives could elevate wheel noise levels. In all cases, mitigation is possible, but would require further analysis.

CRITERIA I | MINIMIZE VISUAL CHANGES ALONG THE CORRIDOR

The trench has train below grade with landscaping option limited to bushes or plants with shallow root systems; the hybrid has train approximately 15 feet above grade with feasible landscaping with trees for screening. **Attachment E** identifies how to access the visuals for each of these alternatives.

CRITERIA J | MINIMIZE DISRUPTION AND DURATION OF CONSTRUCTION

The trench has extended road closures at Meadow and Charleston during construction; hybrid has extended road reductions at Alma, Meadow, and Charleston during construction; viaduct has minimal road closures (weekend/ nights only).

Among the MCT, MCL, and MCV options each one has benefits and tradeoffs based on the screening criteria, but the trench appears to have the greatest degree of impact with the exception of noise and

potential visual changes. Furthermore, substantial engineering challenges around drainage, groundwater, and creek diversion.

Palo Alto Avenue

The Palo Alto Avenue crossing is characterized by its unique setting. Situated in the shadow of the El Palo Alto tree, adjacent to the historic rail bridge spanning San Francisquito Creek, and at the edge of Downtown and Downtown North, and the transit center, the crossing is worthy of its “Primary Gateway” designation in the *Comprehensive Plan 2030*. These characteristics, among other factors, are the primary reasons for staff recommending separating the Palo Alto Avenue crossing from the current *Connecting Palo Alto* analysis and completing separate parallel planning effort as part of a Downtown Coordinated Area Plan. See **Attachment F** for a defined problem statement and recommendation for Council.

The two alternatives under consideration for Palo Alto Avenue, the closure (PCX) and hybrid (PAH) would benefit from the holistic analysis of the coordinated area plan process, as recommended in the *Comprehensive Plan 2030*. Impacts of the closure option would benefit from a circulation analysis that accounts for potential land use changes and projects such as the pedestrianization of University Avenue, which is identified in the comprehensive plan as a vision to consider.

Modified Deep Bore Tunnel

The AECOM team had begun initial evaluations of the citywide deep bore tunnel concept before being redirected to prioritize the development of alternatives for Meadow Avenue and Charleston Road crossings. By that time, however, they had identified a number of key constraints, such as the cost and physical limitations of station impacts at the Caltrain Palo Alto (University Avenue) and California Avenue stations, the location and property impacts of bore pits in north and south Palo Alto, and property impacts for shoofly construction-period rail realignments.

As noted above, the Rail Committee directed staff to bring back information to further evaluate an alternative involving a south Palo Alto deep bore tunnel for passenger rail only with freight trains at surface level. This variation raises some of the same issues as a deep bore tunnel for both passenger and freight rail, while potentially avoiding station impacts. While recognizing significant issues with either concept, staff notes that City Council direction on January 22, 2019 to modify the deep bore tunnel to South Palo Alto only (south of California Avenue) would facilitate this evaluation.

All letters to Council about rail grade separation received between late September and early December 2018 are included with this report in **Attachment G**.

Policy Implications

Connecting Palo Alto is consistent with the following *Comprehensive Plan 2030* goals, policies, and programs:

Policy L-1.7: Use coordinated area plans to guide development, such as to create or enhance cohesive neighborhoods in areas of Palo Alto where significant change is foreseeable. Address both land use and transportation, define the desired character and urban design traits of the areas, identify opportunities for public open space, parks and recreational opportunities,

address connectivity to and compatibility with adjacent residential areas; and include broad community involvement in the planning process.

Program L4.8.1: Prepare a Coordinated Area Plan for Downtown.

Policy L-9.7 Strengthen the identity of important community-wide gateways, including the entrances to the City at Highway 101, El Camino Real and Middlefield Road; the Caltrain stations; entries to commercial districts; Embarcadero Road at El Camino Real and between Palo Alto and Stanford.

Program T1.11.1: Collaborate with Stanford University, VTA, Caltrain and other agencies to pursue improvements to the Palo Alto Transit Center area aimed at enhancing the pedestrian experience and improving circulation and access for all modes, including direct access to El Camino Real for transit vehicles.

Policy T-1.25: Pursue transportation funding opportunities for ongoing transportation improvements that will help mitigate the impacts of future development and protect residents' quality of life. When other sources are unavailable, continue to fund improvements, operations and maintenance through the general fund.

Policy T-1.26: Collaborate with adjacent communities to ensure that Palo Alto and its immediate neighbors receive their fair share of regional transportation funds, proportional to the need and demand for transportation improvements within these communities to address region-wide transportation issues.

Program T1.26.1: In collaboration with regional agencies and neighboring jurisdictions, identify and pursue funding for rail corridor improvements and grade separation.

Policy T-3.15: Pursue grade separation of rail crossings along the rail corridor as a City priority.

Program T3.15.1: Undertake studies and outreach necessary to advance grade separation of Caltrain to become a "shovel ready" project and strongly advocate for adequate State, regional and federal funding for design and construction of railroad grade separations.

Program T3.15.2: Conduct a study to evaluate the implications of grade separation on bicycle and pedestrian circulation.

Policy T-3.18: Improve safety and minimize adverse noise, vibrations and visual impacts of operations in the Caltrain rail corridor on adjoining districts, public facilities, schools and neighborhoods with or without the addition of High-Speed Rail.

Resource Impact

Funding for grade separation alternatives evaluation is included in the Fiscal Year 2019 Adopted Capital Budget in CIP PL-17001, Railroad Grade Separation.

Environmental Review

The proposed action is part of a planning study for a possible future action, which has not been

approved, adopted, or funded and is therefore exempt from the California Environmental Quality Act (CEQA) in accordance with CEQA Guidelines Section 15262. The future decision to approve construction of any one of the identified potential alternatives would be subject to CEQA and require preparation of an environmental analysis.

Attachments:

- Attachment A-List of Meetings Held
- Attachment B-Palo Alto Letter to Peninsula Corridor Joint Powers Board (Caltrain)
- Attachment C-Water District Letter to Palo Alto
- Attachment D-AECOM Meadow and Charleston Alternatives Memos
- Attachment E-Project Plans
- Attachment F-Palo Alto Ave University Problem Statement 121018
- Attachment G- Letters to Council Regarding Rail Grade Separation- Sept-Dec. 2018

Attachment A: Summary of Key Meetings Held Related to Grade Separation Project

List of Engagement Meetings: In addition to all of the meetings mentioned in the staff report, the following meetings have occurred related to Palo Alto's Rail Grade Separation:

Community Meetings

- August 23, 2018 – focused on getting feedback on progress to date.
- November 28, 2018 – focused on the Meadow and Charleston alternatives with 3D visuals of each; early conversation about traffic study and financing options.
- Upcoming: January 23, 2019 – will focus on Palo Alto Ave., Churchill Ave., and the citywide Tunnel alternatives with 3D visuals and follow up traffic and financing information.

Rail Committee Meetings

- April 18, 2018
- June 13, 2018
- August 15, 2018
- September 26, 2018
- October 17, 2018
- November 14, 2018
- November 27, 2018

Community Advisory Panel (CAP) Meetings

- August 15, 2018
- September 17, 2018
- October 10, 2018
- November 7, 2018
- December 12, 2018
- Upcoming: January 9, 2019

Technical Advisory Committee (TAC) Meetings

- November 5, 2018
- December 10, 2018

Stakeholder Meetings

- Santa Clara Valley Water District
- Caltrain
- Safe Routes to School (community partners and City staff)

Upcoming City Council Meetings

- December 17, 2018
- February 2019

Screening Criteria & CAP review

- CAP input to focus each community meeting by location

October 25, 2018

Jeannie Bruins, Chair
Peninsula Corridor Joint Powers Board
1250 San Carlos Ave
San Carlos, California 94070-1306

Dear Ms. Bruins,

The City of Palo Alto and members of our community are actively working to identify a preferred solution for our four existing at-grade rail crossings. While we are making progress there are several recurring technical questions that we need answered by Caltrain for the City to be able to evaluate the feasibility of alternatives under consideration. This letter requests your assistance in responding to these time sensitive and highly critical questions.

The questions are generally: what are the economic, engineering, and regulatory constraints that impact our grade separation options? Please clarify current constraints, and how and where Caltrain might be flexible with design criteria exceptions? Specifically, the questions City staff, community and consulting team have are as follows:

1. Under what conditions would Caltrain accept a grade variance from 1% to 2%, and what would the approval process be?
2. Under what conditions would Caltrain accept a variance to the existing vertical clearance for poles and wires, and what would the approval process be?
3. How are grade separation design criteria and constraints likely to change in the future?
4. What should the City of Palo Alto assume regarding freight on the Caltrain right of way in the future?
5. What is Caltrain's criteria regarding Shooflies that are likely needed for several grade separation under consideration (e.g. trench for East Meadow Ave and Charleston Road alternative)
6. What level of funding support needed to grade separate because of the PCEP can or could be expected from Caltrain?
7. The cost of maintenance for grade separation alternatives may vary greatly, what should the City of Palo Alto assume regarding who will pay for the cost of maintenance?

P.O. Box 10250
Palo Alto, CA 94303
650.329.2477
650.328.3631 fax

The City of Palo Alto appreciates your attention to these questions so that we can effectively and efficiently proceed with our community focused effort to define a preferred solution for our four at grade crossings.

Thank you,

A handwritten signature in blue ink, appearing to read 'Cory Wolbach', written in a cursive style.

Cory Wolbach
Chair, Rail Committee

On behalf of Mayor Liz Kniss

cc: Caltrain Board of Directors
Palo Alto City Council



File: 33812
Various

November 5, 2018

Mr. Jarrett Mullen, Senior Transportation Planner
Office of Transportation
City of Palo Alto
250 Hamilton Avenue, 5th Floor
Palo Alto, CA 94301

Subject: Palo Alto Grade Separation Study—Technical and Regulatory Factors for Waterways

Dear Mr. Mullen:

Santa Clara Valley Water District (District) has reviewed the four conceptual design alternatives for the subject project, presented at our October 12, 2018 meeting. The alternatives are varying vertical alignment options along the existing Caltrain corridor, within the City of Palo, to replace existing at-grade road crossings with grade separated crossings. The Caltrain corridor crosses San Francisquito Creek, Matadero Creek, Barron Creek and Adobe Creek. The District has easement rights over Matadero, Barron, and Adobe Creek across the Caltrain corridor, and any modification to those creeks will require the District's approval and issuance of a Water Resources Protection Ordinance encroachment permit. Although the District has no right of way over San Francisquito Creek at the Caltrain bridge, the District has an interest in ensuring that flood conveyance and stream stability is maintained. The District has the following comments on the four design options presented:

Option 1: Citywide Tunnel

1a. San Francisquito Creek— This creek is not shown on the plans for this option, and the crossing is assumed to be at-grade, similar to the existing bridge crossing. If the new crossing does not constrict the channel and has a soffit elevation equal or higher to the existing bridge soffit, then the District does not anticipate that significant hydraulic impacts will need to be addressed.

1b. Matadero Creek and Barron Creek—The top of the tunnel would be at least 15 feet below the invert of either creek; therefore, there should be no impacts to flood capacity. Impacts to the creek during construction and any groundwater impacts should be studied.

1c. Adobe Creek—The Caltrain crossing is proposed to be in a trench which would intersect Adobe Creek. Any modification to Adobe Creek would need to:

- provide the same conveyance capacity as existing conditions;
- provide equivalent District maintenance requirements as the existing condition and not increase District maintenance costs;



- be functional during all flow events with sediment and debris loading;
- allow fish passage;
- be designed to not increase the potential for flooding or adversely impact existing flooding conditions; and
- be permitted by various regulatory agencies (depending on the proposed creek modification).

Option 2: Meadow Drive and Charleston Road Hybrid

2a. Barron Creek and Adobe Creek—The plan includes at-grade crossings at Barron Creek and Adobe Creek, similar to the existing condition. If the new crossing does not constrict the channel and has a soffit elevation equal or higher to the existing bridge soffit, then the District does not anticipate that significant hydraulic impacts will need to be addressed.

2b. San Francisquito Creek and Matadero Creek—These two creeks are not shown on the plans for this option, and the crossings are assumed to be at-grade, similar to the existing bridge crossings. If the new crossings do not constrict the channel and has a soffit elevation equal or higher to the existing bridge soffit, then the District does not anticipate that significant hydraulic impacts will need to be addressed.

Option 3: Meadow Drive and Charleston Road Viaduct and Full Trench

The plan shows either a viaduct over or full trench through Barron and Adobe Creeks.

3a. Viaduct over Barron Creek and Adobe Creek—This plan would raise the crossing at Barron Creek and Adobe Creek higher than the existing condition. If the foundations for the viaduct are located outside the District's easement for each creek, then the District anticipates no direct impacts.

3b. Full trench through Barron Creek and Adobe Creek—The Caltrain crossing is proposed to be in a trench that would intersect both Barron Creek and Adobe Creek. See comment 1c, above, for impacts that would need to be addressed for both the creeks.

3c. San Francisquito Creek and Matadero Creek— These two creeks are not shown on the plans for this option, and the crossings are assumed to be at-grade, similar to the existing bridge crossings. If the new crossings do not constrict the channel and has a soffit elevation equal or higher to the existing bridge soffit, then the District does not anticipate that significant hydraulic impacts will need to be addressed.

Option 4: Palo Alto Avenue Hybrid

4a. San Francisquito Creek—The Caltrain crossing is proposed to be at-grade or higher than the existing crossing. If the new crossing does not constrict the channel and has a soffit elevation equal or higher to the existing bridge soffit, then the District does not anticipate that significant hydraulic impacts will need to be addressed.

4b. Matadero Creek, Barron Creek, and Adobe Creek—These three creeks are not shown on the plans for this option, and the crossings are assumed to be at-grade, similar to the existing

Mr. Jarrett Mullen
Page 3
November 5, 2018

bridge crossings. If the new crossings do not constrict the channel and has a soffit elevation equal or higher to the existing bridge soffit, then the District does not anticipate that significant hydraulic impacts will need to be addressed.

In addition to the above comments, the District has provided responses to your questionnaire dated October 29, 2018 (attached). If you have any questions, you may contact me at (408) 630-2319, or by e-mail at yarroyo@valleywater.org. Please reference District File No. 33812 on future correspondence regarding this project.

Sincerely,



Yvonne Arroyo
Associate Engineer
Community Projects Review Unit

Enclosure: Completed Questionnaire provided in City's October 29, 2018 letter

cc: U. Chatwani, S. Tippets, M. Richardson, Y. Arroyo, D. Mody, C. Houston, C. Grande, J. Codianne, File

Connecting Palo Alto

Follow-Up questionnaire to SCVWD & Hyperlinks to Grade Separation Design Options

1. What are the key regulations that apply to lowering or covering an existing creek corridor?

There are four creeks that are crossed by the Caltrain corridor (owned in fee title by the Peninsula Corridor Joint Powers Board) being analyzed for grade separation. The District has no right of way at the San Francisquito Creek crossing. The District has easement at the Matadero Creek, Barron Creek, and Adobe Creek crossings. Modifications to creeks where the District has easement will require a District Water Resources Protection Ordinance encroachment permit. Prior to issuance of a District encroachment permit to lower or cover an existing creek, the District must make the findings defined in Section 2.3.3A of the Water Resources Protection Ordinance, which may be found here:

<https://www.valleywater.org/sites/default/files/WRPO.pdf>

2. What other regulatory agencies have oversight of creeks, such as the RWQCB and Army Corps of Engineers?

Lowering or covering any of the four creeks will require regulatory approval from other agencies, including but not limited to California State Department of Fish and Wildlife, San Francisco Bay Regional Water Quality Control Board and the US Army Corps of Engineers. Additionally, in areas within a FEMA floodplain, the City's floodplain administrator must follow National Flood Insurance Program regulations to demonstrate the project will not adversely affect the risk of flooding or follow the process to modify the floodplain limits.

3. Have syphons or other engineering solutions been used to redirect creek corridors for projects of similar magnitude?

District staff does not recall an instance where a creek corridor has been placed in siphons to accommodate an infrastructure crossing (i.e. highway, road, utility, rail, etc.) or for any other reason. The infrastructure crossings of creeks in Santa Clara County involve crossings over the top of the creek via a bridge or culvert structure. Any creek modification will need to provide the same conveyance capacity as existing conditions, provide equivalent District maintenance requirements as the existing condition and not increase District maintenance costs, be functional during all flow events with sediment and debris loading, allow fish passage, be designed to not increase the potential for flooding or adversely impact existing flooding conditions, and be permitted by various regulatory agencies (depending on the proposed creek modification). Additionally, a siphon design will need to address flooding impacts which may result from sediment, debris loads, and blockages at or in the siphon during high flow events.

4. Can SCVWD remove sediment in the creek?
 - Does SCVWD have an existing permit for this type of maintenance? If yes, are there restrictions?

The District has several permits to remove sediment from creeks in accordance with our Stream Maintenance Program (SMP). Information on our SMP, including our permits to conduct the program, can be found on our website at: <https://www.valleywater.org/flooding-safety/stream-maintenance-program> The SMP and our regulatory permits have several limitations, including how much sediment can be removed, where it can be removed, when it can be removed, mitigation requirements, etc. A siphon design will have to consider equipment access and address working in confined spaces in order to remove sediment.

5. What are the historic flows within Matadero, Barron, and Adobe creeks?
 - Has there been historic flooding in these creeks? If so, when?
 - What are the ordinary high water elevations at Alma Street?

Please see attached exhibit for recorded historic flooding limits (excluding the flooding limits from the Christmas flood of 1955 prior to District flood protection improvements on each channel) on Matadero, Barron, and Adobe creeks. Also, on the exhibit is a table of flows and corresponding water surface elevations on each creek at a point just upstream of the Caltrain crossing for the 100-year flow and “ordinary flow” or 2.33-year event. The District has completed improvements on each of the three creeks to provide 100-year flood protection in areas that include the Caltrain crossing.

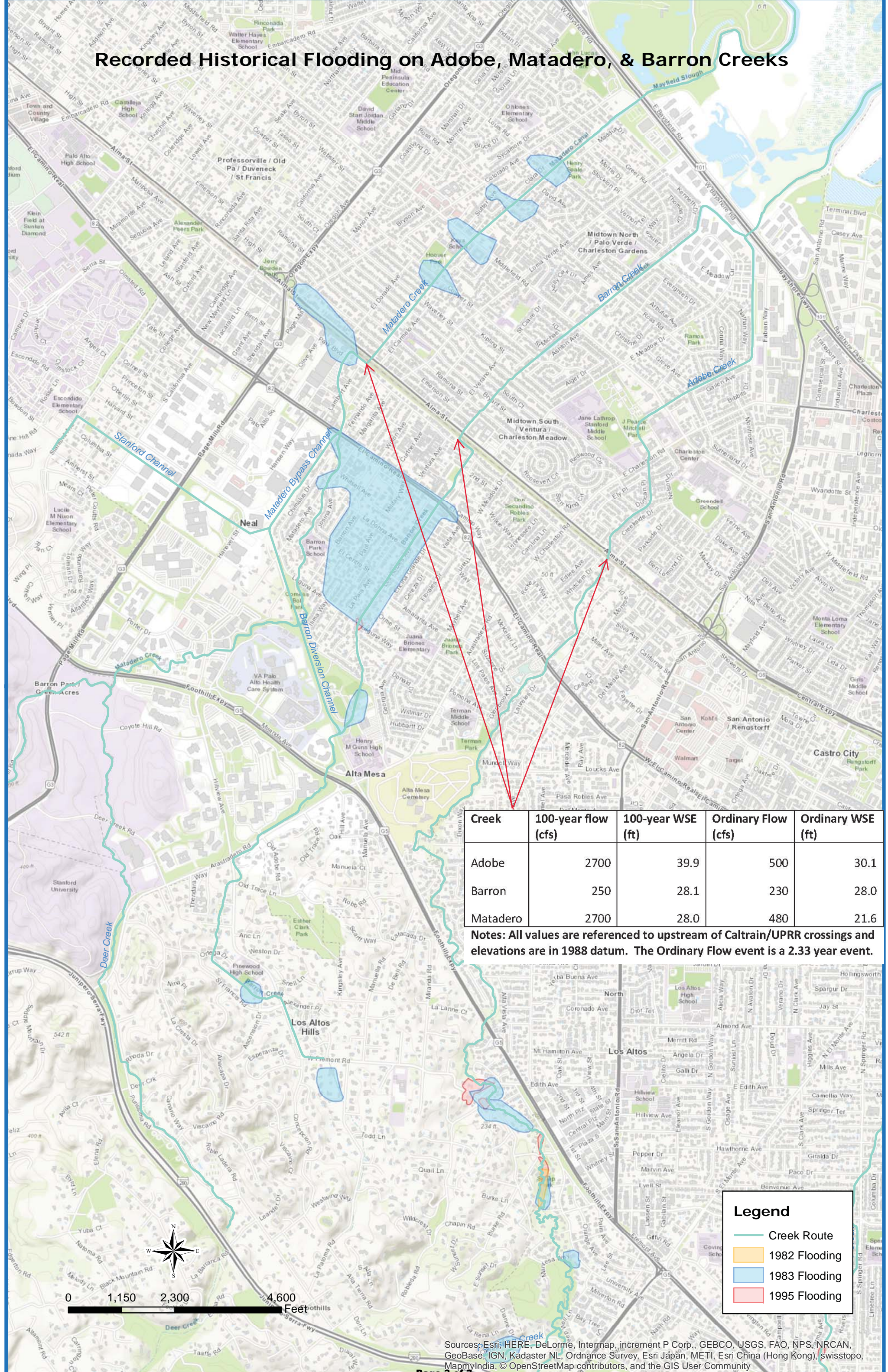
6. Who owns the Matadero, Barron, Adobe, and San Francisquito creek right-of-way?
 - Is flood control also in the SCVWD jurisdiction?

See answer to Question 1 on District right of way at the crossings owned in fee title by the Peninsula Corridor Joint Powers Board. In accordance with the District Act (<https://www.valleywater.org/sites/default/files/Santa%20Clara%20Valley%20Water%20District%20-%20District%20Act.pdf>), the District provides flood protection to Santa Clara County, in addition to providing wholesale water supply and advancing stream stewardship.

Hyperlinks to Remaining Design Options

1. Citywide Tunnel: <https://pagradesep.com/wp-content/uploads/2018/08/Citywide-Tunnel-WBP-Profile.pdf>
2. Meadow Drive & Charleston Road Hybrid: <https://pagradesep.com/wp-content/uploads/2018/08/Meadow-Dr-Charleston-Rd-Hybrid-MCL.pdf>
3. Meadow Drive & Charleston Road Viaduct & Full Trench: <https://pagradesep.com/wp-content/uploads/2018/08/Meadow-Dr-Charleston-Rd-Viaduct-Full-Trench-MCV-MCT.pdf>
4. Palo Alto Avenue Hybrid: <https://pagradesep.com/wp-content/uploads/2018/08/Palo-Alto-Ave-Hybrid-PAH.pdf>

Recorded Historical Flooding on Adobe, Matadero, & Barron Creeks



Creek	100-year flow (cfs)	100-year WSE (ft)	Ordinary Flow (cfs)	Ordinary WSE (ft)
Adobe	2700	39.9	500	30.1
Barron	250	28.1	230	28.0
Matadero	2700	28.0	480	21.6

Notes: All values are referenced to upstream of Caltrain/UPRR crossings and elevations are in 1988 datum. The Ordinary Flow event is a 2.33 year event.

Legend

- Creek Route
- 1982 Flooding
- 1983 Flooding
- 1995 Flooding

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community



AECOM
300 Lakeside Drive
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CA 94612
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Project name:
Palo Alto Rail Program Management Services

Project ref:
60577356

From:
Etty Mercurio

Date:
December 13, 2018

To:
Robert De Geus
City of Palo Alto
City Manager's Office
250 Hamilton Avenue
Palo Alto, CA 94301

CC:
Millette Litzinger, AECOM
John Maher, AECOM

Memo

Subject: Narrative Description for the Meadow Drive and Charleston Road Trench (MCT) Alternative

The following is based on a conceptual engineering evaluation and is intended for discussion purposes only.

Meadow Drive and Charleston Road Trench (MCT)

This narrative describes the railroad and roadway geometry required to lower the railroad tracks in a trench under Meadow Drive and Charleston Road. At the end of the narrative is a listing of an initial assessment of potential impacts associated with this alternative.

Railroad Description during Construction Phase: Temporary tracks (also referred to as a shoofly) are required to bypass the existing/permanent tracks and structures in order to maintain rail service during construction. The temporary tracks will be constructed on the east side of the existing tracks. Starting at the north end and travelling south, the tracks will swing eastward starting around Loma Verde Avenue, run parallel to the existing tracks and Alma Street and then swing back westward into the existing tracks near Ferne Avenue about 600 feet before the north end of the San Antonio Caltrain Station platform. An existing track crossover located within this 600 feet (before San Antonio Station) would need to be relocated. The shoofly will be constructed to the same elevation (grade) as the existing track for the entire length between Loma Verde Avenue and Ferne Avenue. The temporary tracks will not encroach onto Alma Street between intersections, but they will encroach approximately 20 feet into Alma Street at its intersections with Meadow Drive and Charleston Road with the southbound right turning lanes eliminated during construction; however, the turning movements will still be allowed.

The total length of temporary track is approximately 8,400 feet. The temporary track would also have an overhead catenary system for train electrification. The temporary tracks are designed with the required safety and construction clearances and for a maximum speed of 75 mph. Railroad protection devices would be provided at the temporary track grade crossings at Meadow and Charleston and would include standard vehicle and pedestrian/bicycle gates, flashing warning lights, and bells.

Railroad Description Post-Construction: The proposed mainline vertical alignments (profiles) are controlled by the required length of vertical curves, length of tangents between curves and the overall length of new track that can be built once the temporary track is offset 25 feet from the new track. The permanent horizontal alignment will match the existing track. At Meadow and Charleston crossings, the trench will be a minimum depth of 29.5 feet from the top-of-rail elevation to the roadway surface. This assumes a 24.5-foot clearance to the bottom surface of the bridge and an assumed 5-foot bridge structure depth. A 2% grade will be required to achieve the 29.5-foot depth (it should be noted that Caltrain design criteria specifies a 1% maximum grade and that grades exceeding 1% would require a design exception approval from Caltrain on a case-by-case basis for new construction). The permanent tracks would begin descending into a trench 900 feet south of Loma Verde Ave and continue at a depth of approximately 30 feet crossing under Meadow and Charleston and then rising at

2% to meet the existing Caltrain tracks 1,200 feet north of the San Antonio Station. The total length of mainline construction is 6,300 feet.

Roadway Description: The roadways at Meadow Drive and Charleston Road would have the same configuration that exists today once construction is completed with some minor adjustments. However, during construction of the roadway bridges over the proposed trench, Meadow Drive would be closed to all traffic (vehicles, pedestrian and bicycles) while the roadway structure is constructed over the trench at Charleston Road. Once the Meadow structure is completed, Charleston Road would be closed to all traffic and the Charleston structure would be completed.

Class II Buffered Bike Lanes will be provided on Charleston Road, which is consistent with the Charleston-Arastradero Corridor Project.

Drainage Description: The preliminary trench alignment and elevations would obstruct the passage of Adobe Creek and Barron Creek. In order to maintain the existing drainage pattern of the creeks a culvert that consists of an inverted siphon and a pump/lift station would be required at both crossings. The inverted siphon would conceptually consist of a drop structure at the upstream end of the creek that would capture the flow from the creek and would drop to an elevation that is under the proposed trench elevation plus the required cover depth. The culvert would then convey the flow to the downstream end of the creek at a minimal slope. Once the trench section has been cleared, an additional drop structure would be constructed at the downstream end of the culvert. The downstream drop structure would discharge into the existing creek. A significant amount of flow could pass through the inverted siphon through the pressure of the hydraulic grade. However, for large storm events and for maintenance purposes, a pump/lift station would be required on the downstream end of the inverted siphon to increase capacity and to remove standing water from the siphon low point. The location of the pump/lift stations has not yet been determined.

A pump/lift station that would convey the necessary flow rates to mitigate any increases in water surface elevation upstream during large storm events would be significant and would require continuous maintenance and a reliable energy source. A major risk would be potential upstream flooding if the pump/lift station were to fail during a large storm event. Similar designs have been implemented before, but not on the scale that would be required for this project, which would require a full creek diversion with 100-year flow rates greater than 2,500 cubic feet per second (cfs). Due to this, the regulatory risks and challenges are difficult to estimate. There are several regulatory authorities that would need to review and approve the proposed design including FEMA, Santa Clara Valley Water District, United States Army Corps of Engineers, and California Fish and Wildlife.

In addition, a pump station for groundwater seepage and for stormwater removal within the trench will be required at Meadow Drive and Charleston Road. Properties will need to be identified and acquired to accommodate a pumping plant for each location.

Initial Assessment of Potential Impacts:

- Removal of all existing trees in the buffer between Alma Street and the mainline tracks (east side) to construct the temporary double tracks and maintain the Caltrain revenue service.
- To accommodate the temporary tracks, the width of Alma Street will be temporarily reduced approximately 20 feet at the intersections of Meadow Drive and Charleston Road where there are turning lanes – there would be no dedicated right-turning lanes from Alma Street during construction.
- Easements will be required for a ground anchor system to support deep trench retaining walls. The ground anchor system will encroach below Alma Street and below backyards west of the Caltrain right-of-way. Buildings and landscaping will be restricted within easements. Plants with large root systems such as trees will not be permitted as they can impact the structural integrity of the ground anchor systems.
- Utility relocations are required at the Meadow Drive and Charleston Road roadway crossings.
- Construction will close Meadow Drive and Charleston Road when erecting bridge structures over the trench impacting automobile, pedestrian and bicycle traffic. At least one crossing will remain open during construction.
- Fire protection measures will be required in the trench that will require standpipes and fire department hose connections.

- Emergency egress locations, from inside the trench, will be required that may require additional right-of-way.
- High fencing will be required along trench walls for safety to protect high-voltage lines.
- The trench will obstruct Adobe Creek and Barron Creek, requiring inverted siphons to pass the stormwater under the trench. There are no inverted syphons within Santa Clara Valley Water District's system. These types of systems have high maintenance issues/costs and can be prone to blockage with sediment with potential to cause upstream flooding.
- Modification to Adobe and Barron Creeks will require approval from regulatory agencies including FEMA, the Santa Clara Valley Water District, the U.S. Army Corps of Engineers, and California Fish and Wildlife.
- The trench will require a pump station for groundwater seepage and for stormwater removal. Property will need to be identified and acquired for pumping plant.
- Design exception approval required from Caltrain for 2% grade.
- Train horn noise and warning bells will be eliminated with the replacement of the at-grade crossings with grade separations. In the trench, noise could reflect off the walls and impact properties further away; however, this can be mitigated.

To:
Robert De Geus
City of Palo Alto
City Manager's Office
250 Hamilton Avenue
Palo Alto, CA 94301

Project name:
Palo Alto Rail Program Management Services

Project ref:
60577356

From:
Etty Mercurio

Date:
December 13, 2018

CC:
Millette Litzinger, AECOM
John Maher, AECOM

Memorandum

Subject: Narrative Description for the Meadow Drive and Charleston Road Viaduct (MCV) Alternative

The following is based on a conceptual engineering evaluation and is intended for discussion purposes only.

Meadow Drive and Charleston Road Viaduct (MCV)

This narrative describes the railroad and roadway geometry required to raise the railroad tracks in a viaduct over Meadow Drive and Charleston Road. At the end of the narrative is a listing of an initial assessment of potential impacts associated with this alternative.

Railroad Description during Construction Phase: The existing tracks will remain in service during construction. New tracks, the viaduct and an overhead catenary system for train electrification, will be constructed between the existing tracks and Alma Street. An existing track crossover located north of the San Antonio Caltrain Station will be relocated. Upon completion of the new tracks and viaduct, the existing tracks and the railroad crossing gates and warning lights at Meadow Drive and Charleston Road will be removed.

Railroad Description Post-Construction: The new tracks and viaduct will be located between the existing tracks and Alma Street. Starting at the north end and travelling south, the tracks would swing eastward beginning at a point 400 feet north of Loma Verde Avenue, run parallel to the existing tracks and Alma Street and then swing back westward into the existing tracks 500 feet south of Ferne Avenue. The tracks will encroach into Alma Street approximately two feet for the portions north of Meadow Drive and south of Charleston Road, resulting in reduced lane widths on Alma Street. There will be no encroachment between Meadow Drive and Charleston Road. The total length of the new track is 8,400 feet and is designed for 110 mph.

The proposed mainline vertical alignments (profiles) are controlled by the required length of vertical curves, length of tangents between curves and the overall length of new track that can be built once the temporary track is offset 25 feet from the new track. At the Meadow Drive and Charleston Road crossings, the viaduct top-of-rail elevation will be a minimum of 20.5 feet above the existing roadway. This assumes a 15.5-foot vertical clearance from the roadway surface to the underside of a bridge structure and an assumed 5-foot bridge structure depth. The new tracks will begin rising 700 feet south of Loma Verde Avenue at a 1.0% grade. They will be on retained fill for approximately 700 feet and then continue on the viaduct structure over Meadow Drive, stay on an elevated viaduct structure over Charleston Road, and then descend at 1.4% (it should be noted that Caltrain design criteria specifies a 1% maximum grade and that grades exceeding 1% would require a design exception approval from Caltrain on a case-by-case basis for new construction). The viaduct will end at a point 600 feet south of Charleston where the tracks will again be on retained fill for approximately 500 feet. The total length of retained fill is 1,200 feet. The total length of viaduct is 4,200 feet.

Roadway Description: The roadways at Meadow Drive and Charleston Road will have the same configuration that exists today or match what is proposed/under construction for these roadways currently. During construction, falsework (scaffolding) will be constructed above Meadow Drive and Charleston Road to allow motor vehicles, pedestrians and bicyclists to continue to use these roads without disruption during weekdays. Falsework construction will require either weekend or night-time closures to erect (assemble) and to take down (disassemble) the falsework.

Class II Buffered Bike Lanes will be provided on Charleston Road, which is consistent with the Charleston-Arastradero Corridor Project. This will require expanding the width of the road to maintain bike lanes through the underpass of the railroad to accommodate the new column supporting the railroad structure. There appears to be sufficient space to accommodate this width and, ideally this could be provided as a Class IV separated bikeway given the change in vehicle lanes at the column location.

Initial Assessment of Potential Impacts:

- Removal of all existing landscaping, including trees, in the buffer area between Alma Street and the existing tracks in order to construct the new tracks.
- To accommodate the new tracks, the width of Alma Street will be reduced approximately two feet for the portions north of Meadow Drive and south of Charleston Road, resulting in reduced lane widths on Alma Street. There will be no encroachment between Meadow and Charleston.
- The tracks will encroach into Alma Street approximately two feet for the portions north of Meadow Drive and south of Charleston Road, resulting in reduced lanes on Alma Street. There will be no encroachment between Meadow Drive and Charleston Road.
- No private property impacts.
- No impacts to existing creeks.
- Minor utility impacts.
- Visual impacts with the elevated structure.
- Train horn noise and warning bells will be eliminated with the replacement of the at-grade crossings with grade separations. With the elevated track, train wheel noise could radiate out, however, this can be mitigated.
- Construction will require falsework over roadways at Meadow Drive and Charleston Road, but access for all modes will be maintained at most times.
- Design exception approval required from Caltrain for 1.4% grade.
- Opportunity for landscaping upon construction completion between new tracks and properties to the west.

To:
Robert De Geus
City of Palo Alto
City Manager's Office
250 Hamilton Avenue
Palo Alto, CA 94301

Project name:
Palo Alto Rail Program Management Services

Project ref:
60577356

From:
Etty Mercurio

Date:
December 13, 2018

CC:
Millette Litzinger, AECOM
John Maher, AECOM

Memorandum

Subject: Narrative Description for the Meadow Drive and Charleston Road Hybrid (MCL) Alternative

The following is based on a conceptual engineering evaluation and is intended for discussion purposes only.

Meadow Drive and Charleston Road Hybrid (MCL)

This narrative describes the railroad and roadway geometry required to raise the railroad tracks and lower the roadways at Meadow Drive and Charleston Road. At the end of the narrative is a listing of an initial assessment of potential impacts associated with this alternative.

Railroad Description during Construction Phase: Temporary railroad tracks (also referred to as a shoofly) are required to bypass the existing/permanent tracks and structures in order to maintain rail service during construction. The temporary tracks will be constructed on the east side of the existing tracks. Starting at the north end and traveling south, the tracks will swing eastward starting 350 feet south of Loma Verde Avenue, run parallel to the existing tracks and Alma Street and then swing back westward into the existing tracks 250 feet north of Ferne Avenue. The shoofly will be constructed to the same elevation (grade) as the existing track for the entire length between Loma Verde and Ferne Avenue. The temporary tracks will not encroach onto Alma Street between intersections, but they will encroach approximately 20 feet onto Alma Street at its intersections with Meadow Drive and Charleston Road with southbound right turning lanes eliminated during construction; however, the turning movements will still be allowed. Vertical clearance under Meadow Drive and Charleston Road would be temporarily limited to 12 feet during construction, which will require a design exception from Caltrain.

The total length of temporary track is approximately 6,400 feet. The temporary track would also have an overhead catenary system for train electrification. The temporary tracks are designed with the required safety and construction clearances and for a maximum speed of 75 mph. Standard railroad protection devices would be provided at the temporary track grade crossings, including vehicle and pedestrian gates, warning lights, and bells.

Railroad Description Post-Construction: The proposed mainline vertical alignments (profiles) are controlled by the required length of vertical curves, length of tangents between curves and the overall length of new track that can be built once the temporary track is offset 25 feet from the new track. The permanent horizontal railroad alignment will match the existing track. The permanent track will rise near El Verano Avenue at a grade of 1.0% on retained fill into a 350-foot long vertical curve over Meadow Drive. This places the top-of-rail 14 feet above the existing Meadow Drive roadway elevation. It continues at a slope of 0.4% into a 760-foot long vertical curve over Charleston Road. This places the top-of-rail 14 feet above the existing Charleston Road roadway elevation. The track then descends at a 1% grade on retained fill to meet the existing mainline track 1,150 feet north of Ferne Avenue. The Meadow Drive and Charleston Road roadways will be lowered to provide a minimum 15.5-foot vertical clearance between the road surface and the bottom of the rail bridge structure. The total length of mainline construction is 5,000 feet.

Roadway Description: Between Park Boulevard and Alma Street, Meadow Drive will be lowered at a maximum grade of 5%. Beginning at Park Boulevard to the west, it will be lowered a maximum of seven feet from existing grade below the railroad tracks and then it will rise to meet the existing grade approximately 170 feet east of Alma Street. The total length of roadway impacted on Meadow Drive is 460 feet. The total length of roadway impacted on Alma Street 680 feet, 280 feet to the north and 400 feet to the south of Meadow Drive. Alma Street will be lowered a maximum of four feet from the existing grade to maintain the existing intersection with Meadow Drive. The maximum grade on Alma Street will be 1.5%. The design speed for Meadow Drive is 25 MPH and 35 MPH for Alma Street.

Between Park Boulevard and Alma Street, Charleston Road will be lowered at a maximum grade of 5%. Beginning at Park Boulevard to the west, it will be lowered a maximum of seven feet from the existing grade below the railroad tracks and then it will rise to meet the existing grade approximately 190 feet east of Alma Street. The total length of roadway impacted on Charleston Road is 530 feet. The total length of roadway impacted on Alma Street is 540 feet, 270 feet to the north and 270 feet to the south of Charleston Road. Alma Street will be lowered a maximum of 4 feet from the existing grade to maintain the existing intersection with Charleston Road. The maximum grade on Alma Street will be 2.0%. The design speed on Charleston Road is 25 MPH and 35 MPH on Alma Street.

Class II Buffered Bike Lanes will be provided on Charleston Road, which is consistent with the Charleston-Arastradero Corridor Project. This will require expanding the width of the road to maintain bike lanes through the underpass of the railroad to accommodate the new column to support the railroad structure. There appears to be sufficient space to accommodate this width and, ideally this could be provided as a Class IV separated bikeway given the shift in vehicle lanes at the column location.

Drainage Description: A pump station for groundwater seepage and for stormwater removal may be required between Meadow Drive and Charleston Road. Properties will need to be identified and acquired to accommodate a pumping plant at each location.

Initial Assessment of Potential Impacts:

- Removal of the existing trees in the buffer area between Alma Street and the existing tracks to construct the temporary tracks (shoofly) in order to maintain Caltrain service during construction.
- During construction the width of Alma Street will be temporarily reduced approximately 20 feet at the intersections of Meadow Drive and Charleston Road to accommodate the temporary tracks. There would be no dedicated right-turn lanes from Alma Street, but all turns would be permitted.
- Property impacts are relatively minor (driveway modifications only).
- Major utility relocations for utilities located in Alma Street, Meadow Drive and Charleston Road are required to accommodate the excavation for the lowered roadways.
- A pump station may be required for each of the lowered roadways (to pump surface runoff from lowered roadways). Properties will need to be identified and acquired to accommodate a pumping plant at each location.
- Visual impacts with elevated railroad embankment.
- Train horn noise and warning bells will be eliminated with the replacement of the at-grade crossings with grade separations. With the elevated track, train wheel noise could radiate out, however, this can be mitigated. During construction, one lane in each direction would be closed on portions of Alma Street, Meadow Drive, and Charleston Road to permit excavation at the undercrossings.
- Grade changes on Charleston Road will increase challenges for bicyclists, especially less confident bicyclists, and may create challenges for passing.
- Design exception approval required from Caltrain for temporary roadway vertical clearance of 12 feet during construction for both Meadow and Charleston.

Attachment E

Conceptual Project Plans & 3D Animations for Meadow Drive & Charleston Road Alternatives

Conceptual plans are available to the public online and by visiting the Planning and Community Environmental Department on the 5th floor of City Hall at 250 Hamilton Avenue.

Directions to review Project plans online:

1. Go to: <https://pagradesep.com/community-engagement/>
2. Scroll to the bottom of the page and locate the section entitled: "Community Meeting, November 28, 2018"
3. Click on the desired document

Direct Link to Plans & 3D Animations:

MCL MEADOW DR. & CHARLESTON RD. | **Hybrid**

Meadow Drive and Charleston Road railroad over roadway hybrid and build Loma Verde Avenue bike/pedestrian crossing to connect to Margarita Avenue bicycle boulevard

[3D Animation](#) | [Conceptual Plans](#)

MCT MEADOW DR. & CHARLESTON RD. | **Rail Trench or Tunnel**

Meadow Drive and Charleston Road roadway over railroad trench or tunnel Alma street would not be within trench or tunnel (maintains Alma Street connections to Meadow Drive and Charleston Road) with Alma Street in its existing alignment or a new alignment;

[3D Animation](#) | [Conceptual Plans](#)

MCV MEADOW DR. & CHARLESTON RD. | **Viaduct**

Meadow Drive and Charleston Road railroad over roadway viaduct.

[3D Animation](#) | [Conceptual Plans](#)

Attachment F: Palo Alto Avenue Problem Statement

Palo Alto Avenue/University Avenue/Palo Alto Caltrain Station Transportation/Land Use Planning Problem Statement

As part of its citywide Connecting Palo Alto effort to ensure safety and community compatibility of the Caltrain corridor, the City of Palo Alto is evaluating a range of options for improving the existing rail/street crossing at Palo Alto Avenue. Based on the analysis completed to date, it has become increasingly clear that factors, such as engineering constraints, land use plans and urban design, and access needs, affecting design options as part of the Downtown University Avenue vicinity require a more comprehensive planning effort. Such an effort for this location needs to be separated from the current citywide grade separation planning project.

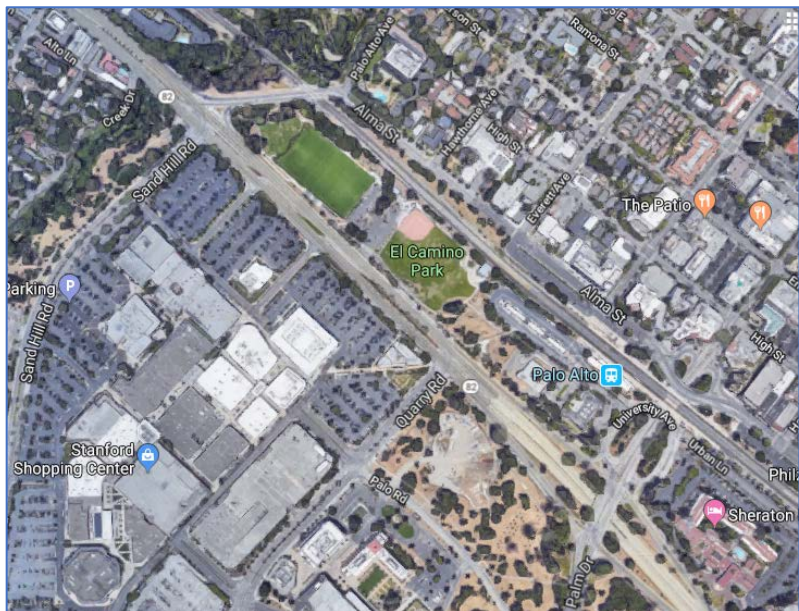
Location

The existing crossing of the Caltrain tracks at Palo Alto Avenue is one of the four at-grade crossings being evaluated for possible grade separation. This crossing is also referred to by various landmarks, including the Palo Alto/Menlo Park city limit, Palo Alto Avenue, El Camino Real, San Francisquito Creek, and historic landmarks of the El Palo Alto namesake tree and trestle bridge. The evaluation of grade separation alternatives and potential property impacts highlighted the interdependency of options at this location and University Avenue (located less than 2,000 feet from Palo Alto Avenue). University Avenue is grade separated from Caltrain and is the location of Caltrain's "Palo Alto" Station (which is the second-busiest Caltrain station after San Francisco's Fourth and King Station).

Transportation Context

Major arterial streets in the area reflect the high activity level of the Downtown Palo Alto/Stanford University interface, with Alma Street (south of the Caltrain Station) carrying 29,000 vehicles per day, University Avenue carrying 12,000 vehicles per day, Lytton Avenue carrying 11,000 vehicles per day, Hamilton Avenue carrying 8,000 vehicles per day, Palo Alto Avenue (west of Alma Street) carrying 13,000 vehicles per day, and El Camino Real carrying 36,000 vehicles per day. Palo Alto Avenue is a key connection between El Camino Real and Downtown Palo Alto given the concentration of multimodal activity at University Avenue.

The Palo Alto Caltrain Station services the second highest volume



of riders on system, following the San Francisco Station and roughly 50% higher than the San Jose Diridon Station. The University Avenue transit station also serves VTA, SamTrans, AC Transit, and Stanford Marguerite buses. Pedestrian and bicycle access to the Caltrain station as well as between Downtown and Stanford is highly constrained.

Land use Context

The Palo Alto Avenue and University Avenue vicinity (downtown area) is distinct from the other existing Palo Alto at-grade crossings given the activity level as a bustling downtown area and the interface between Downtown Palo Alto and Stanford University. The County of Santa Clara is currently considering an application for proposed development (General Use Permit, or “GUP”) from Stanford University for up to 2.275 million square feet of academic and support facilities and 3,150 net new housing units/beds. This GUP application is currently undergoing environmental review.

Narrow parcels located between Alma Street and the Caltrain tracks are currently developed with surface parking. Larger parcels located between Caltrain and El Camino Real are currently developed with the transit center north of University Avenue and a Sheraton Hotel south of University Avenue.

Recommended Planning Approach

The complexity of transportation and land use interfaces suggest that planning for this vicinity requires evaluation of issues beyond the scope of “simple” grade separation alternatives analysis. In order to continue progress on the evaluation of grade crossing options at Churchill, Meadow, and Charleston, the City would remove Palo Alto Avenue from the ongoing “Connecting Palo Alto” work effort and begin scoping an independent planning effort to address Downtown issues.

The City of Palo Alto uses a planning process known as a Coordinated Area Plan to guide land use and transportation alternatives evaluation, as well as community and stakeholder engagement. Planning for this vicinity would presumably also need to address forecasted ridership increases at the Caltrain Palo Alto Station. This is especially important given growth at Stanford University, as well as potential development of properties located between Alma Street and El Camino Real.

This recommendation is in alignment with the Palo Alto Comprehensive Plan regarding University Avenue and Downtown. The specific policy areas include:

Policy L-4.7 Maintain and enhance the University Avenue/Downtown area as a major commercial center of the City, with a mix of commercial, civic, cultural, recreational and residential uses. Promote quality design that recognizes the regional and historical importance of the area and reinforces its pedestrian character.

Policy L-4.8 Ensure that University Avenue/Downtown is pedestrian-friendly and supports bicycle use. Use public art, trees, bicycle racks and other amenities to create an environment that is inviting to pedestrians and bicyclists.

Program L4.8.1 Prepare a Coordinated Area Plan for Downtown.

Program L4.8.2 Study the feasibility of converting parts of University Avenue to a pedestrian zone.

Financial Considerations

There are two current issues related to funding. The first is the availability and application Santa Clara County Measure B funds. The Santa Clara Valley Transportation Authority (VTA) recently began discussion of their approach to implementation of voter-approved funding for Caltrain grade separations in Palo Alto, Mountain View, and Sunnyvale. While this program approach is not yet active given pending Measure B litigation, VTA staff has suggested an approach that emphasizes the need to set priorities among prospective grade separation projects, potentially setting up a competition among the cities for funding. This reinforces the importance of Palo Alto positioning projects as “ready to go” as quickly as possible. The greatest opportunities to finalize locally preferred alternatives are at the Churchill, Meadow, and Charleston crossings. The costs for these crossings alone will likely exceed funding available through Measure B and ensure Palo Alto remains in position for use of Measure B funds.

The second issue is funding of the anticipated planning effort and ultimately construction of any recommendations developed for improving Downtown circulation. Upon approval of the recommended approach, staff will pursue external funding for a coordinated area planning effort. As the interface between transportation and land use is a regional and statewide priority with implications for national economic and urban planning significance, we anticipate that several federal, state, and private funding sources can be sought for the work required. Similarly, the outcomes of this planning effort may involve land use and multimodal improvements such that staff anticipates separate (non-Measure B) funding will be sought.

Next Steps

Based on the expanded scope involved with a Coordinated Area Plan or similar planning effort, staff will seek city council approval to remove the Palo Alto Avenue crossing from the ongoing evaluation of citywide grade separation alternatives. The Connecting Palo Alto evaluation will then focus on the other existing at-grade crossings at Churchill Avenue, Charleston Road, and Meadow Drive crossings.

Initiation of a Coordinated Area Plan for Downtown circulation will depend on scoping, identification of funding, and staff capacity to support plan development. At this time, we anticipate that planning work could begin in late 2019.

Attachment G – Letters to Council About Rail Grade Separation

This document contains the following:

1. Letters to Council about Rail Grade Separation Received in the Month of December to Date
2. Presentations Shared by CAP Members at the December 12th CAP Meeting
3. The Townsend Legislative Letter Presented to the Rail Committee on November 27, 2018
4. Letters to Council about Rail Grade Separation Received in the Month of November 2018
5. Letters to Council about Rail Grade Separation Received in the Month of October 2018
6. Letters to Council about Rail Grade Separation Received in the Month of September 2018

Carnahan, David

From: martin@sommer.net
Sent: Thursday, December 6, 2018 4:58 PM
To: Council, City
Cc: arobeso@menlopark.org
Subject: Attn: Rail Committee, Palo Alto

Email sent to Angela Obeso, City of Menlo Park:

Please address the issue of: a) closing the Palo Alto Ave rail crossing, in conjunction with b) taking Alma directly across the creek between Menlo Park and Palo Alto.

Thank you!

Martin

--

Martin Sommer
650-346-5307
martin@sommer.net
<http://www.linkedin.com/in/martinsommer>

"Turn technical vision into reality."

----- Original Message -----

Subject: Great meeting you last night
Date: 2018-12-06 10:24
From: martin@sommer.net
To: arobeso@menlopark.org

Good morning Angela,

It was great meeting you last night at the Menlo Park Caltrain meeting. I had proposed the idea of closing the Palo Alto Ave rail crossing in Palo Alto, and taking Alma directly across the creek between Menlo Park and Palo Alto. I had also suggested moving the small El Palo Alto Park to the other side of the tracks, and extend the El Camino Park.

This idea would: a) eliminate the cost of another grade separation, b) eliminate train noise wrt to current crossing, and c) lower the number of track crossings, between Menlo Park and Palo Alto.

Please let me know, if I can help you explain this idea to Menlo Park and/or Palo Alto stake holders.

Thanks again,

Martin

--

Martin Sommer

650-346-5307

martin@sommer.net

<http://www.linkedin.com/in/martinsommer>

"Turn technical vision into reality."

Carnahan, David

From: Wolfgang Dueregger <wolfgang.dueregger@alumni.stanford.edu>
Sent: Monday, December 3, 2018 6:45 PM
To: Council, City; Keene, James; Shikada, Ed
Cc: Neilson Buchanan; John Guislin; Paul & Karen Machado; Carol Scott; Christian Pease; evergreen-park-discuss@yahoogroups.com Use THis One
Subject: Fwd: No teamwork for train

Dear City Council and city managers,

it seems Palo Alto has not gotten in touch with its neighbors reg/ a common approach to build a tunnel underneath the majority of our cities along the Peninsula.

Would you think now is maybe the right time to start this work?

thank you

Wolfgang

----- Forwarded message -----

From: **Wolfgang Dueregger** <wolfgang.dueregger@alumni.stanford.edu>
Date: Mon, Dec 3, 2018 at 6:23 PM
Subject: No teamwork for train
To: Wolfgang Dueregger <wolfgang.dueregger@alumni.stanford.edu>

NEWS

No teamwork on undergrounding train

BY EMILY MIBACH
Daily Post Staff Writer

Some Mid-Peninsula residents and council members along the Caltrain corridor have long wanted for the main tracks to be tunneled or trenched, but when Menlo Park's City Council reached out to other councils about the possibility of teaming up to do so, only one city got back to them.

In June, Menlo Park Mayor Peter Ohlaki sent letters to the mayors of Palo Alto, Atherton, Mountain View, Redwood City and Sunnyvale, to see if they were interested in teaming up to tunnel or trench the train tracks.

While Redwood City and Atherton officials got back to Menlo Park, saying they would be interested in talking about the possibility, Redwood City is the only one that is interested in coordinating their plans, according to Senior Transportation Engineer Angela Obeso.

However, when the Redwood City

Mid-Peninsula cities taking different routes

council discussed what to do regarding the Whipple Avenue train crossing, there was not a lot of support to trench or tunnel the train due to the cost.

But during the Oct. 1 Redwood City Council meeting, the council was interested in coordinating efforts between cities in order to make sure commuter's rides are not like roller coaster rides as a train travels below or above a street, as Vice Mayor Diane Howard put it.

Tomorrow, the Menlo Park City Council will hear a report from Obeso on the plans for a train bridge at Ravenswood Avenue and the attempt to work with other cities on a tunnel or trench.

Talk but no money

Atherton officials told Menlo Park that while they're interested in meeting



TRAIN IN A TRENCH — An aerial view of construction of a trench in San Gabriel in 2016. Photo by Brian O'Neil.

on the topic, they are not interested in contributing any money, because the town has other priorities, according to a report from Obeso.

Sunnyvale and Mountain View were not interested in pursuing the trench or tunnel option as both cities have already decided what to do with their rail crossings. However, Mountain

View officials said they are interested in discussing the future of the Caltrain corridor.

Palo Alto officials did not respond to Ohlaki's letter, however, the city has long been studying what to do with the train tracks at Charleston Road and Meadow Drive, Churchill Avenue and Palo Alto Avenue.

THE UPDATE FROM PAGE 1

Seattle yesterday. The 49ers fell to 2-10 while the



Embarcadero and Palo Alto Ave Concepts

David Shen, Tony Carrasco, Jason Matlof

V5 12-10-18

Embarcadero Ave

Why talk about Embarcadero?

- 1930s structure overdue for upgrade.
 - Alma on bridge necks down from 4 to 3 lanes.
 - Embarcadero underneath necks down from 4 to 3 lanes.
- Traffic flow between two arterials, Alma and Embarcadero, is not optimal
 - Not enough protected access ramps to/from each road and in all directions.
 - Traffic flows through neighborhood streets to make transition
- Traffic lights at Town and Country and El Camino do not encourage good flow

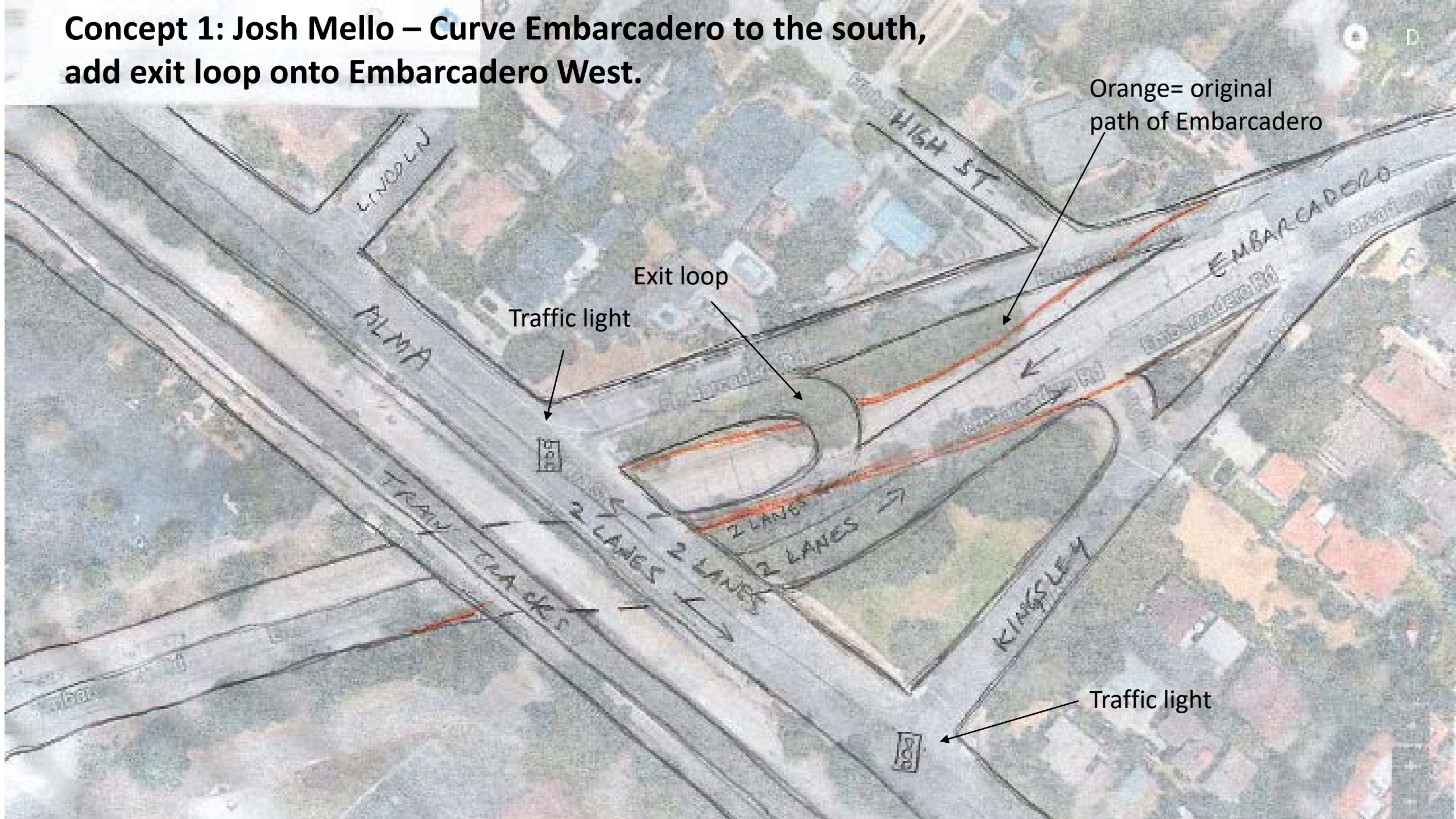
Goals

- Upgrade/update old 1930s structure.
- Reduce traffic flow in neighborhood streets.
- Increase safety and access for pedestrians and cyclists.
 - Preserve/enhance pedestrian and cyclist access under Alma with rebuild.
 - Improve Paly student pedestrian light with another option, ie. Ped/bike underpass.
- Fix traffic lights between Alma and El Camino.
 - Remove a light or two if possible.
 - Coordinate lights to improve traffic flow.
- Do all this without property takings
 - “Minimize eminent domain”

Concept Goals

- STIMULATE THINKING AND POSSIBILITIES
 - NOT ACTUAL SOLUTIONS TO BE DEBATED
 - NEED FURTHER DESIGN AND STUDY
- TREAT TRAFFIC SOLUTIONS IN PALO ALTO AS A SYSTEM
 - NOT AS INDIVIDUAL INTERSECTIONS

Concept 1: Josh Mello – Curve Embarcadero to the south, add exit loop onto Embarcadero West.



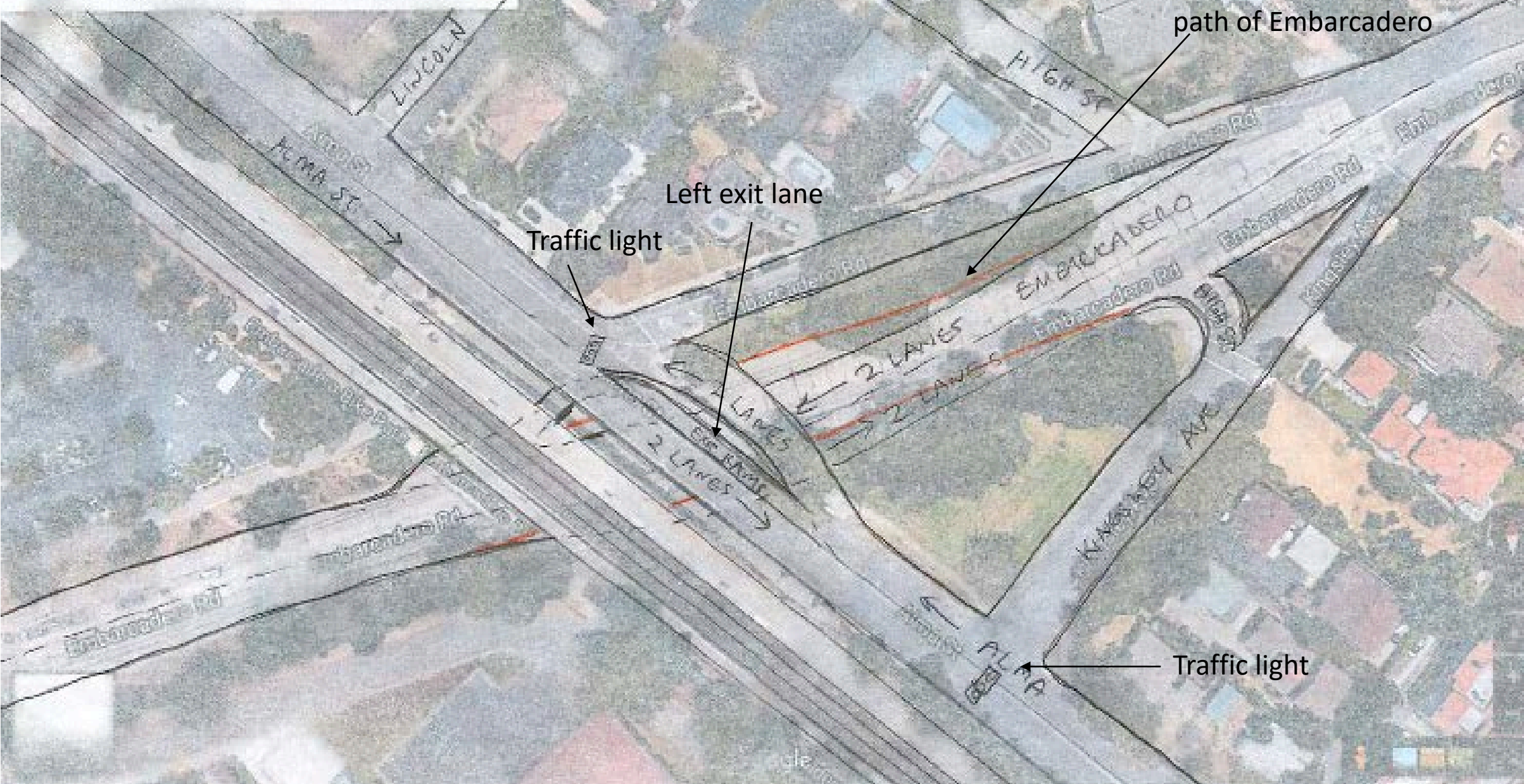
Orange= original path of Embarcadero

Exit loop

Traffic light

Traffic light

Concept 2: Josh Mello – Curve Embarcadero to the south, add left exit lane from Alma North onto Embarcadero West.



Orange= original path of Embarcadero

Left exit lane

Traffic light

Traffic light

Concept 3: Exit ramp from Alma North onto Embarcadero West. Curve Embarcadero to south

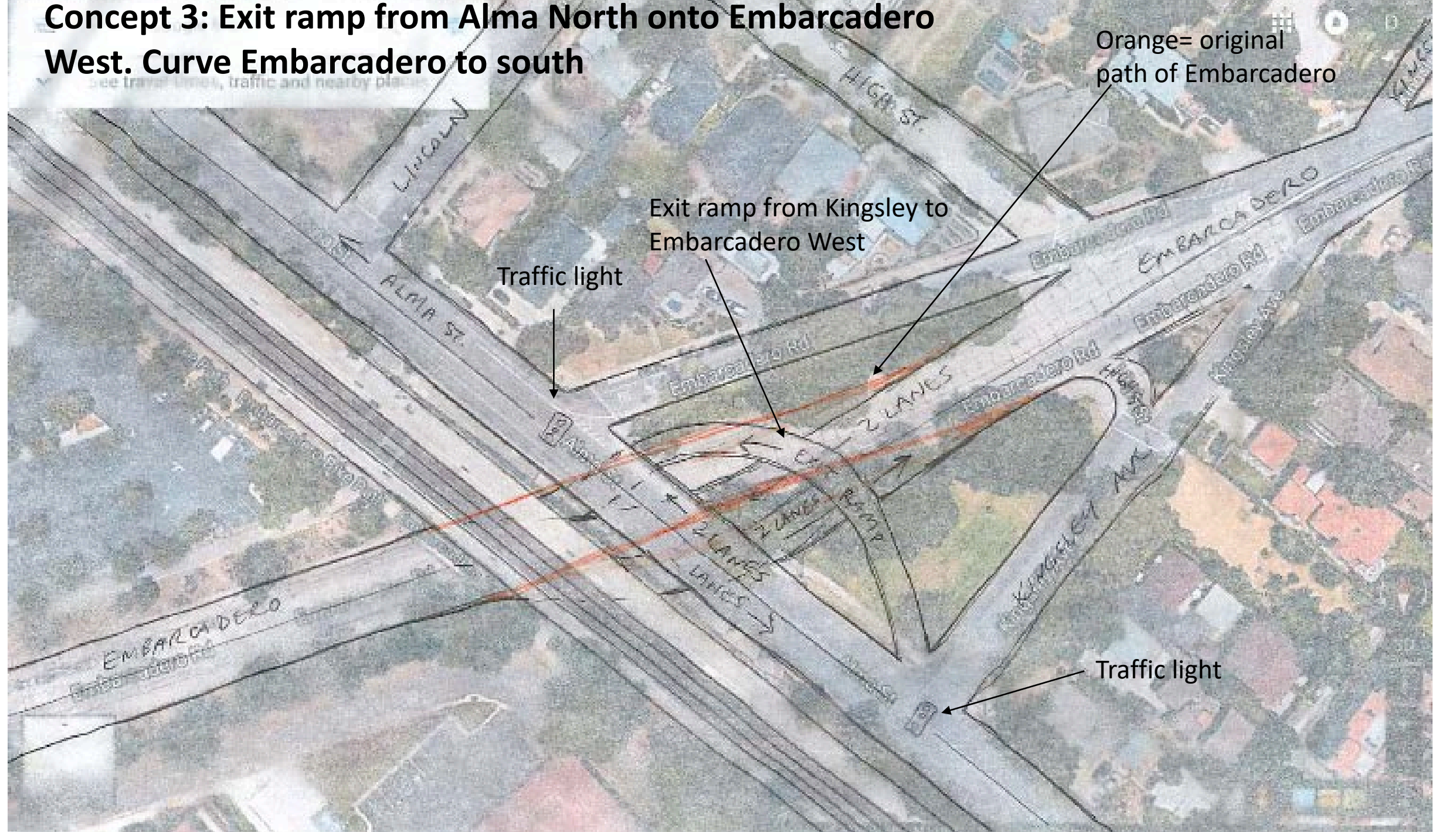
See travel lanes, traffic and nearby places

Orange = original path of Embarcadero

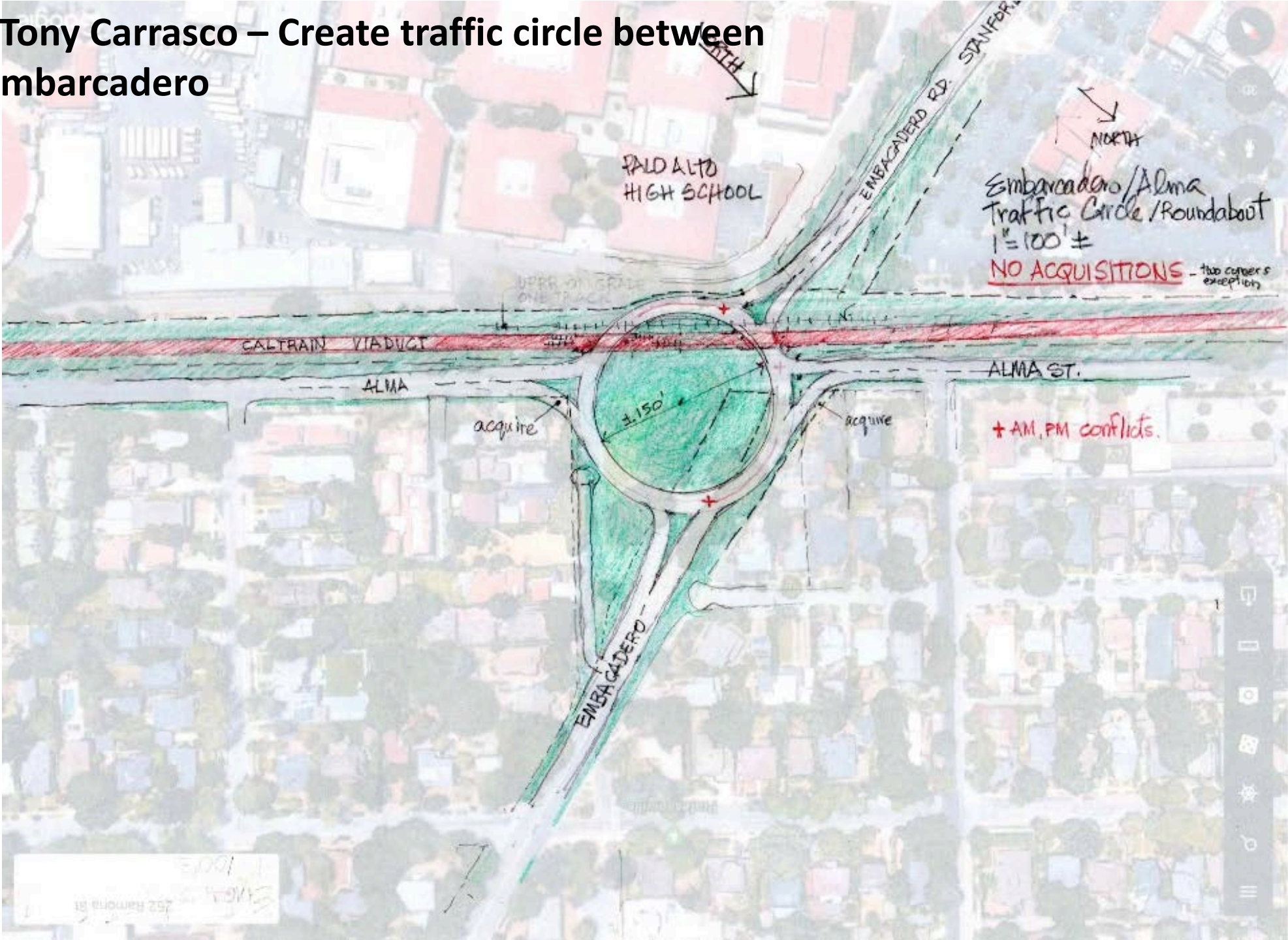
Exit ramp from Kingsley to Embarcadero West

Traffic light

Traffic light



Concept 4: Tony Carrasco – Create traffic circle between Alma and Embarcadero



Palo Alto Ave

Goals

- Maintain access from Alma to El Camino into Menlo Park.
 - Improve traffic flow
- Maintain pedestrian/cyclist access
 - Create separated ped/bike access path alongside roadway
- Protect historic bridge and El Palo Alto tree.
- Do all this without property takings
 - “Minimize eminent domain”

Concept Goals

- STIMULATE THINKING AND POSSIBILITIES
 - NOT ACTUAL SOLUTIONS TO BE DEBATED
 - NEED FURTHER DESIGN AND STUDY
- TREAT TRAFFIC SOLUTIONS IN PALO ALTO AS A SYSTEM
 - NOT AS INDIVIDUAL INTERSECTIONS

Concept 1: Shift new road to El Camino to the south, take over park area of El Camino Park. Add sloping down road alongside Alma to drop down to underpass. If 2% grade, slope down begins at Everett.



2 lanes slope up to meet El Camino, approx. 2-4% grade

107'
27091
2% GRADE

Adjacent drop down
2 lanes, approx. 2-3%
grade

Train tracks remain
at same level

Traffic light
governs flow

Soccer
FIELD

EL CAMINO
PARK

LOT

ALMA ST.

EVEREST AVE

≡ **Concept 1a: Shift new road to El Camino to the south, take over park area of El Camino Park. Add sloping down road alongside Alma to drop down to underpass. If 5% grade, slope can start in/around Hawthorne.**



2 lanes slope up to meet El Camino, approx.
5% grade

300 ft
5% GRADE

Adjacent drop down
2 lanes, approx. 5%
grade

Train tracks remain
at same level

Traffic light
governs flow

SOCCER
FIELD

EL CAMINO
PARK

LOT

Concept 2: Tony Carrasco – Create rail viaduct from Menlo Park through Palo Alto downtown, change path of train tracks around historic bridge



FINAL WORD

- AGAIN: CONCEPTS TO STIMULATE THINKING AND CREATIVITY
- ADVOCATE FOR EMBARCADERO TO BE INSERTED INTO THE WORK PLAN NOW
 - FURTHER WORK AND STUDY IS NEEDED
- ADVOCATE FOR MORE STUDY ON PALO ALTO AVE
- GOALS:
 - MAKE PALO ALTO OVERALL A BETTER ENVIRONMENT FOR CARS, BIKES, AND PEDESTRIANS
 - PRESERVE *ALL* NEIGHBORHOODS' INTEGRITY
 - DO IT ALL WITHOUT PROPERTY TAKINGS

APPENDIX

About Grade and Grade Standards

4. Grades (slope) and Why They Matter



- The steepness (slope) of the road/track is known as the **grade**.
- Percent grade is how much the road or track **rises** (in feet) for every 100 feet of distance (the **run**).

1% grade means for every 100 ft along track, the train climbs 1 ft in height.

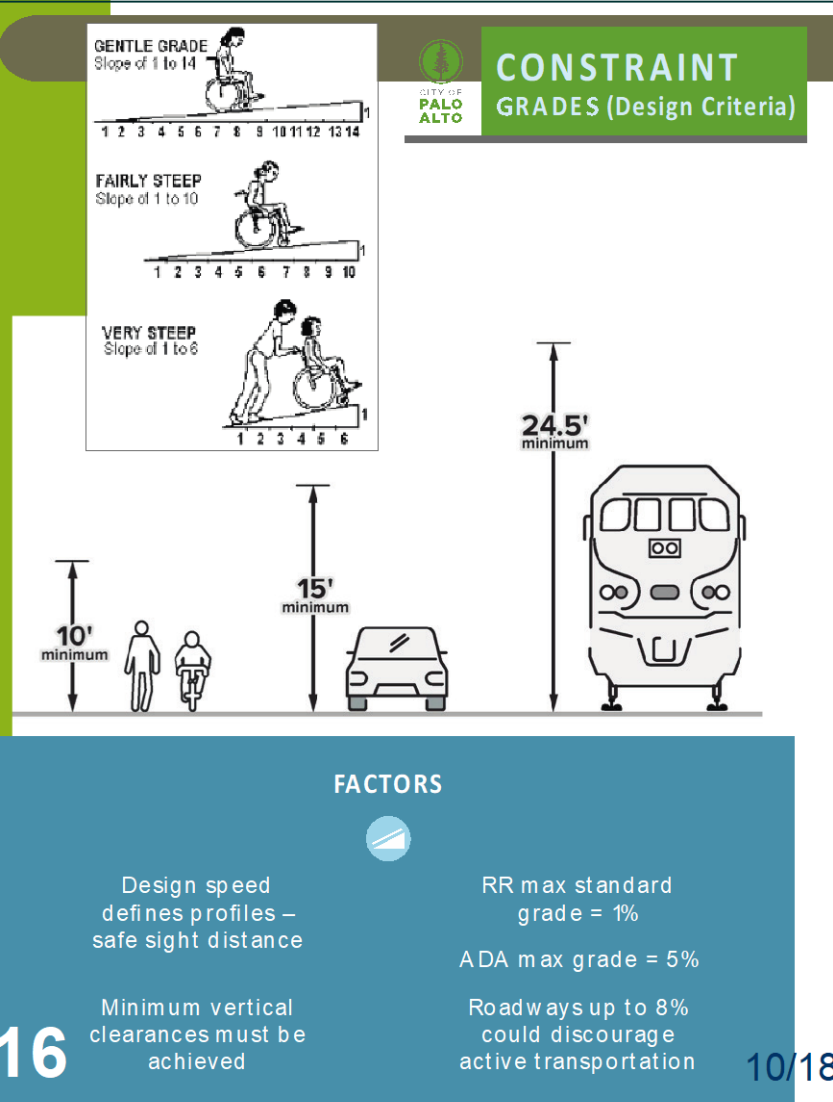
2% grade means the train rises 2 feet in the same 100 feet of run (so it's steeper).

To go up 10 ft, you need 1000 feet of runway (1%), but at 2% you only need 500 feet of runway. **Steeper grades make for cheaper projects!**

Hatch Mott study for Palo Alto: 1% trench cost \$1.15 Billion

2% trench cost \$480 million!

Grade Standards Impact Projects



- Design standards govern steepness of roads and tracks
- For bikes/peds, ADA requires max 5% grade (10 ft min clearance)
- Roadways can go up to 8% grade (15 ft clearance)
- Trains need a more gradual grade than cars, bikes/peds
- Caltrain has a design standard of 1% grade **with a possibility of going up to 2% grade with permission (not on chart!)**.
- Based on what we know, 2% grade is possible (Caltrain standards, UP Contract)
- Freight trains can go 2% and High Speed Rail can go 4-6% (all prefer flatter)



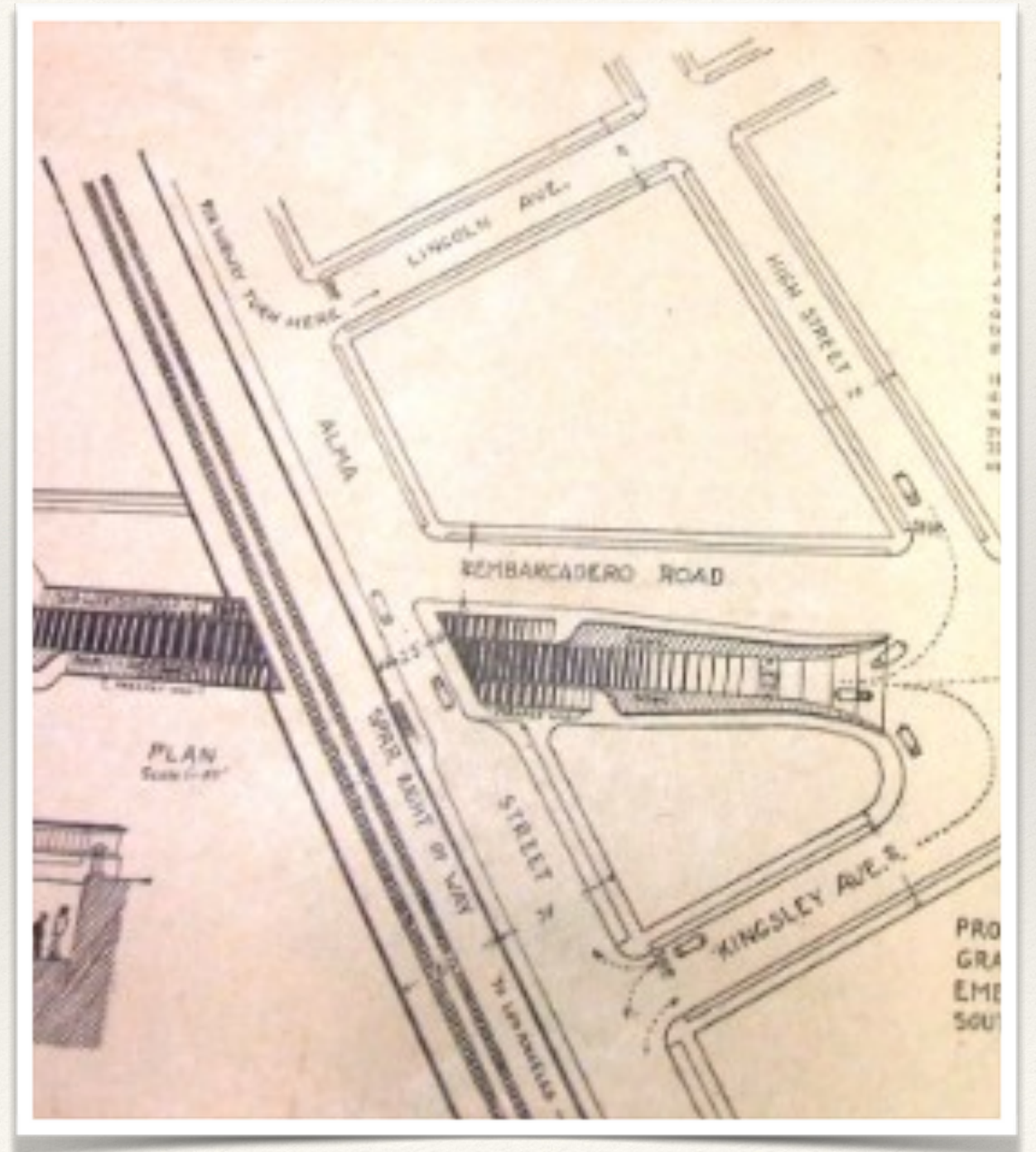
Megan Kanne

Downtown Neighborhoods & Palo Alto Rail Crossings

Professorville
Downtown North
University South

Embarcadero Underpass

- ❖ Thank you to David, Jason, and Tony
- ❖ Interesting ideas worthy of study



Embarcadero Underpass

- ❖ Removed from the scope of work in June¹
- ❖ Measure B funds can't be used
- ❖ Limited resources are available, both with respect to funding and in manpower, to study additional alternatives at this time

¹ See City Council Action Minutes June 19, 2018 <https://www.cityofpaloalto.org/civicax/filebank/blobdload.aspx?t=83343.25&BlobID=65728>

Traffic Study

- ❖ Comprehensive and multimodal
- ❖ Account for GUP / Stanford's growth (3k new units)
- ❖ Make the raw traffic study data **public**
- ❖ Implement **test closures** of the Churchill Ave. and Palo Alto Ave. crossings, both separately and potentially together



“No Build” Options

- ❖ Include the “No Build” options in the options matrix
- ❖ Including a ped / bike tunnel or Homer-style underpass
- ❖ Determine the economic impact of “No Build” options

Rail Committee Recommended Ide				
Type of Separation (Alphabetical Order)	Citywide	Palo Alto 2017 ADT (vehicles/day) = 16,200 (+ 550 bikes)	Churchill 2017 ADT (vehicles/day) = 9,200 (+ 1,020 bikes)	
Closure		Palo Alto Ave Closed, Add Improvements (PCX)	Churchill Ave Closed, Add Improvements (CAX)	
Hybrid (Road over Rail)			Churchill Ave Reverse Hybrid (CAR)	
Hybrid (Road under Rail)		Palo Alto Ave Hybrid and/or Viaduct (PAH)	Churchill Ave Hybrid (CAH)	
No Build / Do Nothing	Default Options			
Rail under Road (Trench)				
Rail under Road (Tunnel)	City-Wide Tunnel within Palo Alto (WBP)			
Rail over Road (Berm/Viaduct)				
Road Over Rail				
Road under Rail				

CITY OF PALO ALTO

Process

- ❖ Improved **outreach** using City resources (email, Twitter, etc)
- ❖ **Signage** at the crossings themselves announcing the project to the public
- ❖ Take the time to **gather data and feedback** before decisions are made to close these vital east/west traffic arteries

Thanks!

Design Alternative for **ONLY Meadow and Charleston**

Nadia Naik

December 17th, 2018

Palo Alto City Council

info@calhsr.com
www.calhsr.com



Californians Advocating
Responsible Rail Design

Problem

- PA residents prefer an underground solution.
- Tunnels at stations are costly (high cost of burying station)
- Trench under Meadow and Charleston may be fatally flawed because of the creeks
- Hybrid and Viaduct options are not well liked

Goal of this concept:

- Creative solution
- Addresses community preference for underground solution
- Increases design alternatives
- Minimize costs and impacts

Design Challenges:

- Caltrain and Freight must maintain operations during construction
- Temporary “Passing Tracks” during construction are highly disruptive and expensive
- Underground utility relocation is complicated and costly
- Matadero, Barron and Adobe Creeks create obstacles to underground alternatives
- Freight trains can’t handle steeper grades and constrain design alternatives
- Diesel freight tunnels require extra ventilation that electric trains don’t need (>\$).

Existing Opportunities?

- Only 3 freight trains per day in PA – all at night and don't impact circulation
- Freight makes up less than 5% of operations on the corridor
- Without freight, we have more design flexibility
- Future Dumbarton Rail Corridor improvements could reduce or eliminate freight trains
- Future freight could be electrified

New Design Alternative:

A short, electric train only tunnel
under Meadow and Charleston ONLY
with a single track of freight on the surface.
Requires **two** twin bore tunnels (TBM)

We are NOT advocating this as a SOLUTION
Only that it be included as an ALTERNATIVE for further study

This is a NEW idea that developed based on the early issues identified by preliminary AECOM engineering – it was NOT part of the original Master List of Alternatives

Electric train tunnel with 1 track of freight on surface



Maladero Creek

Barron Creek

Meadow Dr

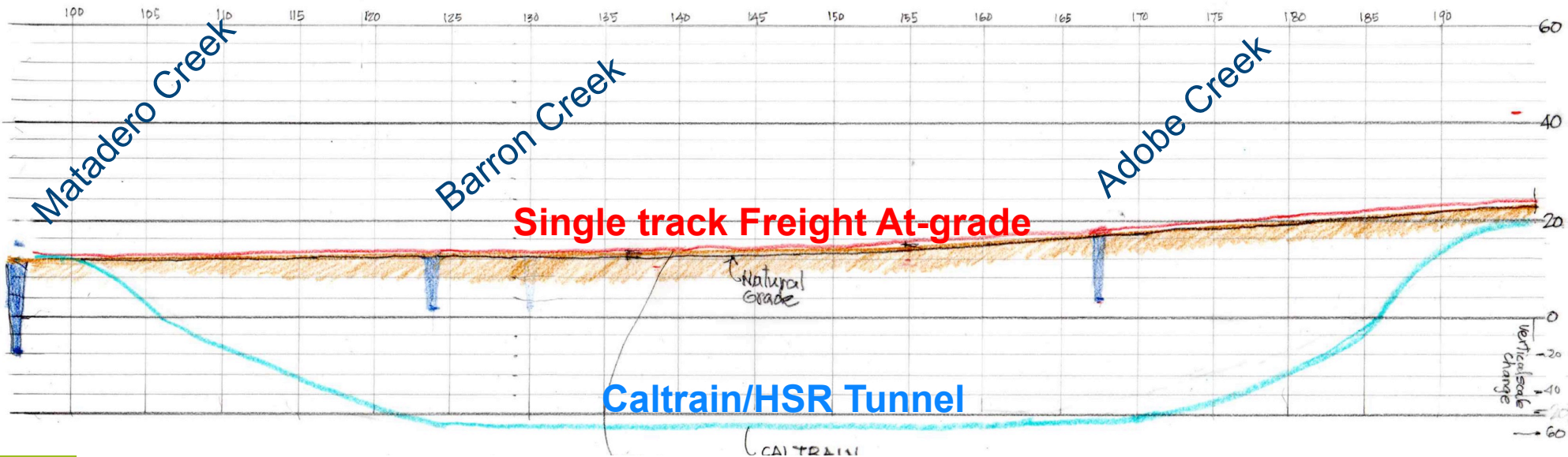
Charleston Rd

Adobe Creek

San Antonio Rd

CALTRAIN TUNNEL

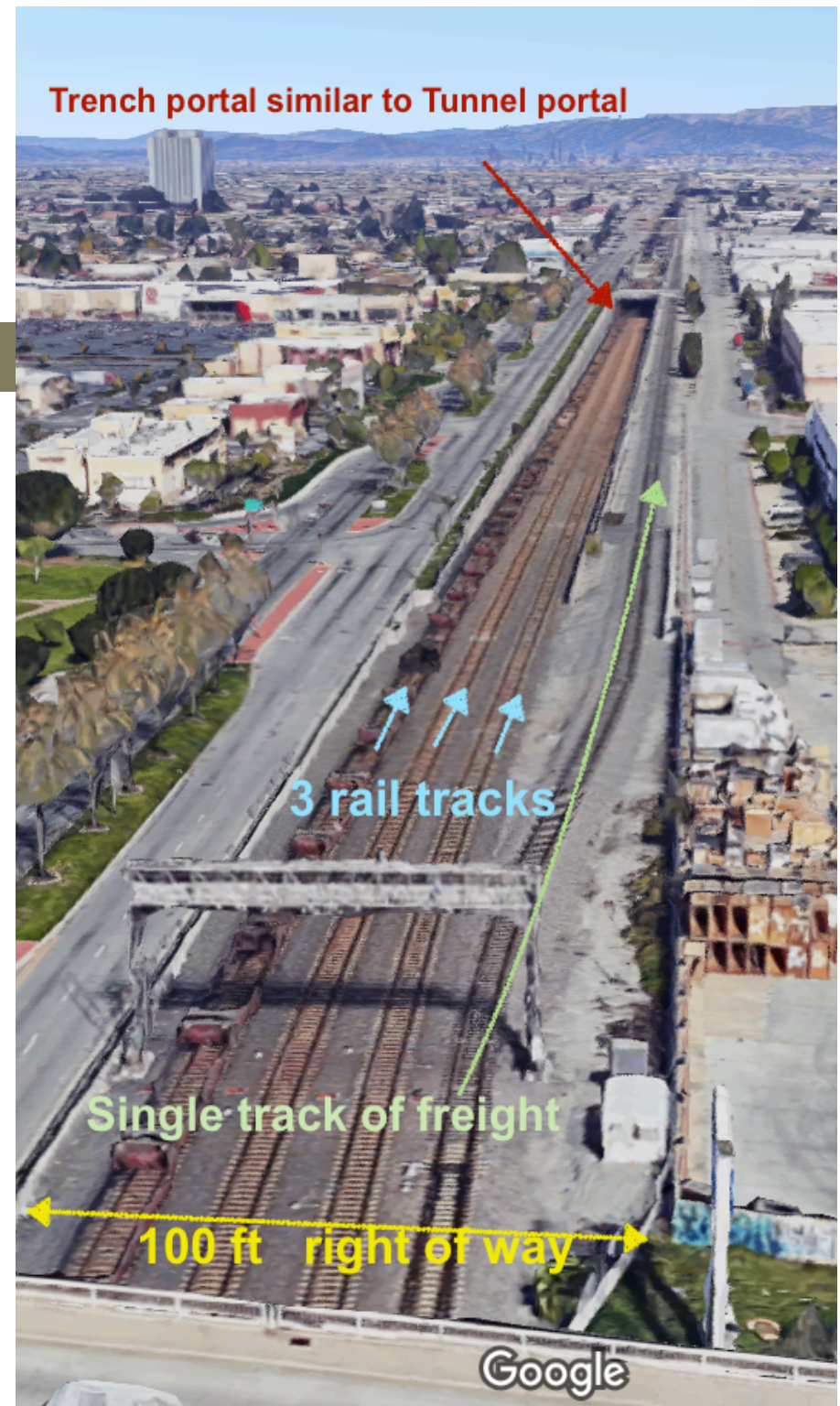
UPRA SINGLE TRACK ON GRADE



Conceptual example

Alameda Trench Corridor (E. Compton Blvd and Alameda Street, Compton)

- NOTE: This shows a TRENCH – we are proposing **TUNNEL**
- Right of Way (ROW) is 100 feet (same as South Palo Alto)
- This ROW fits 4 tracks – PA would have 2 Caltrain (in tunnel) and one freight track (at grade)
- A simple curve is needed to separate the single freight track
- 3 tracks enter a trench in Alameda instead of a tunnel – but similar concept



Considerations:

- Electric only tunnel can be >2% grade (design flexibility)
- Goes under creeks (avoiding potential fatal flaw)
- Tunnel goes under the utilities, reducing the cost.
- Can maintain Caltrain/Freight operations during construction
- Tunnels without a station are much cheaper
- Tunnels are faster to build.
- Construction time is much shorter - less work window issues and little to no road disruption.

Additional Considerations:

- Temporary passing tracks (shoo-fly tracks) only at tunnel portal entrance & exit vs entire right-of-way (saves money)
- With careful planning, TBM's can be reused by other cities
- Some or all future freight may be re-routed over Dumbarton Rail route (currently being studied) leaving space for other land use options.
- **Needs further study:** Temporary space for the tunnel portal **may be** necessary and could require **minimal** commercial or residential eminent domain that could be returned to the commercial/housing stock on completion of the project

Source on TBM Reuse: <https://www.herrenknecht.com/en/services/global-services/tbm-refurbishment.html>

Comparative Project: Central Subway Tunnel in SF

- Built in 2014 in downtown San Francisco
- Two twin bore machines (TBM) with 20.7 ft diameter for 1.7 miles
- \$234 million dollars (2014 dollars)
- Built **under an active BART line**
- Went through various soils: soft to thinly bedded siltstone, shale and sandstone bedrock
- Some soil even deemed “Potentially Gassy with Special Conditions” by Cal/OSHA.
- Navigated steep, turning alignment
- Worked with low cover, urban utilities, and sensitive structures requiring precautions to limit settlement impact and ensure the structures in downtown SF were safe.

View of Central Subway Twin Bore Tunnels



View of TBM Extraction Point



(above) View of Low Clearance under which Central Subway was built (and under ACTIVE BART line!)

Cost Comparisons

In 2014, Hatch Mott MacDonald estimated a trench under Meadow and Charleston (2% grade) would be \$480 M. (Source: HMM Study 2014)

In 2018, AECOM estimated same trench would be \$800 - \$950 M – so costs have almost doubled since 2014. (Source: PA Community Meeting 11/14/18 slide 41)

	Hybrid	Viaduct	Trench	Short Tunnel (no freight)
Estimated Cost 2018 \$	\$200M - \$250M	\$400M - \$500M	\$800M – 950M	\$400M - \$550M*

**CARRD estimated the Short Tunnel (No freight) alternative based on 2x price of similar 2014 SF Central Subway tunnel project in downtown SF*

Note: Costs could potentially be reduced further (next slide)

Reducing Tunnel Cost further

- Reducing the tunnel diameter helps lower costs
- 2014 – HSR White paper on Tunneling - significant cost reductions by reducing max operating speeds assumptions from 220 to 200 mph thus reducing tunnel diameters from 29.5' to 28' ID (Inside Diameter).*
- AECOM studying City Wide tunnel with freight used 28' Inside Diameter (assumes 200 mph)
- Tunnel diameter can be reduced since Caltrain/HSR will only operate max 125 mph on Peninsula
- Caltrain Electrification EIR shows that San Francisquito Creek bridge will have a maximum clearance of just 19ft. (See CARRD's previous public comments re: Vertical Clearance assumptions)

Direct Comparison of Tunnels

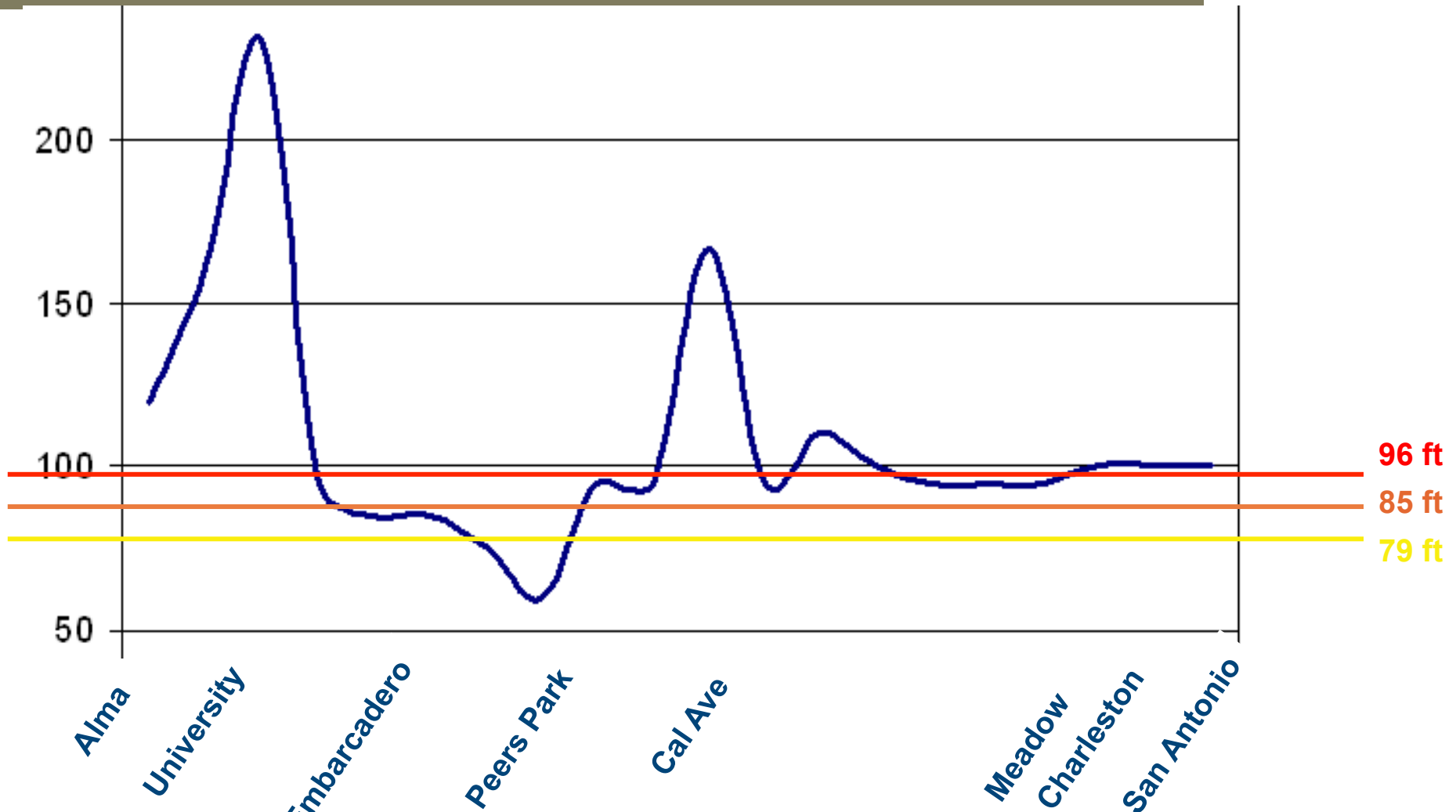
	Central Subway No freight	PA Short Tunnel No freight
Length:	1.7 miles	1.6 miles
Tunnel Diameter:	20.7 ft	28ft* (could be reduced)
Constraint:	Built under active BART	Under active Caltrain
Soil types:	5 various soil types including hazardous soils	Unknown but PA Tunnel White Paper says suitable for tunneling
Setting:	Dense urban setting	Empty suburban ROW
Conditions:	Steep, turning alignment with vertical clearance issues	Relatively flat, straight alignment with no vertical clearance issues
Special Circumstances:	Required special planning to support adjacent tall buildings	No buildings in ROW and no adjacent skyscrapers

Final Thoughts

- CARRD is NOT advocating that this is THE alternative – only that it be given further analysis
- Further preliminary analysis and study is needed and warranted for this alternative given strong community preference for underground solution.
- Too early to evaluate if this is the right solution vs. other design alternatives – need more info

Appendix

Palo Alto Right Of Way Widths



*Approximate – not perfectly to scale. Not official diagram.

MEMO

To: James Keene, City Manager
Ed Shikada Assistant City Manager
Rob de Geus, Deputy City Manager
Heather Dauler, Intergovernmental Affairs Officer

From: Christopher Townsend, President, Townsend Public Affairs, Inc.
Niccolo De Luca, Senior Director
Alex Gibbs, Senior Associate

Date: November 26, 2018

Subject: Suggested strategy regarding grade separation funding and opportunities

SUMMARY

Townsend Public Affairs, Inc. (TPA) has prepared this memo for the City of Palo Alto outlining potential opportunities to secure grade separation funding, the various aspects to consider, proposed next steps, and other items.

This memo is intended to provide background, identify some of the challenges we would face, and make recommendations for the City to consider. TPA has secured grade separation funds over the years and we have first hand knowledge on what it takes to be successful.

1. Overview

Successfully securing grade separation funding takes time, patience, and persistence. The top priorities for these competitive funds are to support goods movement and address safety and mobility issues. TPA will tell our Palo Alto-specific story, help build up a regional coalition, work with our legislative delegation and others to first educate and then work on funding opportunities.

2. Recommended strategy Phase 1

Due to the competitive nature of these funds, and the large price tag involved, we recommend education as the first phase of advocacy. We need to create briefing materials that explain the problem, what we are doing to address it locally, and why additional outside funding is needed for project completion.

We need to be able to clearly articulate what problem we are trying to solve and provide data to back it up such as estimated design and construction costs, future traffic counts, future bicycle and pedestrian counts, negative air quality from cars idling, the benefits of commuting, as well as any potential negative impact of electrification on neighborhoods.

3. Recommended strategy Phase 2

Once our materials are complete, we recommend multiple advocacy trips to Sacramento to meet with decision makers, legislators, and members of the new Administration. It would be very helpful if this delegation would include the Mayor or others on the Council.



Meetings targets would include, but not be limited to:

- The State Transportation Secretary
 - a. More than likely Governor-Elect Newsom will appoint his own Secretary
- The Executive Director of the California Transportation Commission (CTC) and her top staff
- Caltrans executives who oversee rail
- Palo Alto's legislative delegation Senator Jerry Hill and Assembly Member Marc Berman
- Neighboring members such as Senator Wiener, Assembly Members Mullin and Ting
- Senate Transportation and Housing Chair Jim Beall and his committee staff
- Assembly Transportation Chair Jim Frazier and his committee staff
- Vice Chair of the Senate Transportation and Housing Committee
- Vice Chair of the Assembly Transportation Committee

After our advocacy trips, we will have briefed many stakeholders and decision makers. From our experience, it's prudent to keep them continuously updated and in the loop so they become vested in our efforts. The form of these updates can be in person briefings, email updates, or written updates.

4. Multiple funding sources

We recommend identifying multiple funding sources as the final price tag of the overall grade separation needs in the City could be high. This includes federal, state, regional and local funding sources.

Funding opportunities including the following existing programs, and, fortunately, with the SB1 funds withstanding a recall, there are other options available, such as:

California Public Utilities Commission:

- The Section 130 Grade Crossing Hazard Elimination Program provides federal funds to local agencies (cities and counties) and railroads to eliminate hazards at existing at-grade public highway-rail crossings.
- The Section 190 Grade Separation Program provides state funds to local agencies to grade-separate at-grade crossings (crossings), or to improve grade-separated crossings.

California Transportation Commission:

- Solutions for Congested Corridors Program (SCCP). The purpose of the Solutions for Congested Corridors Program is to provide funding to achieve a balanced set of transportation, environmental, and community access improvements to reduce congestion throughout the state.
- Local Partnership Program (LPP). The Road Repair and Accountability Act of 2017 (Senate Bill 1) created the Local Partnership Program, which is modeled closely after the Proposition 1B State Local Partnership Program. The purpose of this program is to provide local and regional transportation agencies that have passed sales tax measures, developer fees, or other imposed transportation fees with a continuous appropriation of \$200 million annually from the Road Maintenance and Rehabilitation Account to fund road maintenance and rehabilitation, sound walls, and other transportation improvement projects.



5. Opportunities for partnerships

The electrification of Caltrain will have an impact on Palo Alto and other cities throughout the Peninsula. This works to our advantage for two reasons. The first is it helps us build a coalition of municipalities and other organizations to frame this as a regional matter. The second is by growing our coalition we can increase the likelihood of securing funding or better yet creating a specific funding source for cities to access for grade separation projects.

6. Potential barriers

As highlighted in the overview section, it could take multiple years to secure all the funds needed to fully address grade separation locations throughout the City. Other potential barriers could include requests for design exemptions, state wide demand for these funds, and regional needs.

7. Next steps

Depending on the feedback and discussion to the points above impacts our next steps. However, we recommend the creation of briefing documents as soon as possible so we can then shift to briefing and educating decisions makers in Sacramento.



NOVEMBER 2018 EMAILS TO CITY.COUNCIL ABOUT CONNECTING PALO ALTO GRADE SEPARATION

From: [Sumita Debata](#)
To: [Council, City](#)
Subject: [Request] Underground the Train option
Date: Wednesday, November 14, 2018 8:25:44 AM
Attachments: [IMG_20161228_102715.jpg](#)
[IMG_20161228_103701.jpg](#)

Subject: Intent to voice vote for underground the train option.

Hi Team,

In 2016 December there was a CALTRAIN accident near Charleston. The train and car crash rolled into my backyard in Park Blvd. Almost 10-15ft inside my backyard breaking the fence. I live with my family and kids and it's was very scary seeing the train car crash inside my backyard.

Train above the ground is very dangerous option having been through personally. My vote is to underground the train.

Train accident after crash picture attached for reference.

Thanks,
Sumita

From: [Larry and April Alton](#)
To: [Council, City](#)
Subject: Alma street train crossing
Date: Wednesday, November 14, 2018 6:13:09 PM

Dear Council Members,

I believe the best train crossing for Alma would be tracks under the road and creek. Alma is one of the main entrances to Palo Alto and we want it to be beautiful and representative of our high class city! This is certainly possible from an engineering standpoint and the additional cost would not be that great considering the overall cost of the train route thru Palo Alto.

Thanks,
Larry Alton

From: [Florence LaRiviere](#)
To: [Council, City](#)
Subject: Caltrain Electrification
Date: Tuesday, November 13, 2018 4:46:01 PM

Dear Rail Committee and City Council members,

I ask you to please add Charleston/Meadow tunnel (passenger train tunneled, freight at grade) to the AECOM work plan for further detailed review. Some have suggested that moving the tunnel eastward towards Alma would be a less impactful location. Please spend the time and resources to seriously study the underground options in this part of town. It seems like it is time to eliminate or merge the raised options.

Rail Committee members, we respectfully request that at your meeting tomorrow the above issues be added to the City Council agenda so that AECOM can proceed.

Thank you for the work done so far in this complex and far reaching project.

Yours sincerely, Florence and Virginia LaRiviere

From: [Florence Keller](#)
To: [Council, City: cory.wolbach@gmail.com; adrianfine@gmail.com; Filseth, Eric \(external\); kou.pacc@gmail.com; tomforcouncil@gmail.com; greg@gregtanaka.org; Scharff, Greg; electcormack@gmail.com](#)
Cc: [Palo Alto Citizens](#)
Subject: Charleston/Meadow Rail Crossings
Date: Tuesday, November 13, 2018 3:58:40 PM

Dear Board Members.

First, thank you for all you do.

Thank you also for responding to the sensitivities of Palo Alto Residents by assiduously avoiding invoking eminent domain in your consideration of how best to address the issues posed by the enhanced numbers of trains projected to travel through our intersections. The truth is, however, that for the neighbors most immediately affected by Caltrain (I do not count myself among these), the notion of having a 14 foot (or 40 foot when there is a train passing), berm or a Viaduct in their backyard--eliminating even the pretense of pleasure or privacy in one's backyard, may be worse than eminent domain. (I choose not to dwell on the horrors of living in these houses during the construction period of whatever choice you make,) And economically speaking, those folks whose properties immediately abut the railroad, are about to be slammed. I noticed this weekend that the sales prices of two houses that are for sale and situated immediately adjacent to the rails between Charleston and Meadow have been reduced. I do not believe either of them have yet been sold. You worry about what citizens of Palo Alto will have to pay for a trench or a tunnel, but those living in the neighboring residences will, I expect, end up paying substantially more, financially, acoustically, and visually, if a berm or viaduct is the solution selected by you.

Palo Alto is too important, and frankly too rich, to make major decisions based primarily on economics. And, in considering the various solutions to problems posed by the increased numbers of trains, I hope you will not, as Boards in the past have so frequently done, put the greatest burden on South Palo Alto residents. A tunnel, or at least a trench, is the only humane approach to this problem.

Sincerely,

Florence Keller

4124 Wilkie Way

From: [Phil Burton](#)
To: [De Geus, Robert](#)
Cc: [Council, City](#); ["Chris Logan"](#); [Carrasco, Tony](#); ["Dave Shen"](#); ["Greg Brail"](#); ["Inyoung Cho"](#); ["Megan Kanne"](#); ["Kari Hodgson"](#); ["Mandar Borkar"](#); ["Parag Patkar"](#); ["Patricia Lau"](#); ["Nadia Naik"](#)
Subject: Concern and frustration about lack of effective communications
Date: Thursday, November 15, 2018 5:41:37 PM
Attachments: [image002.jpg](#)

Rob,

At the most recent City Council Rail Committee meeting, the third of three handouts was a June 28, 2017 letter from then mayor Scharff to Francisco Castillo, Director of Public Affairs, Union Pacific Railroad. I was surprised to read the following:

"The electrification of Caltrain will allow for higher grades, *as electric service can easily deal with up to a two percent grade.*" [my italics] The maximum grade has been a central point of both Rail Committee and CAP meeting discussions, because of the impact on construction costs as well as feasibility of certain alternatives. To the best of my knowledge, no one on staff ever stated that the elected officials or staff already understood this point. When several speakers, including me, made this point at various meetings, there was no staff response in the spirit of, "We already understand this point, and are prepared to raise it with Caltrain and/or UPRR."

I find it surprising and a bit frustrating that CAP members and members of the general public (speaking at Rail Committee meetings) aren't aware of the full history of this key issue. With full awareness of the history, CAP members can be more effective as intermediaries between project staff and residents of our respective neighborhoods.

The online search "Union Pacific RR shortline RFP process" yields a link <http://www.caltrain.com/Assets/Public+Affairs/pdf/UP+Agreement+FAQs.pdf>, a March 1, 2017 *Caltrain / UP Agreement*. *The FAQ contains this question and answer:*

However, the link in the answer is no longer valid.



Thus we have no way to know if and how the UP responded to Mayor Scharff's letter, yet an understanding of their response, if any, might have a vital bearing on current discussions of this issue. Is there any way for staff to provide CAP members, or the general public, with copies of the relevant documents?

The other key issue involving UP is vertical clearance above top of rail. Has there been any correspondence with UP on this issue?

I would like to point out that electric multiple-unit trains can easily climb a grade of well over 2%. I am personally familiar with grades on the New York City Transit System, which also uses electric MU trains. You can read here that there are several locations on this system with grades over 4%. <https://www.nyctransitforums.com/topic/39935-what-is-the-steepest-grade-that-subway-cars-can-handle/>

Respectfully,

Phil Burton

From: [Rachel Kellerman](#)
To: [Council, City](#); [Shikada, Ed](#); [De Geus, Robert](#); [Gaines, Chantal](#)
Cc: [Tom Kellerman](#); [Megan Kanne](#); [Barbara Ann Hazlett](#); [YORIKO KISHIMOTO](#)
Subject: Connecting Palo Alto Mailer - Neighborhood Traffic Impacts Decision Criteria Not Included
Date: Thursday, November 8, 2018 12:26:14 PM
Attachments: [IMG_8200.JPG](#)

Dear Honorable City Council Members, Mr Shikada, Mr de Geus, Ms Gains,

I attended the CAP meeting yesterday and was dismayed that the decision making criteria concerning the local traffic impacts of all rail grade crossing options was omitted from the Connecting Palo Alto mailer that is being sent to all Palo Alto addresses. Criteria bullet point 8 on the mailer reads: *Maintain or improve local access* while on the Connecting Palo Alto Fact Sheet posted on the Connecting Palo Alto webpage it reads: *Maintain or improve local access while reducing regional traffic on neighborhood streets*. (References: https://pagradesep.com/wp-content/uploads/2018/08/City_of_Palo_Alto_FactsheetV2.pdf I have also attached my copy of the mailer-apologies for the scribbles.)

Why is this important? Council has instructed staff to consider neighborhood traffic impacts when weighing all rail grade crossing options. Neighborhood traffic impacts should not be an afterthought, but an integral part of the consideration process. I don't have enough neighborhood input to speak authoritatively on a number of issues related to rail grade crossings, but I know without a doubt that neighborhood traffic is a huge concern for Professorville neighbors if Churchill and Palo Alto Avenue are closed to East/West traffic. Neighborhood traffic reduction criteria also did not appear on the "decision matrix" slides that were presented yesterday.

We are not asking for the mailer to be reprinted but we are asking that all future communication, especially the decision making matrices that are presented at community meetings, include the entire criteria as agreed upon by the Council and posted on the CAP webpage: *Maintain or improve local access while reducing regional traffic on neighborhood streets*.

As always, we greatly appreciate all your hard work on this difficult and complicated matter.

Regards,
Tom and Rachel Kellerman



From: [Marilyn Bauriedel](#)
To: [Council, City](#)
Subject: Further concerns about Rail Crossings in Palo Alto
Date: Monday, November 12, 2018 9:27:24 PM

Dear Mayor Kniss and City Council Members:

As you continue to work on the options and plans for the Palo Alto rail crossings I would urge you to do the following:

Add Charleston/Meadow tunnel to the AECOM work plan for next level detail;

Have AECOM explore moving the trench towards Alma (Eastward) to further reduce the impact on residential properties, and

Eliminate or merge the raised options; eliminate Viaduct and/or merge with Hybrid; spend more time and resources on studying underground options.

I live in the Fairmeadow Eichler neighborhood and will be very much affected by how these new crossings are handled.

Thank you.

Marilyn Bauriedel
3673 South Ct
Palo Alto

Marilyn U. Bauriedel
mbauriedel@ursu.com

From: [Tracy Mallory](#)
To: [Council, City](#)
Subject: grade separation of rail crossings
Date: Monday, November 19, 2018 10:03:34 AM

As one of many residents commenting on the project, I'd like to ask if the project evaluation criteria ever included loss of property value with the various options, and also ask again why the reversed hybrid option has been dismissed?

If an above grade-level option for the train of any kind is selected the increase in noise, especially at night and the visual blight (especially during the day;-) will obviously have a dramatic effect on the value of properties on either side of the tracks, with greater reductions closer to the rail line.

It should not be hard to get some "real" estimates, but the following is more likely to be low than high.

Conservatively:

1 mile of significantly impacted housing, call it 50 lot lengths along the route, but could be twice this

5 lots deep on each side seriously affected - lose 10% property value

10 lots further on each side moderately affected - lose 5% property value

10 lots further mildly affected - lose 2.5% property value

On east side average property value is ?? 2.5M

On west side average property value is ?? 2M

$$\begin{aligned} & ((250 * 2M) + (250 * 2.5M)) * 0.1 + \\ & ((500 * 2M) + (500 * 2.5M)) * 0.05 + \\ & ((500 * 2M) + (500 * 2.5M)) * 0.025 \end{aligned}$$

$$= \$281,250$$

It's pretty clear why a lot of residents are very upset about the direct cost to them of a cheap solution. It is not acceptable to compare this to existing raised track solutions farther north. Once you get to Redwood city there are relatively few houses along the route, but south Palo Alto is all single-family housing.

I'm surprised that the "other" hybrid option of raising the roads and lowering the rail line has been dismissed. I would be very distressed by having my house taken as a result of eminent domain needs, but losing ten houses, perhaps paying the owners twice what they are worth, would be much, much cheaper than impacting thousands of homeowners for the rest of their lives and dividing the south end of the city permanently with visual as well as a physical wall. We don't need massive structures of the magnitude of San Antonio Road. Although fairly wide, the roadway could have quite a low load limit, requiring trucks to use San Antonio or Oregon as today. Sink the train 15 feet (not 30) which would put it 17 feet below where it is today (it's above grade now) and raise the road 10 feet and everyone except for a few well-compensated home-owners will be much happier than with any of the current plans.

Sincerely,

Tracy Mallory
650-279-0037

PS: Here's the math:

```
>>> expr \(\( 500 \* 2000000 \) + \( 500 \* 2500000 \) \) \* 5 \vee 100 \) \+ \(\( 500 \* 2000000 \) + \( 500 \* 2500000 \) \) \* 25 \vee 1000 \) \+ \(\( 250 \* 2000000 \) + \( 250 \* 2500000 \) \) \* 10 \vee 100 \)
281250000
```

From: [Nadia Naik](#)
To: [Council, City](#)
Cc: [De Geus, Robert](#); [Shikada, Ed](#); [Elizabeth Alexis](#); [Megan Kanne](#); [Parag Patkar](#); [Mandar Borkar](#); [Goodwin Eileen](#); [Keene, James](#); [Chris Logan](#); [Dave Shen](#); [Philip Burton](#); [Carrasco, Tony](#); [Inyoung Cho](#); [Greg Brail](#); [Levin, Adina](#); [etty.mercurio@aecom.com](#); [millette.litzinger@aecom.com](#); [Kari Hodgson](#); [Patricia Lau](#); [Penny Ellson](#)
Subject: Grade Separation Suggestion: Alternate Viaduct Design
Date: Thursday, November 29, 2018 4:04:41 PM

Dear City Council,

As we consider viaduct alternatives, I wanted to send along another idea for a viaduct that has a lower profile - a "U-shaped grade separation."

The full details are available here:

<https://caltrain-hsr.blogspot.com/2015/11/the-u-shaped-grade-separation.html>


Nadia Naik

From: [Roland Lebrun](#)
To: [Council, City](#)
Cc: [Nadia Naik](#); [Keene, James](#); [Shikada, Ed](#); [De Geus, Robert](#); [apexstr@pacbell.net](#); [etty.mercurio@aecom.com](#); [millette.litzinger@aecom.com](#)
Subject: London's high speed tunnel diameters and costs
Date: Wednesday, November 28, 2018 1:25:12 AM
Attachments: [HS1 Tunnel diameters.bmp](#)
[Slide1.GIF](#)
[Slide1.GIF](#)

Dear Council members,

Further to Nadia Naik's comments about reduced tunnel costs achieved through context-sensitive tunnel design, London's high-speed tunnels were designed with a 23.5-foot internal diameter and were tested at 160 MPH: <https://youtu.be/Uv14yLjqvM>

Please refer to the attached file for the cost of the tunnels, portals (including a freight connection), vent shafts and the 1/4 mile open trench station 25 seconds into the video

	<h3 data-bbox="743 856 1411 951">Eurostar test train running at 255 kmh in London Tunnels</h3> <p data-bbox="743 982 1411 1108">This is the only footage available of a Eurostar test train running at Maximum Test Speed + 10% (255 km) on the Section 2 of the London Tunnels on the Channe...</p> <p data-bbox="743 1140 1411 1213">youtu.be</p>
--	---



Sincerely,

Roland Lebrun

From: [The Cowies](#)
To: [Keene, James](#); [Shikada, Ed](#); [De Geus, Robert](#); [Council, City](#); cory.wolbach@gmail.com; adrianfine@gmail.com; [Filseth, Eric \(external\)](mailto:Filseth, Eric (external)); kou.pacc@gmail.com; tomforcouncil@gmail.com; greg@gregtanaka.org; [Scharff, Greg](#); electcormack@gmail.com
Subject: Please tunnel the train at Meadow and Charleston
Date: Monday, November 12, 2018 10:48:50 PM

Hi Folks,

Please keep working on getting the train tunneled at Meadow and Charleston. It's super important in so many ways. Thanks for all you are doing!!

Liz Cowie
El Dorado Ave
Palo Alto

From: [Nadia Naik](#)
To: [Council, City](#)
Cc: [Keene, James](#); [Shikada, Ed](#); [De Geus, Robert](#); [Goodwin Eileen](#); etty.mercurio@aecom.com; millette.litzinger@aecom.com; [Elizabeth Alexis](#)
Subject: Public Comment: Request to add an alternative for study for the Meadow/Charleston Grade separations
Date: Monday, November 12, 2018 9:11:22 PM
Attachments: [CARRD Comment - Short Electric tunnel only recommendation.pdf](#)

Dear City Council Members,

We support the Staff Report recommendation to not eliminate any grade separation alternatives at this time. While the Viaduct is the least favored alternative, it remains worthy of further analysis because it is the lowest cost and allows more connectivity than a Hybrid (which functions effectively as a wall).

In addition, we would like to propose an alternative that was mentioned previously: a short tunnel for electrified trains, with freight remaining at the surface.

Please see the attached letter for further details.

If you have any questions, please let me know.

Nadia Naik
Co-founder, CARRD



Californians Advocating
Responsible Rail Design

November 12, 2018

Subject: Recommendation of adding alternative of short tunnel for electrified trains only with freight at the surface for Meadow and Charleston alternatives.

Dear City Council Members,

We support the Staff Report recommendation to not eliminate any grade separation alternatives at this time. While the Viaduct is the least favored alternative, it remains worthy of further analysis because it is the lowest cost and allows more connectivity than a Hybrid (which functions effectively as a wall).

In addition, we would like to propose an alternative that was mentioned previously: a short tunnel for electrified trains, with freight remaining at the surface. The slope, clearance, ventilation and Fire Life Safety requirements driven by freight and other diesel trains in the tunnels add significant costs to the tunnel proposal currently under consideration. Freight tentatively remaining at the surface for the present would not liberate all of the ROW land for other uses, but the vehicular crossing capacity issue would be addressed.

A key condition has recently changed along the corridor making this a feasible alternative; Caltrain is no longer considering running both diesel and electric trains and will now have a fully electric fleet. In addition, the Dumbarton Rail project recently received approval to begin its investigation of whether to rebuild the old rail bridge that formerly carried freight across the Bay. If this came to fruition, freight might be partially or fully diverted to a Dumbarton route and no longer pass through Palo Alto, leaving the right-of-way above the tunnel free for other uses.

We have identified a similar tunneling project, the San Francisco Central Subway Tunnel, which seems to indicate that tunneling may even be much cheaper than a trench.

HMM Trench Study:

As you may recall, in 2014, HMM gave a rough estimated cost for a trench below Meadow and Charleston at \$488 Million (in 2014 dollars).

Here was the breakdown:

Description	Unit	Unit Cost	Rail Trench 1% Max Grade (Caltrain Preferred)		Rail Trench 2% Max. Grade (w/Design Exception)	
			Qty	Total Cost	Qty	Total Cost

Estimate Summary

Construction				622,440,744		289,191,768
Utility Relocation and Protection				213,300		104,400
Subtotal A				622,654,044		289,296,168
Professional Services (% of Subtotal A)		35%		217,928,915		101,253,659
Right of Way (incl. ROW Services)				-		-
Subtotal B				840,582,960		390,549,826
Contingency (% of Subtotal B)		25%		210,145,740		97,637,457
Total Project Cost (2014 dollars)				1,050,728,700		488,187,283

note 1) Professional Services includes Design Engineering, Project Mgmt, and Construction Mgmt.

Central Subway Tunnel Without Freight

Also in 2014, the Central Subway project in San Francisco completed a 1.7 mile dual subway tunnel using two 20.7 ft diameter tunnel boring machines (TBM). While the overall cost of the project is very high, the vast majority of the cost is related to several very deep and complex stations. The cost to complete the tunnel portion of the project: \$234 million dollars (2014 dollars). For reference, the distance from Loma Verde Ave to San Antonio Road in Palo Alto is 1.6 miles. Palo Alto would likely have a additional costs beyond what was needed on the subway project (signaling, larger diameter bore, etc.) but the price difference is worth investigating and maybe minimal with the use of a single bore tunnel.

Unlike Palo Alto's right of way, these tunnels were built in densely urban San Francisco and **under an active BART line**¹. The TBMs went through various soils ranging from soft soils to thinly bedded siltstone, shale and sandstone bedrock - with some area designated as "Potentially Gassy with Special Conditions" by Cal/OSHA². The TBMs also had to navigate the

¹ <http://www.therobbinscompany.com/project-category/epb-tbm/>

² <http://www.therobbinscompany.com/project-category/epb-tbm/>

steep and turning alignment in an area where they dealt with low cover, nearby utilities, and sensitive structures requiring analyses and precautions to limit settlement impact and ensure the structures in downtown SF were safe. Given Palo Alto is in a suburban area with less constraints, it seems reasonable to consider this alternative closely.

Palo Alto Short Tunnel

Another way to reduce the cost of a tunnel is to reduce the diameter. In 2014, the High Speed Rail Authority's White Paper on Tunneling describes how they achieved significant cost reductions by reducing maximum operating speeds assumptions in the tunnels from 220 mph to 200 mph, thereby allowing them to reduce tunnel diameters from 29.5' to 28' ID (Inside Diameter).³

CARRD requested from AECOM information on the tunnel assumptions being used for the City wide tunnel (which include freight) and they responded that they are using a "28 ft Inside Diameter Tunnel" which would large enough to allow 200 mph speeds. A significantly smaller diameter would be required to accommodate planned speeds of 110 mph. And, as noted in our previous public comment on height clearances, the Caltrain Electrification EIR specifically notes that the clearance levels at the San Francisquito creek bridge (where freight passes today) is actually 19ft. It is therefore worth investigating whether the tunnel dimensions for a short, electrified train only tunnel in Palo Alto where maximum speed for both Caltrain and HSR is 110 miles per hour would allow us to have a tunnel diameter that is less than 28'.

Other key things to consider for the short tunnel with freight on the surface (EOT) option:

- Without freight, the 1% grade requirement could more readily change to 2% or even 3% grade, which would allow for more design flexibility.
- Caltrain and freight could continue operations during construction with minimal disruption except at the site of tunnel boring machine entrance and exit.
- Traffic during construction would be minimally disrupted
- Tunnels in stations are expensive, but this option would not impact stations
- Tunnels are faster to build. Construction time is dramatically reduced because the work window issues and the phasing required on the road side are much less.
- It would go under the utilities, reducing the cost.
- It could go under the creeks.
- It does not impact the streets.
- The equivalent of shoofly tracks are needed near the portal, but not along the entire right-of-way.

³ California High-Speed Rail Program Whitepaper On Cost Reduction Strategies, July 25, 2014

- With careful planning and analysis, TBM's can be reused - perhaps by other cities along the corridor.⁴
- In the future, some or all freight could be re-routed over the Dumbarton Rail route (currently being studied) thus freeing up space along the right-of-way for other potential land use options.
- **Temporary** space for the tunnel portal may be necessary and could require minimal eminent domain that could be returned to the housing stock on completion of the project.
- The ROW closer to San Antonio road is much wider than other parts of the City (150 ft wide). If the TBM was launched from that end, then the removal requires less space.

To see the space required for extracting a TBM, see this video showing the removal of the TBMs used on the Central Subway project in SF. <https://bit.ly/2PpntNC> Note the size of the extraction point is quite small.

Summary:

Preliminary design of grade separations are vague and costs climb when one considers the issues of staging, prolonged construction, utility relocation, ground water issues, and maintaining operations on a heavily trafficked railway during construction. What initially seems like a cheaper solution, can become expensive quickly when these costs are all tallied up. For this reason, we support the inclusion of a short electric train only tunnel with freight on the surface.

If you would like any additional information or have any additional questions, please let us know.

Sincerely,

Nadia Naik and Elizabeth Alexis
Co-founders
CARRD

⁴ <https://www.herrenknecht.com/en/services/global-services/tbm-refurbishment.html>

From: [Gregory Brail](#)
To: [Council, City](#)
Subject: Public comment: Request to stop removing grade separation options
Date: Monday, November 12, 2018 10:31:29 PM

Dear City Council Members:

In advance of Wednesday's Rail Committee meeting, I am writing to request that the Council hold off on eliminating any more grade separation options for South Palo Alto until the Council and staff are able to gather more information and hear more public input.

At the previous Rail Committee meeting, a proposal was made to eliminate the viaduct option from consideration. I urge the Council and Committee to wait until we all have more information before making this decision.

As a member of the Community Advisory Panel on Grade Separation, I am concerned that the Council is moving quickly to limit our choices without giving the staff and the CAP enough time to understand the options and share them with the entire city.

When all is said and done, I believe that the viaduct may not be as obvious a non-starter as many believe. For example:

- Without detailed engineering drawings and 3D graphics, it is premature to make assumptions about the visual impact of a 20' viaduct versus a 15' embankment.
- Similarly, without a thorough understanding of the impact of a 30' deep trench on our creeks and on the surrounding community, it is premature to move this solution closer to reality by eliminating an alternative.

I hope that the Council can instead continue to carefully study the matter, reach out to the community, staff, and the CAP. We will all be able to make a considered decision together in a few months.

Gregory Brail
2046 Edgewood Drive
greg@brail.org

From: [Laurie Winslow](#)
To: [Council, City](#)
Subject: Put the train Underground
Date: Friday, November 9, 2018 11:03:41 AM

Dear City Council,

On the subject of what to do with Caltrain through the City of Palo Alto, my vote is to put the train Underground or at the very least in a trench. Underground would have the added advantage that we could have bike paths and walking paths and a linear park on the top. It also doesn't divide the city the way the current proposal to close roads would.

Laurie Winslow

From: [Lindsay Joye](#)
To: [Council, City](#)
Cc: [Keene, James](#); [Shikada, Ed](#); [De Geus, Robert](#); "Mandar Borkar"
Subject: Rail Committee Motion Request
Date: Tuesday, November 13, 2018 2:03:50 PM

As a 25 year resident of Palo Alto with a home on Park Blvd. adjacent to the Caltrain Right of Way, I am requesting that the Rail Committee motion to place the following items on the next City Council meeting agenda for approval:

- 1. Add the Charleston/Meadow tunnel (passenger train in tunnel and freight at grade) to AECOM's work plan for further detailed analysis.**

- 2. Direct AECOM to explore moving the Trench towards Alma (Eastward) so that it further reduces impact to residential properties.** This will mitigate visual, noise, and vibration impacts as well as the requirement to ban trees and possibly ADU construction in adjacent Park Blvd. backyards to install trench wall anchors.

- 3. Eliminate or merge raised options; Eliminate Viaduct and/or merge with Hybrid; Spend more time and resource on studying underground options;**

Thank you!

- Lindsay Joye

From: [Ben Tarbell](#)
To: [Council, City](#); cory.wolbach@gmail.com; adrianfine@gmail.com; [Filseth, Eric \(external\)](#); kou.pacc@gmail.com; tomforcouncil@gmail.com; greg@gregtanaka.org; [Scharff, Greg](#); electcormack@gmail.com; [Keene, James](#); [Shikada, Ed](#); [De Geus, Robert](#)
Subject: Rail Committee Request
Date: Tuesday, November 13, 2018 10:20:07 AM

Dear City Council members and city staff,

Thank you for your service to our city.

I am a 12 year resident of South Palo Alto (off E. Meadow) and writing to request further consideration of tunnel or trench train track options at Charleston/Meadow. Please add these options to the AECOM work plan so we can investigate them further. If required to do so, please eliminate the viaduct option or merge it with the hybrid option to allow for more time and resources to continue investigation of the underground options.

Rail committee, please make a motion to add this to the next city council meeting agenda for their approval.

Thank you for your consideration,

Ben Tarbell

From: [Lindsay Joye](#)
To: [Council, City](#)
Cc: [Keene, James](#); [Shikada, Ed](#); [De Geus, Robert](#); [Mandar Borkar](#)
Subject: Rail Grade Separation
Date: Tuesday, November 13, 2018 2:03:04 PM

I am a 25 year resident of Palo Alto with a home on Park Blvd. adjacent to the Caltrain Right of Way.

I am requesting that the Rail Committee motion to place the following items on the next City Council meeting agenda for approval:

- 1. Add Charleston/Meadow tunnel(passenger train in tunnel and freight at grade) to AECOM work plan for next level detail.**
- 2. Suggest AECOM to explore moving the Trench towards Alma (Eastward) so that it further reduces impact to residential properties;** (This will mitigate visual, noise, and vibration impacts as well as the requirement to ban trees and possibly ADU construction in adjacent Park Blvd. backyards to install trench wall anchors.)
- 3. Eliminate or merge raised options; Eliminate Viaduct and/or merge with Hybrid; Spend more time and resource on studying underground options;**

Thank you!

- Lindsay Joye

From: [James Taylor](#)
To: [Council, City](#)
Subject: Rail options in Palo Alto
Date: Sunday, November 18, 2018 2:35:31 PM

Hi

A quick bit of feedback from someone currently living in Greenmeadow who grew up in England living near electrified trains (at grade in one case, elevated on an embankment in the other case - both within 2 house widths, one MUCH more frequent than caltrain dreams of).

It seems to me that the only realistic option is to run the trains at grade level and close Charleston, Churchill and Meadow. The track could be raised a little to allow a pedestrian / cycle path such as the one at N. California to pass under (allowing the majority of Gunn, Paly and Fletcher students to make the crossing). San Antonio/Oregon/University/Embarcadero are surely enough crossings for what is, at the end of the day, a small city. Once they were closed traffic would sort itself out and the city could then invest in improving the new hotspots created.

All the other options are either prohibitively expensive (tunnels), thoroughly unpleasant for those living nearby (viaduct) or just utterly impractical given the water table (trench and probably tunnel too).

As a city we need and should want a regular electric rail service. This means the at-grade crossings have to go. Closing them is the only option as no matter what people say, they won't be will be willing to pay the taxes necessary for anything else.

I appreciate you listening to the local population but you should be realistic about what can be done. And a tunnel is too expense, the trench seems unlikely and the viaduct will never make it past the voters.

Thanks for listening
James

From: [Laurie Winslow](#)
To: [Council, City](#)
Subject: Rail UNDERGROUND
Date: Monday, November 12, 2018 3:47:16 PM

The rail UNDERGROUND isn't a rock band! It's me voting as a citizen to ask that you consider more strongly the idea of putting the train in a tunnel preferably or a trench. That introduces some problems but it solves more long-standing problems and some of the new ones that extra trains will create.

Laurie Winslow

From: [Michal Sadoff](#)
To: [Council, City](#); [Keene, James](#); [Shikada, Ed](#); robert.deGeus@cityofpalotalto.org
Subject: Request for Rail Committee and City Council regarding items for AECOM work plan
Date: Tuesday, November 13, 2018 9:52:01 AM

Hello to the Rail Committee, City Council members, and City staff. I am a resident in Greenmeadow. The matter of our future rail design matters greatly to me. For reasons of aesthetics, preservation of the character of our city, and noise, I am NOT in favor of a viaduct or hybrid. I DO want the city to put more resources into exploring a tunnel, as I do not think that has gotten sufficient exploration. I understand that now is the time to ask that the Rail Committee members place onto the City Council agenda a recommendation that the council approve that AECOM work on the below items, and that the Council approve these:

1. MOST IMPORTANT: **Add Charleston/Meadow tunnel (passenger train in tunnel and freight at grade) to AECOM work plan for next level detail.**
2. Suggest that AECOM explore moving the Trench towards Alma (Eastward) so that it further reduces impact to residential properties;
3. Eliminate or merge raised options; Eliminate Viaduct and/or merge with Hybrid; **Spend more time and resource on studying underground options;**

Thank you for taking the time to read and consider my request.

Sincerely,
Michal Ruth Sadoff
431 Adobe Place

From: [Miriam Madigan Brown](#)
To: [Shikada, Ed](#); Robert.DeGeus@cityofpaloalto.o; adrianfine@gmail.com; [Filseth, Eric \(external\)](#); kou.pacc@gmail.com; tomforcouncil@gmail.com; greg@gregtanaka.org; [Scharff, Greg](#); electcormack@gmail.com; [Keene, James](#); [Council, City](#)
Cc: [Mandar Borkar](#)
Subject: REQUEST: Add further rail options to AECOM Work Plan
Date: Monday, November 12, 2018 8:59:04 PM

Greetings City Council and City Staff:

My family and I are residents of the Ventura neighborhood in Palo Alto, we bought a home here 15 years ago. We have two children in the neighborhood public schools, and my husband and I are active members of the community - volunteering in youth sports leagues, in the schools, and with local organizations such as PACCC.

We care a great deal about the community and are deeply invested in ensuring that Palo Alto remains a community that prioritizes quality of life for residents.

With this in mind, I ask that you please help us guide toward wise long-term decisions in the railway planning that is currently taking place. What is under consideration right now will be with our community for a long, long time - decades (centuries?) into the future. It is critical that we not take short-sighted approaches, but rather look at this work through a truly big-picture lens - asking "how might we" work toward a plan that meets both the needs for more transportation, AND increases livability rather than eroding it further.

More specifically, I ask that the rail committee make a motion on Wednesday to add to the next City Council agenda approval to have AECOM work on the following:

- 1. TOP PRIORITY: Add Charleston/Meadow tunnel (passenger train in tunnel and freight at grade) to AECOM work plan for next level detail.**
- 2. Direct AECOM to explore moving the Trench towards Alma (Eastward) so that it further reduces impact to residential properties;**
- 3. Eliminate or merge raised options; Eliminate Viaduct and/or merge with Hybrid; Spend more time and resource on studying underground options**

Adding these options to the work plan will ensure that we are able to fully consider and weigh the tradeoffs of a range of options as we make this critical decision for our community.

Please support this full consideration by adding these items to the AECOM workplan.

Thank You,
Miriam Brown
Fernando Ave.

From: [Deborah Waxman](#)
To: [Council, City](#); cory.wolbach@gmail.com; adrianfine@gmail.com; [Filseth, Eric \(external\)](#); kou.pacc@gmail.com; tomforcouncil@gmail.com; greg@gregtanaka.org; [Scharff, Greg](#)
Subject: Support for under grounding the train
Date: Friday, November 9, 2018 3:16:50 PM

Dear City Council Members,

I live in Palo Alto near the Charleston/Alma intersection. I've lived here for more than a decade, through the many suicides at the Charleston and the West Meadow intersections and through the increasingly dense noise and traffic. The current trains already pose a significant hazard and a cost to our quality of life. Adding above grade options will greatly exacerbate these issues.

I strongly oppose an above-grade rail design as unsafe, unsightly, and a huge contributor to the already severe traffic congestion at this intersection.

I understand your concern about costs, but I also know the cost to safety, property values, and quality of life that will endure for decades. We have already lost two families, who have moved away because they can't endure the options that have been proposed. I urge you to consider the long-term impacts of this project rather than succumbing to short-term cost concerns. Underground tracks will minimize train noise and safety issues, and free up land for better, more neighborhood friendly uses. It would also save many families from the loss of their homes through eminent domain.

I can only hope that you will consider a tunnel option and allow the communities to find ways to fund a tunnel rather than peremptorily deciding against an option that will do so much good for the community.

Thank you for your consideration,

Deborah Waxman

4166 Park Blvd

Palo Alto, CA 94306

From: [Amie Neff](#)
To: [Keene, James](#); [Shikada, Ed](#); [De Geus, Robert](#); [Council, City](#); cory.wolbach@gmail.com; [Adrian Fine](#); [Filseth, Eric \(external\)](#); kou.pacc@gmail.com; tomforcouncil@gmail.com; greg@gregtanaka.org; [Scharff, Greg](#); electcormack@gmail.com
Subject: Train Committee Meeting Feedback Nov 14
Date: Wednesday, November 14, 2018 1:16:40 PM
Attachments: [image.png](#)
[image.png](#)

Hi All,

I'm sorry we were forced to an early conclusion, I was looking forward to hearing more about the passenger tunnel, freight above option. I have 2 thoughts to share:

1) Given the constraints currently making the City Wide Tunnel and even shallow trench options difficult (drainage, subsurface right-of-way claims, maintenance, costs, venting, train recovery, etc.), we may be at a better advantage if we can eliminate the freight and put Cal-Train below grade. I am in favor of investigating this option. While it doesn't eliminate the tracks running through the city, it does give us an opportunity to decouple the issue of freight from our city-wide response to increased Cal-Train frequency and ridership, and this is smart. I would like to Echo Nadia Niak's request that AECOM remain impartial in presenting each option with an equal amount of enthusiasm and skepticism. It is not in our best interest to follow the desires of our consultant. That I am now painfully aware of the 1st choice of our consultants makes this process feel like lip-service.

2) Eddie briefly mentioned her team was looking at relocating the viaduct to the shoefly location, but declined to go into further detail. It seemed as if Lydia Kou, another speaking member of the community (whose name I forget) and myself all had the impression that pushing the viaduct into the shoefly, might mean that Alma street, (when the viaduct was completed) would be bifurcated by the viaduct overhead. This isn't a bad idea. If we could push the viaduct over far enough into our current existing traffic lane, then we would stack transportation vertically, instead of taking up valuable land required to put the train adjacent to Alma.

The viaduct doesn't demand the same width as an at-grade train, and the space below is freed up for alternate uses. Putting a park beneath isn't realistic, but putting cars beneath? Why not? Shifting the viaduct away from people's back yards is a nice idea. Plus, you'll be able to leave the train in place during the bulk of construction. Of course, the train will have to shift back to the original track, and Alma will have to be adjusted to accommodate that shift, but if you did it away from the existing crossings, near, for example, Bruce Bauer lumber on the South end, and near El Dorado on the North end, you could avoid impacting any roadway crossings. The bike lane could then roughly link San Antonio Station with the new development at Fry's. Here are a couple of imperfect images to sample:

image.png

image.png



I'd love to see details on AECOM's suggestion, and investigate how far over we could push the train viaduct into Alma.

Thanks All.

--

Amie Neff
M.Arch, LEED® AP

--

cell: 650/ 396/ 9146

amie.neff@gmail.com

www.capabledesign.com

From: [Wolfgang Dueregger](#)
To: [Council, City](#)
Cc: [Neilson Buchanan](#); [Paul & Karen Machado](#); [Carol Scott](#); [Christian Pease](#); [David Schrom](#); [John Guislin](#)
Subject: tunnel
Date: Tuesday, November 27, 2018 9:06:57 PM

Dear City Council,

here is an update about what the Boring Company is doing in LA.

Did you receive a bid in the meantime for our tunnel?

<https://la.curbed.com/2017/12/4/16734696/elon-musk-tunnels-boring-company-map>

Wolfgang Dueregger

From: gmahany@aol.com
To: [Shikada, Ed](#); [De Geus, Robert](#); [Council, City](#); cory.wolbach@gmail.com; adrianfine@gmail.com; [Filseth, Eric \(external\)](#); kou.pacc@gmail.com; tomforcouncil@gmail.com; greg@gregtanaka.org; [Scharff, Greg](#); electcormack@gmail.com
Subject: Viaduct noise cansulation at grade railcrossings
Date: Tuesday, November 27, 2018 12:08:38 PM

hello all

I know that there is a reflex to say that a viaduct is just an eye sore but for affordability we may have to accept an eye sore. However, when I am not looking at the viaduct, I do not want to hear it.

Noise cancellation features to the viaduct design are a must have.

AECOM consultants show sound walls for noise cancellation, this is a good design feature.

Other noise cancellation features like resilient material to isolate the rails from rail platform should also be used especially on the bridges over Charleston Rd and Meadow Ave.

Gary Mahany

Carnahan, David

From: Phil Burton <philip-b@comcast.net>
Sent: Thursday, November 15, 2018 5:41 PM
To: De Geus, Robert
Cc: Council, City; 'Chris Logan'; Carrasco, Tony; 'Dave Shen'; 'Greg Brail'; 'Inyoung Cho'; 'Megan Kanne'; 'Kari Hodgson'; 'Mandar Borkar'; 'Parag Patkar'; 'Patricia Lau'; 'Nadia Naik'
Subject: Concern and frustration about lack of effective communications

Rob,

At the most recent City Council Rail Committee meeting, the third of three handouts was a June 28, 2017 letter from then mayor Scharff to Francisco Castillo, Director of Public Affairs, Union Pacific Railroad. I was surprised to read the following:

“The electrification of Caltrain will allow for higher grades, *as electric service can easily deal with up to a two percent grade.*” [my italics] The maximum grade has been a central point of both Rail Committee and CAP meeting discussions, because of the impact on construction costs as well as feasibility of certain alternatives. To the best of my knowledge, no one on staff ever stated that the elected officials or staff already understood this point. When several speakers, including me, made this point at various meetings, there was no staff response in the spirit of, “We already understand this point, and are prepared to raise it with Caltrain and/or UPRR.”

I find it surprising and a bit frustrating that CAP members and members of the general public (speaking at Rail Committee meetings) aren’t aware of the full history of this key issue. With full awareness of the history, CAP members can be more effective as intermediaries between project staff and residents of our respective neighborhoods.

The online search “Union Pacific RR shortline RFP process” yields a link <http://www.caltrain.com/Assets/Public+Affairs/pdf/UP+Agreement+FAQs.pdf>, a March 1, 2017 *Caltrain / UP Agreement*. *The FAQ contains this question and answer:*

However, the link in the answer is no longer valid.

2. QUESTION: Where can I find a copy of the documents

ANSWER: Documents are available at www.caltrain.com/about/JPB_Agreements

Thus we have no way to know if and how the UP responded to Mayor Scharff’s letter, yet an understanding of their response, if any, might have a vital bearing on current discussions of this issue. Is there any way for staff to provide CAP members, or the general public, with copies of the relevant documents?

The other key issue involving UP is vertical clearance above top of rail. Has there been any correspondence with UP on this issue?

I would like to point out that electric multiple-unit trains can easily climb a grade of well over 2%. I am personally familiar with grades on the New York City Transit System, which also uses electric MU trains. You can read here that there are several locations on this system with grades over 4%. <https://www.nyctransitforums.com/topic/39935-what-is-the-steepest-grade-that-subway-cars-can-handle/>

Respectfully,

Phil Burton

Carnahan, David

From: Tracy Mallory <tracylists1@gmail.com>
Sent: Monday, November 19, 2018 10:03 AM
To: Council, City
Subject: grade separation of rail crossings

As one of many residents commenting on the project, I'd like to ask if the project evaluation criteria ever included loss of property value with the various options, and also ask again why the reversed hybrid option has been dismissed?

If an above grade-level option for the train of any kind is selected the increase in noise, especially at night and the visual blight (especially during the day;-) will obviously have a dramatic effect on the value of properties on either side of the tracks, with greater reductions closer to the rail line.

It should not be hard to get some "real" estimates, but the following is more likely to be low than high.

Conservatively:

- 1 mile of significantly impacted housing, call it 50 lot lengths along the route, but could be twice this
- 5 lots deep on each side seriously affected - lose 10% property value
- 10 lots further on each side moderately affected - lose 5% property value
- 10 lots further mildly affected - lose 2.5% property value

On east side average property value is ?? 2.5M

On west side average property value is ?? 2M

$$\begin{aligned} & ((250 * 2M) + (250 * 2.5M)) * 0.1 + \\ & ((500 * 2M) + (500 * 2.5M)) * 0.05 + \\ & ((500 * 2M) + (500 * 2.5M)) * 0.025 \end{aligned}$$

= \$281,250

It's pretty clear why a lot of residents are very upset about the direct cost to them of a cheap solution. It is not acceptable to compare this to existing raised track solutions farther north. Once you get to Redwood city there are relatively few houses along the route, but south Palo Alto is all single-family housing.

I'm surprised that the "other" hybrid option of raising the roads and lowering the rail line has been dismissed. I would be very distressed by having my house taken as a result of eminent domain needs, but losing ten houses, perhaps paying the owners twice what they are worth, would be much, much cheaper than impacting thousands of homeowners for the rest of their lives and dividing the south end of the city permanently with visual as well as a physical wall. We don't need massive structures of the magnitude of San Antonio Road. Although fairly wide, the roadway could have quite a low load limit, requiring trucks to use San Antonio or Oregon as today. Sink the train 15 feet (not 30) which would put it 17 feet below where it is today (it's above grade now) and raise the road 10 feet and everyone except for a few well-compensated home-owners will be much happier than with any of the current plans.

Sincerely,

Tracy Mallory
650-279-0037

PS: Here's the math:

$$\begin{aligned} >>> \text{expr } ((500 * 2000000) + (500 * 2500000)) * 0.1 + \\ & ((500 * 2000000) + (500 * 2500000)) * 0.05 + \\ & ((500 * 2000000) + (500 * 2500000)) * 0.025 \\ & 281250000 \end{aligned}$$

Carnahan, David

From: James Taylor <jamet1234@gmail.com>
Sent: Sunday, November 18, 2018 2:35 PM
To: Council, City
Subject: Rail options in Palo Alto

Hi

A quick bit of feedback from someone currently living in Greenmeadow who grew up in England living near electrified trains (at grade in one case, elevated on an embankment in the other case - both within 2 house widths, one MUCH more frequent than caltrain dreams of).

It seems to me that the only realistic option is to run the trains at grade level and close Charleston, Churchill and Meadow. The track could be raised a little to allow a pedestrian / cycle path such as the one at N. California to pass under (allowing the majority of Gunn, Paly and Fletcher students to make the crossing). San Antonio/Oregon/University/Embarcadero are surely enough crossings for what is, at the end of the day, a small city. Once they were closed traffic would sort itself out and the city could then invest in improving the new hotspots created.

All the other options are either prohibitively expensive (tunnels), thoroughly unpleasant for those living nearby (viaduct) or just utterly impractical given the water table (trench and probably tunnel too).

As a city we need and should want a regular electric rail service. This means the at-grade crossings have to go. Closing them is the only option as no matter what people say, they won't be will be willing to pay the taxes necessary for anything else.

I appreciate you listening to the local population but you should be realistic about what can be done. And a tunnel is too expense, the trench seems unlikely and the viaduct will never make it past the voters.

Thanks for listening
James

FOR THE EXCLUSIVE USE OF CNSBUCHANAN@YAHOO.COM

From the Silicon Valley Business Journal:

<https://www.bizjournals.com/sanjose/news/2018/11/27/caltrain-business-plan-electrification-ridership.html>

Caltrain launches public process on ambitious 20-year business plan

Nov 27, 2018, 5:57am PST

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Electric trains from Gilroy to San Francisco. Speeds topping 100 miles per hour. BART-like frequencies. No grade crossings.

Caltrain has begun working on its first business plan in years, one that looks ahead two decades to a time when the railroad could be carrying nearly a quarter-million passengers a day, four times as many as now, taking a bigger bite out of the Peninsula travel market.

"This corridor is the envy of nearly every city that has a commuter railroad," Sebastian Petty, Caltrain's senior policy advisor, said Monday night at a community meeting in San Jose. The meeting was the last of three in each of the Caltrain-served counties that's being used to kick off the public part of the two-year work schedule to develop the plan.

"There's no way we could build this railroad today where it is because it goes right through the center of every city we serve."

Not only did Peninsula cities sprout around stations on the 155-year-old line — exactly the kind of transportation hubs modern city planners dream of — but Silicon Valley's growth has created two-way commutes filling seats on trains in both directions, efficiencies that simply don't exist on the vast majority of similar railroads elsewhere in the world.

Petty said plans being explored for the future rely heavily on two assumptions: That the full railroad will be converted to electric operation and that high-speed rail, which has planned since 2013 for its trains to share its tracks, will actually be built so that that project can continue to share in the costs of upgrading and maintaining the line.

"This is really not a 'greenfield exercise,'" Petty said. "The Caltrain corridor is about as far from a green field as you can get. We're talking about visions, not blue-sky planning, that really exist within this framework of existing policy decisions. There a number of those but probably biggest one is the commitment to high-speed rail."

In its most recent two-year business plan, the California High-Speed Rail Authority extended its plan for "blended service" — conventional and high-speed trains sharing track between San Francisco and San Jose



CALTRAIN

An artist's rendering of one of the new electric trains that Caltrain has ordered from Stadler Rail AG in Switzerland. The trains are now being built in Stadler's Salt Lake City plant.

— all the way south to Gilroy, Caltrain's current terminus.

That would save money for high-speed rail construction and allow Caltrain to switch exclusively to faster electric trains. It's also the kind of improvement that was endangered in early 2017 when California's Republican congressional delegation temporarily blocked the federal share of funding to begin Caltrain's \$1.9 billion electrification project on the Peninsula because it would help high-speed rail.

Electrification work is now under way with about a third of funding coming from high-speed rail. The first electric Caltrain service is scheduled for 2020.

Petty said one of the most immediate challenges for the plan to address is how to reduce or eliminate the 42 street grade crossings that still exist on the line, which means traffic backs up when trains pass through and railroad speeds are limited. It costs about \$100 million to convert each crossing to a bridge or underpass, he said.

Jody Meacham

Reporter

Silicon Valley Business Journal





Californians Advocating
Responsible Rail Design

November 12, 2018

Subject: Recommendation of adding alternative of short tunnel for electrified trains only with freight at the surface for Meadow and Charleston alternatives.

Dear City Council Members,

We support the Staff Report recommendation to not eliminate any grade separation alternatives at this time. While the Viaduct is the least favored alternative, it remains worthy of further analysis because it is the lowest cost and allows more connectivity than a Hybrid (which functions effectively as a wall).

In addition, we would like to propose an alternative that was mentioned previously: a short tunnel for electrified trains, with freight remaining at the surface. The slope, clearance, ventilation and Fire Life Safety requirements driven by freight and other diesel trains in the tunnels add significant costs to the tunnel proposal currently under consideration. Freight tentatively remaining at the surface for the present would not liberate all of the ROW land for other uses, but the vehicular crossing capacity issue would be addressed.

A key condition has recently changed along the corridor making this a feasible alternative; Caltrain is no longer considering running both diesel and electric trains and will now have a fully electric fleet. In addition, the Dumbarton Rail project recently received approval to begin its investigation of whether to rebuild the old rail bridge that formerly carried freight across the Bay. If this came to fruition, freight might be partially or fully diverted to a Dumbarton route and no longer pass through Palo Alto, leaving the right-of-way above the tunnel free for other uses.

We have identified a similar tunneling project, the San Francisco Central Subway Tunnel, which seems to indicate that tunneling may even be much cheaper than a trench.

HMM Trench Study:

As you may recall, in 2014, HMM gave a rough estimated cost for a trench below Meadow and Charleston at \$488 Million (in 2014 dollars).

Here was the breakdown:

Description	Unit	Unit Cost	Rail Trench 1% Max Grade (Caltrain Preferred)		Rail Trench 2% Max. Grade (w/Design Exception)	
			Qty	Total Cost	Qty	Total Cost

Estimate Summary

Construction				622,440,744		289,191,768
Utility Relocation and Protection				213,300		104,400
Subtotal A				622,654,044		289,296,168
Professional Services (% of Subtotal A)		35%		217,928,915		101,253,659
Right of Way (incl. ROW Services)				-		-
Subtotal B				840,582,960		390,549,826
Contingency (% of Subtotal B)		25%		210,145,740		97,637,457
Total Project Cost (2014 dollars)				1,050,728,700		488,187,283

note 1) Professional Services includes Design Engineering, Project Mgmt, and Construction Mgmt.

Central Subway Tunnel Without Freight

Also in 2014, the Central Subway project in San Francisco completed a 1.7 mile dual subway tunnel using two 20.7 ft diameter tunnel boring machines (TBM). While the overall cost of the project is very high, the vast majority of the cost is related to several very deep and complex stations. The cost to complete the tunnel portion of the project: \$234 million dollars (2014 dollars). For reference, the distance from Loma Verde Ave to San Antonio Road in Palo Alto is 1.6 miles. Palo Alto would likely have a additional costs beyond what was needed on the subway project (signaling, larger diameter bore, etc.) but the price difference is worth investigating and maybe minimal with the use of a single bore tunnel.

Unlike Palo Alto's right of way, these tunnels were built in densely urban San Francisco and **under an active BART line**¹. The TBMs went through various soils ranging from soft soils to thinly bedded siltstone, shale and sandstone bedrock - with some area designated as "Potentially Gassy with Special Conditions" by Cal/OSHA². The TBMs also had to navigate the

¹ <http://www.therobbinscompany.com/project-category/epb-tbm/>

² <http://www.therobbinscompany.com/project-category/epb-tbm/>

steep and turning alignment in an area where they dealt with low cover, nearby utilities, and sensitive structures requiring analyses and precautions to limit settlement impact and ensure the structures in downtown SF were safe. Given Palo Alto is in a suburban area with less constraints, it seems reasonable to consider this alternative closely.

Palo Alto Short Tunnel

Another way to reduce the cost of a tunnel is to reduce the diameter. In 2014, the High Speed Rail Authority's White Paper on Tunneling describes how they achieved significant cost reductions by reducing maximum operating speeds assumptions in the tunnels from 220 mph to 200 mph, thereby allowing them to reduce tunnel diameters from 29.5' to 28' ID (Inside Diameter).³

CARRD requested from AECOM information on the tunnel assumptions being used for the City wide tunnel (which include freight) and they responded that they are using a "28 ft Inside Diameter Tunnel" which would large enough to allow 200 mph speeds. A significantly smaller diameter would be required to accommodate planned speeds of 110 mph. And, as noted in our previous public comment on height clearances, the Caltrain Electrification EIR specifically notes that the clearance levels at the San Francisquito creek bridge (where freight passes today) is actually 19ft. It is therefore worth investigating whether the tunnel dimensions for a short, electrified train only tunnel in Palo Alto where maximum speed for both Caltrain and HSR is 110 miles per hour would allow us to have a tunnel diameter that is less than 28'.

Other key things to consider for the short tunnel with freight on the surface (EOT) option:

- Without freight, the 1% grade requirement could more readily change to 2% or even 3% grade, which would allow for more design flexibility.
- Caltrain and freight could continue operations during construction with minimal disruption except at the site of tunnel boring machine entrance and exit.
- Traffic during construction would be minimally disrupted
- Tunnels in stations are expensive, but this option would not impact stations
- Tunnels are faster to build. Construction time is dramatically reduced because the work window issues and the phasing required on the road side are much less.
- It would go under the utilities, reducing the cost.
- It could go under the creeks.
- It does not impact the streets.
- The equivalent of shoofly tracks are needed near the portal, but not along the entire right-of-way.

³ California High-Speed Rail Program Whitepaper On Cost Reduction Strategies, July 25, 2014

- With careful planning and analysis, TBM's can be reused - perhaps by other cities along the corridor.⁴
- In the future, some or all freight could be re-routed over the Dumbarton Rail route (currently being studied) thus freeing up space along the right-of-way for other potential land use options.
- **Temporary** space for the tunnel portal may be necessary and could require minimal eminent domain that could be returned to the housing stock on completion of the project.
- The ROW closer to San Antonio road is much wider than other parts of the City (150 ft wide). If the TBM was launched from that end, then the removal requires less space.

To see the space required for extracting a TBM, see this video showing the removal of the TBMs used on the Central Subway project in SF. <https://bit.ly/2PpntNC> Note the size of the extraction point is quite small.

Summary:

Preliminary design of grade separations are vague and costs climb when one considers the issues of staging, prolonged construction, utility relocation, ground water issues, and maintaining operations on a heavily trafficked railway during construction. What initially seems like a cheaper solution, can become expensive quickly when these costs are all tallied up. For this reason, we support the inclusion of a short electric train only tunnel with freight on the surface.

If you would like any additional information or have any additional questions, please let us know.

Sincerely,

Nadia Naik and Elizabeth Alexis
Co-founders
CARRD

⁴ <https://www.herrenknecht.com/en/services/global-services/tbm-refurbishment.html>

Carnahan, David

From: gmahany@aol.com
Sent: Tuesday, November 27, 2018 12:08 PM
To: Shikada, Ed; De Geus, Robert; Council, City; cory.wolbach@gmail.com; adrianfine@gmail.com; Filseth, Eric (external); kou.pacc@gmail.com; tomforcouncil@gmail.com; greg@gregtanaka.org; Scharff, Greg; electcormack@gmail.com
Subject: Viaduct noise cansulation at grade railcrossings

hello all

I know that there is a reflex to say that a viaduct is just an eye sore but for affordability we may have to accept an eye sore. However, when I am not looking at the viaduct, I do not want to hear it.

Noise cancellation features to the viaduct design are a must have.

AECOM consultants show sound walls for noise cancellation, this is a good design feature. Other noise cancellation features like resilient material to isolate the rails from rail platform should also be used especially on the bridges over Charleston Rd and Meadow Ave.

Gary Mahany

Carnahan, David

From: Neilson Buchanan <cnsbuchanan@yahoo.com>
Sent: Tuesday, November 27, 2018 9:36 AM
To: Council, City
Cc: Dave Price; Gennady Sheyner
Subject: SOS for the Rail Committee meeting Nov 27
Attachments: 181127 Caltrain 20 year business plan SV Biz Journal Nov 27 2018.pdf

SOS = seriously out of sync

When I read the attached SV Business Journal coverage [Nov 27] of Caltrain and HSR, I had an out of body experience. Should I even be concerned at age 74; I have actuarial probability of 11.7 more years of life.

Based on Caltrain record of success, I don't seriously consider Caltrain's 20-year planning.

20-year planning does not have to be totally fact-based but some of Caltrain's HSR options may not exist for me or anyone else.

It is very hard to reconcile the gap between our Caltrain grade crossings' pressures and the happy-face projected by Caltrain's senior policy adviser.

I urge Palo Alto and other SC County cities create more order out of this chaos.

Neilson Buchanan
155 Bryant Street
Palo Alto, CA 94301

650 329-0484
650 537-9611 cell
cnsbuchanan@yahoo.com

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cnsbuchanan@yahoo.com

Monday, December 3, 2018

Dan Richard
Chairman of the Board of Directors
California High Speed Rail Authority

Dan- Here is a Fresno Bee article re the fireworks in Sacramento over the auditor's report:

https://www.fresnobee.com/news/local/high-speed-rail/article222399890.html?utm_source=Morning+Roundup&utm_campaign=3764128db3-EMAIL_CAMPAIGN_2018_12_03_04_29&utm_medium=email&utm_term=0_165ffe36b2-3764128db3-78450701&mc_cid=3764128db3&mc_eid=7afa3a94f3

No doubt some of the criticism is valid, but the bulk of the opposition comes from Republicans who want to deny the American people the lavish lifestyle that we provide to the Japanese, Germans and other Europeans and to the Koreans. I think the Republicans are bribed and bribed lavishly to do that.

Seen in that light, the rich Republicans who bankroll the opposition to high speed rail in California are revealed as the borderline traitors that they are. The United States supplies a free military defense for all of Europe, Japan, S. Korea, Taiwan, and a lot of other places, and we have done so since 1945. Those countries then spend their military money on high speed rail, affordable universities, magnificent national health care systems, and a lot more. All over the world, the American people are held in contempt for letting their government kick them around like that. The American political system is now hard-wired to ruin the lives of the American people and to enrich the lives of the people of Europe, Japan and Korea. This total Republican opposition to California high speed rail is emblematic of that perversion.

The Republican scum who are trying to stop California high speed rail rely on the ignorance of the American voters. The schools in the United States are some of the worst in the world, by design. Trump's defense budget is \$716 billion. That of Britain is 50 billion pounds. A U.S. defense budget of \$400 billion would probably be an obscene waste of money. The American people are bled white to pay to defend much of the free-loading world. They get high speed rail, and we get little border-line traitors like Jim Patterson yelling his head off in Sacramento trying to deny HSR to the American people. The American people should wake up to this fraud and remove people like Patterson from our political life. He's a paid hatchet man for the Republicans.

The American people need to take action against the Republican scum who work tirelessly to ruin their lives. We need a political revolution in the United States, if not a real one. Then we need to see our money spent to improve the lives of the American people. I think we have done enough to atone for defeating Germany and Japan in WWII, if that is what this is about.

It is mainly about keeping the population of the Central Valley ignorant and exploitable by the rich Republicans who rule the roost here. To have educated, high income Silicon Valley people buy homes here would be to open the eyes of the poor people who exist here now. To enable people here to get high-paying jobs in Silicon Valley would be to empower them, and the Republicans who own the Central Valley want to keep them powerless.

Again, just consider that we spend \$716 to provide a free military defense for much of the world, many of whom have high speed rail, and the Republicans fight desperately to deny it to the American people. That starts to meet the definition of treason. I have very strong feelings about the Republicans, and I restrain myself from expressing them fully.

Please hang in there, Chairman Richard. You have done an impossible job very well.

L. William Harding
Fresno

OCTOBER 2018 EMAILS TO CITY.COUNCIL ABOUT CONNECTING PALO ALTO GRADE SEPARATION

From: [Amie Neff](#)
To: [Council, City](#)
Subject: Elimination of the viaduct
Date: Wednesday, October 17, 2018 10:49:29 AM

I vehemently oppose elimination of the viaduct option without also eliminating the hybrid option.

Between the two above ground options I feel the viaduct offers a much better option for the community for the following reasons:

It opens up space below the raised rail for landscaping, possible bike or walking lanes, and should train ever become obsolete, offers the community a walking path option to reclaim.

The hybrid will visually divide our city, it will severely degrade housing values, block light in people's yards, and be a general eyesore.

If you plan on keeping any elevated options on the table at all, which I believe is a different question entirely, do not eliminate the viaduct.

Thank you
Amie Neff

From: [Jagdish Pamnani](#)
To: [Council, City](#)
Subject: Grade separation at Meadow and Charleston rail crossings
Date: Tuesday, October 16, 2018 8:33:50 PM

Dear City Council Rail Committee,

I live a few blocks from the Meadow rail crossing. My **strongly preferred choice** for both the Meadow and Charleston crossing is the shallow trench option as it significantly reduces the noise of passing trains, hides the train below grade level and allows a slightly elevated road over rail. However, to make this choice as cost-effective as possible, we need to do the following:

1. Get Caltrain to approve a 2% grade, publish the progress of this issue as a standing agenda item for the CAP and city council meetings.
2. Get Caltrain to approve 18.5ft top of rail to bridge clearance instead of 24.5ft, publish the progress of this issue as a standing agenda item for the CAP and city council meetings.

The residents (550 of them who signed the petition) also need an update on the "Tunnel Option". AECOM / Rail Committee cannot make the unilateral decision to suddenly stop the tunnel option and merge this option with the Shallow Trench.

There are two distinct options: Shallow trench and the Tunnel for Charleston/Meadow should be analyzed with **Caltrain electric for tunnel and freight single rail at grade**. The CAP/Residents need to be provided with detailed analysis on both these options.

Also to keep the options to three, merge the least popular options of raised rail (Hybrid and Viaduct) into one.

Items 1, 2 will significantly reduce costs of whatever final option is chosen so it is extremely important for the council to get answers to these questions before making any final decision.

Regards, Jagdish

From: [Wolfgang Dueregger](#)
To: [Council, City](#)
Cc: [Paul Machado](#); [Neilson Buchanan](#); [Carol Scott](#)
Subject: Grade separation
Date: Monday, October 22, 2018 4:58:51 PM

Dear City Council,

there has been a lot of discussion, lots of money spent on studies (in the hundreds of thousands) but so far no actionable solution has been found how/if to separate the rail tracks from the car crossings along the train tracks running through Palo Alto.

We always hear tunneling is too expensive. Is it? Can you show us the numbers from an actual bid received from the Boring Company?

Please read on:

<https://www.nbcnews.com/business/business-news/elon-musk-says-his-first-tunnel-will-open-december-n922726>

This happens 400 miles south of us.

And we, Palo Altans, always wanting to be ahead of everybody else, cannot ?

Why have you, Dear Council, not done this so far?

Once the numbers are on the table one can tackle the difficult question of how to raise the money, but first we need to know what the numbers actually are.

Please do not loose even more time by trying to solve problems (like over/underpass) for which you will not get a majority from the residents but start working on something that can be a solution, i.e. tunneling through the whole length of Palo Alto. And once Palo Alto puts the stakes into the ground, it would be very surprising if neighboring cities would not follow suit and join Palo Alto in a deep tunnel bored by the Boring Company.

thanks

Wolfgang Dueregger

P.S.:I have no affiliation whatsoever with Tesla, Elon Musk or the Boring Company.

From: [Amie Neff](#)
To: [Council, City](#); [Keene, James](#); [Shikada, Ed](#); [De Geus, Robert](#)
Cc: [Mandar Borkar](#)
Subject: Public Comment , Wednesday October 17th. Caltrain Grade Separation
Date: Tuesday, October 16, 2018 9:16:43 AM

Good Morning Council and Rail Committee Members,

I'd like to address the committee and our city transportation specialists about a few clarifications and requests I believe are crucial before moving forward with the very costly and important decision about how to address Caltrain's pending electrification and increased ridership goals.

I would like to thank the committee for their time, and the city for providing access to the big Design Boards that were presented at the August 23rd meeting. I was not able to attend that meeting and am glad to be able to see what is being discussed with more time and attention. You provided enough information that I see where each option begins and ends, the depth or height of the tracks, and the slope profile.

There are notable omissions on the "Typical Section" images which makes it difficult to understand how each alternative might look.

PLEASE SEE:

<https://pagradesep.com/wp-content/uploads/2018/08/Meadow-Dr-Charleston-Rd-Viaduct-Full-Trench-MCV-MCT.pdf>

The 100' graphical scale in the right hand bottom corner is only applicable to the already graphed section and mapped segment. That scale doesn't apply to the "Typical Sections" of the train in the trench, or elevated options on either board.

In fact, the Typical Sections, (images which are most relatable to us,) have no scale, no context and no dimensions. Other than information about track height or depth, I have no way of understanding, if I live along Park, how close that wall or viaduct will be to my back deck or roofline or how high it is in relation to my house. I know the average home heights along the track are 12'-0", if the tracks might be 3'-0 or even 8'-0" above the top of my house, how high will the train be? How tall is a train?

I hope that we can ask the team who put together these boards to go a small step further in giving us a sense of the proposals that corresponds to our understanding of the real world. It doesn't take much to draw in a tree, a house, a car, or a person for context, but it informs our understanding enormously.

More importantly, I want to make it clear that without an approval from CalTrain that we can design with a 2% grade, the option to trench in South Palo Alto is not on the table. Why continue to entertain a trenching option without that approval? I would ask that the City Council do their due diligence. Request the following design assurances and clarifications from Caltrain:

- 1) Grant us permission to design for 2% grade due to the streams we are working around.
- 2) Elsewhere clearance height for trains is 18-1/2', why are we being held to different design standard of 24-1/2'? Can we shoot for the lower clearance?
- 3) We would like clarification about what options we have to reclaim the space returned to us in the right of way now occupied by the rails should we chose to construct a tunnel or a

viaduct. Will that space be available to Palo Alto's community?

Finally, I would like the committee to leave among our options the construction of a short, shallow tunnel between San Antonio and Cal Ave stations that allowed the freight to remain in place above and CalTrain to go in a tunnel below. It can be lumped into the city wide tunnel option.

Many Regards,

--

Amie Neff
M.Arch, LEED® AP

From: pol1@rosenblums.us
To: [Council, City](#)
Subject: Rail Committee Agenda Item 1 October 17th 2018
Date: Saturday, October 13, 2018 2:45:33 PM

Members of the Rail Committee:

I have long been an advocate for the city wide tunnel option because I believe it offers the best outcome for the long term future of Palo Alto. There would be complete east west connectivity with the railroad right of way no longer blocking views or minimizing the number of cross connections. I do not accept the position that any option for grade separation that does not make the situation worse is acceptable, For a community with our values and wealth it should be possible to come up with a more fitting solution such as Berkeley was able to do with their BART tunnel. Financing is the main issue and needs to be looked at seriously with all options on the table. This has not been done. I outright reject any option that allows the rail bed to rise above ground level as this requires the construction of a long dirt wall which would further separate the east and west sides of our city with an even more visually imposing physical barrier with NO likelihood of improved east-west connectivity.

For this reason, I urge you all to put the alternative of rail on raised pylons (viaduct) as one of the alternatives on our list. To me it is the second best alternative to a bored tunnel as it allows full east-west connectivity, allowing passage under the tracks as deemed suitable by future traffic studies and our Comprehensive Plan. The area under the tracks could become a green space or developed commercially.

As has been pointed out many times by Nadia Naik in the past and Council Member Wolbach recently, we need to do some serious investigation into the issue of freight traffic on the right of way. This has extremely serious cost and noise issues associated with any chosen solutions. If it were possible to buy out the freight option, this might offer a very cost effective solution.

Stephen Rosenblum
Santa Rita Ave, Palo Alto

From: [Kellerman, Thomas W.](#)
To: [De Geus, Robert](#)
Cc: [Shikada, Ed](#); [Council, City](#); [Megan Kanne](#); [Rachel Kellerman](#)
Subject: Rail Crossing Planning Process
Date: Sunday, October 21, 2018 7:01:43 PM
Attachments: [Rail Committee Ltr.docx](#)

Dear Mr. de Geus:

Please see the attached letter regarding the Palo Alto rail crossing planning process. Residents of the Professorville and University South neighborhoods would like to arrange a meeting with the appropriate City staff to discuss the inclusion of mitigation measures in the scope of the alternatives under consideration. We are writing to you given that the position formerly held by Josh Mello is currently vacant. Please feel free to contact us to arrange a time that fits within your schedule or to identify the appropriate staff member with whom we should meet. Thank you.

Regards,

Tom and Rachel Kellerman

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From: gmahany@aol.com
To: [Council, City](#)
Subject: rail noise mitigation
Date: Monday, October 15, 2018 9:27:21 AM
Attachments: [RAIL SYSTEM NOISE AND VIBRATION CONTROL.pdf](#)
[IPOL-TRAN ET\(2012\)474533 EN-one.pdf](#)

Hello Rail Committee

Please find attached the some information on how noise from railroad trains and tracks are generated and how to muffle that noise.

RAIL SYSTEM NOISE AND VIBRATION CONTROL

George Paul Wilson

Wilson, Ihrig & Associates, Inc., 5776 Broadway, Oakland, California 94618, USA

Abstract

Control of noise and vibration emitted by steel wheel and rail transportation systems has a long history of designs and techniques, some of which were dismal failures and some which worked very well. Many of the early efforts had a valid technical base for the design, however, there were also many based on intuition or ideas with great expectations, but which had no real technical basis. In the last four decades the technology and materials used for rail noise and vibration control, particularly for the control of groundborne vibration from rail systems, has developed and benefited from thoughtful technical analyses and application of simple engineering principles. These also were not always successful in all respects but provided for a continuing development of the technology with ever-improving success and performance. Included in this presentation are a review of the development of rail noise and vibration control systems, including the lightweight, undamped concrete floating slab track for reduction of groundborne noise and vibration, and of the development of structurally integrated sound barriers with absorption materials for control of airborne sound. The presentation includes anecdotes and discussion of some of the unexpected results from new design installations, an outline of design progress and application extensions, and review of the concepts and designs which are successful and currently in use by rail systems located in many different parts of the world.

Introduction

There has been impressive progress over the last 40 years in the development of rail system noise and vibration control technology and designs. Design criteria for rail system noise and vibration were once either not considered or treated as a secondary item but the importance as a major design parameter is now recognized by new system designers. Sometimes there is still resistance to incorporation of non-revenue producing features in the rail system design, but as each new generation of project managers and designers become educated, there is acceptance of the need for incorporation of noise and vibration control in the overall system design.

In the mid-60's when I began work with assessment and control of noise and vibration from rail systems there were three new rail transit systems in design development: the San Francisco Bay Area Rapid Transit District, BART; the National Capital Transportation Agency, now the Washington, D.C. Metro; WMATA, and the Baltimore Region Rapid Transit District, BRRT. These were the first major new rail transit facilities that had been considered in the United States since the 1930's. In Toronto, Canada the TTC Yonge Subway was opened in 1954 and was the first subway to be built in North America since the beginning of WWII. This was the first North American system to use resilient rail fixation on concrete. Extensions were opened in the period from 1963-1968 and with 34 kilometers total it became the catalyst for resurgence of rail or fixed-guideway transit on the North American continent.

Because of the negative image created in the U.S. by the very noisy steel elevated structures in Chicago and New York, new transit system planners did have

concerns about noise and vibration. As a result, studies and surveys were commissioned to develop information which could be used to set new facility design criteria. One of these surveys completed for the Washington, D.C. Metro, by the Office of Research and Experiment, ORE, of the International Railway Union, IUC, asked ORE members to rank order operational problems. The result was almost universal ranking of (1) vandalism and (2) noise and vibration as the two top priority problems.

Partly as a result of the survey, but also because of the general concern regarding patron exposure to noise and vibration and the effects on adjacent communities, a large number of measurement programs and research studies were completed in the 1960's and '70's. One survey by ORE published in 1981 listed 192 separate reports produced or published during the period from about 1965 to 1979 on various aspects of rail system noise and vibration, including standards or regulations and exposure or annoyance assessment.

The studies and experiments with rail system noise and vibration included a number of trial installations of resilient rail fixation designs and floating slab track for reduction of the ground and structure-borne noise. Examples include the Paris Metro in coordination with the Regional Express Line, RER, and the French National Railway, SNCF, installing a number of test tracks with of various rail fastener designs and floating track slab. German railways also were experimenting with resilient rail fixation on concrete. In Vienna, floating track slabs supported on continuous glass fiber panels were installed in an effort to reduce groundborne noise from streetcar lines. In Toronto several trial installations of floating slab track using polystyrene foam boards as the isolation media were installed. The Paris Metro installations provided valuable information on

performance of various resilient track fixation systems. The continuously supported track slabs in Vienna and Toronto were not successful.

Much of the concern relative to noise and vibration in new rail systems was with respect to the in-vehicle noise and ride quality. These were perceived as affecting the attractiveness of public transit to the patrons and, therefore, directly related to revenue. This made in-vehicle noise and ride quality very important design parameters. Thus, many of the early studies were confined to in-vehicle noise and vibration assessments, development of appropriate criteria and development of procedures for improving the design of vehicles, waystructures and track to control the vehicle interior noise and ride quality. Similar importance was placed on control of noise in new station facilities, resulting in application of acoustical absorption materials both to control noise in the stations and to improve intelligibility of public address systems.

The technology and design procedures for control of in-vehicle noise and ride quality had a long history of development prior to the startup of the new system designs in the 1960's and 70's. This background coupled with the results of the various interior noise and ride quality studies commissioned by the new systems for identifying the best practices resulted in a relatively well defined set of criteria, design procedures, technology and materials for control of car interior noise and ride quality. Control of noise and reverberation in stations was also studied and then included on architectural design.

However, rail fixation technology was relatively poorly developed and, in many cases, traditional ballast and sleeper track or wood sleepers cast-in-concrete were still considered the primary design choice because of the long experience and known characteristics. There was limited experience with ballastless resilient rail fixation and floating slab track so these were considered unproved technology, viewed with caution and required both persuasion and demonstration of their potential to induce adoption.

The many studies which showed potential benefit to noise and vibration control, and which demonstrated operational safety and potential for reduced maintenance costs did result in adoption of resilient rail fixation. Further development followed including the light weight undamped floating slab concept. This presentation is a review of the designs developed and implemented for reduction of ground and structure-borne noise from the rail systems and the control of wayside airborne noise from surface and viaduct guideways.

Following the initial successes with the then new rail fixation technology, the work on development of improved and more effective noise and vibration control technology for the rail systems continued throughout the 1980's and 90's. In some cases this was a continuing effort to reduce costs and/or improve performance. However, it was also due to the imposition of more and more restrictive wayside noise and vibration requirements. Generally the same car interior noise and

station platform noise criteria as were developed early on continue to be used. But as more and more cities or jurisdictions adopted restrictive environmental controls it has become an increasing requirement that new rail transit systems provide extensive vibration and noise control. One of the most graphic examples is the requirement for very low wayside noise and vibration by the Hong Kong Environmental Protection Department, EPD, as part of its overall program to reduce future outdoor noise levels in one of the noisiest cities in the world.

Track Fixation Developments

In evaluating and developing new or existing technology regarding the noise and vibration generated, it is extremely important that all aspects contributing to the noise and vibration be considered. There are numerous instances in the literature presenting glowing results which were in fact due to change of two or multiple parameters rather than the item being studied or evaluated. For example, considering the wayside noise from trains operating on at-grade or viaduct guideway, the principle noise sources are the propulsion system, including the motors and gearing, the wheel/rail system and auxiliary equipment such as air conditioners. At higher speeds, the propulsion system noise usually predominates, unless the wheels and rail are in poor condition. At medium speeds the wheel/rail noise usually predominates, but may be affected by auxiliary equipment noise. At low speeds or stopped, the auxiliary equipment noise dominates. Application of mechanical service brakes can also result in dominant noise. Thus, all of these factors must be considered when assessing the wayside noise.

Factors which affect the structure-radiated noise from a viaduct or the groundborne noise and vibration from at-grade and subway installations are primarily the guideway deck and girder construction, the rail fixation system and the dynamics of the vehicle bogie, principally the unsprung weight and the primary suspension resonance frequency. In several instances a change in the bogie dynamics resulted in erroneous evaluation of the effect of rail fastener changes which were being evaluated because the bogie dynamics change created a larger more dominant effect. Evaluation of the rail fastener performance without knowledge or recognition of the bogie change resulted in erroneous conclusions.

The high ranking of noise and vibration as an operational problem did result in the three new U.S. systems and the Toronto system commissioning studies intended to extend the existing knowledge and develop new technology for reduction of ground and structure-borne noise and vibration. The objectives of the studies included developing appropriate acceptability criteria. Feasibility and installation costs were also items of substantial concern.

One of the significant factors at the time was the success of the TTC system introducing resilient direct

fixation in place of the conventional ballast and sleeper track or wood sleepers cast in concrete as used in subways built in the 1920's and 30's. The original motivation for the TTC introduction of resilient direct fixation rail fastener on concrete trackbed was to increase durability and life of the rail installation. The improvement in noise and vibration performance was an unexpected benefit.

In addition to the studies and research projects commissioned by the three U.S. projects, the Paris Metro extensive research program on direct fixation rail fasteners, resiliently supported ties (STEDEF system) and floating track slab as a means for reduction of wayside noise and vibration from subways provided valuable data and insights. Paris Metro also had a parallel program of refurbishing old subway lines via changing from steel wheels to pneumatic rubber tires as a means to improve the overall noise and vibration performance and other operational aspects. Although marketed in other countries as a quiet system, the pneumatic rubber tire system was never adopted by Paris Metro as a feature for new installations, and was used only for renovation of older subways.

One of the studies initiated by the BRRT was an evaluation of pneumatic rubber tire systems compared to steel wheel and rail to determine whether or not there was sufficient noise and vibration benefit to justify adoption of pneumatic rubber tire rather than steel wheel technology. The evaluation included the Transit Expressway vehicles on a test track in Pittsburgh, Pennsylvania and the Paris Metro rubber tired lines. The result of the study was the finding that, when compared on an equal train speed and equal passenger carrying capacity, the rubber tire system created the same or greater noise levels in the vehicle and at the wayside for surface guideways. The only benefit was reduced groundborne vibration and noise. It was concluded that in fact well maintained steel wheel and rail systems were potentially quieter with regard to airborne noise than can be expected for a pneumatic rubber tire system for equal operating conditions.

Much of the early work on development of rail fixation methods which would reduce the noise and vibration compared to either standard ballast and tie track or wood sleepers embedded in concrete, as used for most systems installed prior to the 1960's, was concentrated on the development of resilient rail fixation fasteners (baseplates). As part of its technology development program, the San Francisco BART system during the design development period constructed a test track and obtained three "laboratory" cars for assessment of various aspects of the transit technology, including noise and vibration. The test track included ballast and tie and viaduct with concrete girders and decks.

Figure 1 presents drawings of the three basic types of resilient rail fasteners used for fixing the rail directly to concrete roadbed with a low profile device: (1) the unbonded elastomer pad under a flat rail baseplate, (2) the bonded assembly with flat top and bottom plates and

(3) the elliptical shaped bonded fastener with elastomer in shear rather than compression. The first type with unbonded flat elastomer was the type used in Toronto, and was the type investigated during the Paris Metro testing. Early experience showed the need for steel springs at the anchor bolts to prevent fatigue failure of the bolts. To eliminate the need for anchor bolt springs, the bonded fastener configuration evolved and a number of this type were included in the BART test track evaluations. There were many versions of the unbonded and bonded types of rail fasteners that were developed and which were evaluated for noise and vibration characteristics, both wayside noise and structure-borne noise. Figure 2 is a photograph showing the experimental setup for measuring wayside noise and ground vibration at the BART test track in 1966.

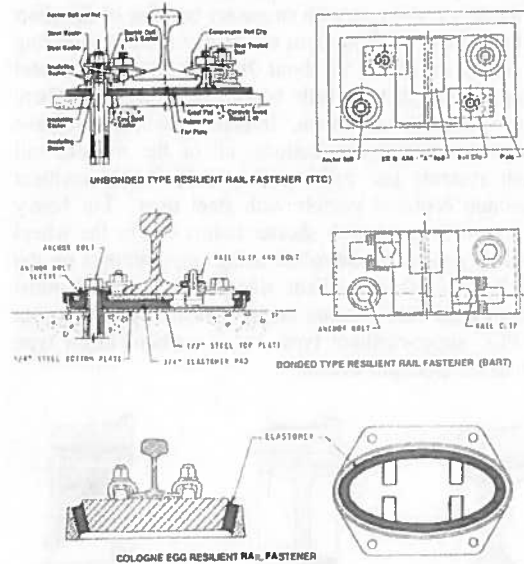


Figure 1 Three basic types of resilient direct fixation rail fasteners, unbonded, bonded and Cologne Egg



Figure 2 Photo of BART Test Track concrete viaduct and trial sound barrier wall

The requirements for rail support safety and durability resulted in rejection of many configurations developed by various manufacturers. Many candidates that had promising noise and vibration performance failed the 3 or 5 million cycle alternating vertical and lateral load test imposed. Also, providing for limited lateral rail deflection reduced the vibration and noise control effectiveness, eliminating further submissions.

In addition to resilient rail fastenings, resilient wheels of various types have been one of the features considered for transit vehicles for reduction of noise and vibration. Figure 3 shows the main types of resilient wheels which have been considered and which were included in the testing at the BART test track. Note that the PCC type wheel is a super-resilient design which has been used since the 1930's on streetcars for general noise reduction, particularly reduction of wheel squeal noise. This was particularly important with streetcars because of the short radius curves. With modern rail transit systems, limiting the minimum radius to about 200-250 m avoids wheel squeal. Thus, there is little benefit from use of resilient wheels on heavy rail transit. In general, while there have been experimental installations, all of the modern rail transit systems use solid steel wheels or non-resilient aluminum centered wheels with steel tires. For heavy rail transit systems with shorter radius curves the wheel squeal is generally controlled using ring-dampers on the wheels rather than resilient wheels. In contrast, most modern light rail systems do have resilient wheels, not the PCC super-resilient type, but a resilient insert type such as the Bochum wheel.

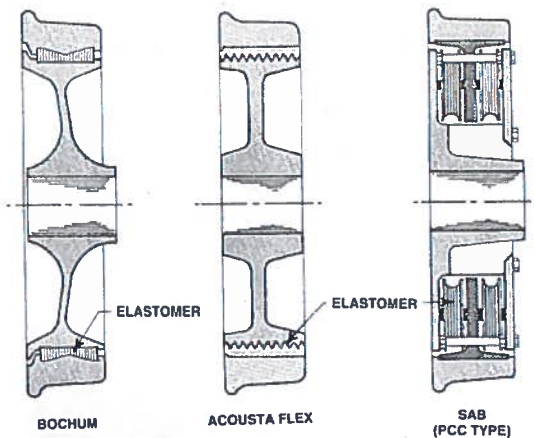


Figure 3 Three types of resilient wheels tested for application to rail transit

Because resilient wheels were one of the parameters being tested via the "laboratory" cars at the BART test track, many of the initial tests on the effectiveness of different types of resilient rail fasteners were inconclusive and in fact incorrect. This occurred because the particular laboratory vehicle used for all of the initial rail fastener tests at the concrete aerial structure was

equipped at the time with the SAB (PCC) type resilient wheels. This wheel had resilience that was far greater than that of any of the rail fasteners, resulting in the measurements showing essentially no difference regardless of the stiffness or other characteristics of the rail fastener. The result of this evaluation was selection of a relatively stiff resilient fastener, about 75 kN/mm for the BART viaduct and subway installations. When later tests with standard steel wheels revealed the error in the early conclusions, the result was identification that a rail fastener stiffness in the range of 17 to 22 kN/mm was about the optimum compromise between maintenance of rail stability and minimizing structure-borne noise radiated from viaduct or transmitted from subways.

At the BART system concrete viaducts, the stiff fastener did result in some low frequency noise radiated from the structure but it was barely audible and did not increase the total A-weighted wayside noise level from the trains. Systems constructed later have used the softer fasteners with the result that there is lower radiation of noise from the viaduct structures and use of sound barrier walls is more effective in controlling wayside noise.

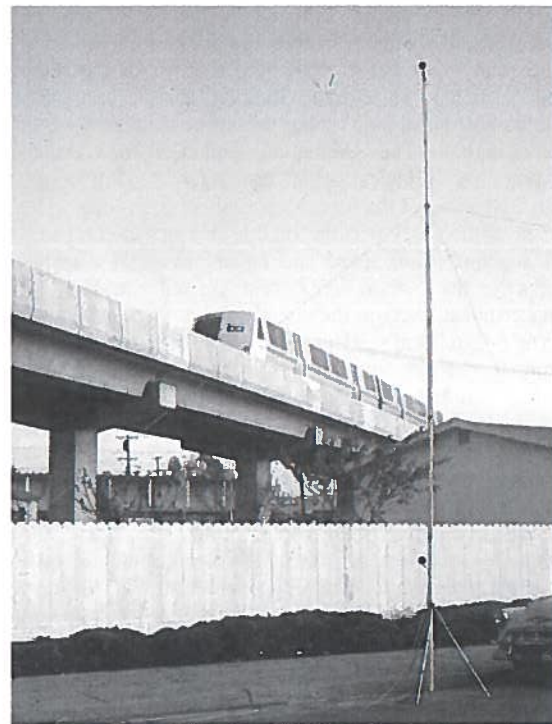


Figure 4 BART concrete viaduct with sound barrier wall

Most of the noise control provisions of the initial 112 kilometer BART system were concentrated on control of noise at the vehicle via specified maximum noise levels for the propulsion system and auxiliary equipment and because wayside noise was not considered an important parameter beyond the provisions of continuous welded

rail and concrete aerial structure. There was only one small section of sound barrier wall. Figure 4 is a photo showing the sound barrier wall applied to the BART viaduct, a modification which resulted in about 6 dBA reduction of wayside noise.

The Metropolitan Atlanta Rapid Transit, MARTA, system followed the design of the three earlier U.S. systems and as a result incorporated more of the provisions for control of noise and vibration. Figure 5 is a photo of a MARTA steel girder and concrete deck aerial structure on which the softer variety of rail fasteners and the sound barrier wall were used extensively to reduce wayside noise from the viaducts. In this case, because the design requirements for safety walks on the outside edges of the viaduct deck made the deck much wider with resulting increased noise radiation, it was essential that the softer direct fixation fasteners be used in order to allow sound barrier walls to produce the expected noise reduction. Without the softer version of the rail fastener, the structural radiation from the MARTA aerial structure would have been a dominant source of noise. Constrained layer damping was used on the steel girders to give approximately the same noise radiation as for concrete girders along noise sensitive sections of trackway, including all sections with sound barrier wall. At locations where the viaduct girders do not have the constrained layer damping, there is significant noise radiation from the steel girders. The MARTA sound barriers provided 8-9 dBA reduction of wayside noise.



Figure 5 MARTA double track concrete deck with damped steel girder and sound barrier wall

There has been continuing development of new configurations and versions of the resilient rail fasteners. The major variation from the flat plate rail fasteners, as shown on Figure 1, was the introduction in about 1979 of the elliptical-shaped "Cologne Egg" fastener which places the elastomer in shear for vertical load and compression for lateral loads. This allows for a much softer rail support while maintaining the rail stability

required for safe operation of the rail vehicles. The Cologne Egg type fasteners can have a vertical stiffness in the range of 9 to 13 kN/mm, which is of significant benefit in reducing structure-borne radiation from viaduct structures with steel girder and in reduction of groundborne vibration and noise from subway or at-grade rail installations.

The basic limitations on rail support lateral stiffness and/or rail lateral deflections limit the lower range of stiffness which can be achieved with the flat plate type of rail fastener, either the bonded or non-bonded configuration. Thus, there is a practical limit to the reduction of groundborne noise and vibration from at-grade and subway installations of flat plate type of rail fasteners. As it turns out, the minimum practical stiffness results in groundborne vibration and noise similar to that resulting from ballast and tie track. Because of the characteristics of the Cologne Egg type fastener, the result is a reduction by 6 to 8 dB of the groundborne vibration and noise for frequencies above about 40 Hz. In many cases, this is sufficient to achieve satisfactory results, particularly for new rail facilities placed adjacent to non-noise-sensitive land uses.

An alternative design which also provides about 6-8 dB greater reduction of groundborne noise for frequencies above about 40-50 Hz is the resiliently supported or booted double tie. This is the STEDEF design which was included in the early Paris Metro studies and has been used at some locations where the additional reduction was considered adequate, particularly before the Cologne Egg gained acceptance. The resilient double tie system, now called Low Vibration Track, is not low profile, requiring a second pour of concrete to embed the ties, but does have the advantage of reduced radiation of airborne noise from the rail because of the stiff fixation to the concrete tie mass.

Floating Slab Track

There are many instances where the control of ground and structure-borne noise levels achieved by resilient rail fasteners, or the alternative Cologne Egg or Low Vibration Track, are not low enough for satisfactory or acceptable results. Adjacent land uses which are noise sensitive, such as residential, school or performing arts facilities, and in some cases even commercial facilities such as office or court buildings may require a higher degree of noise reduction. In these instances the practical alternative is a fully vibration isolated or floating track slab design.

As a part of the noise and vibration assessments performed for the new U.S. transit systems, measurements were made of the groundborne noise and vibration at various locations in buildings near the existing subways in Toronto and at other existing transit systems such as those in Philadelphia and Chicago. Further, information from the Paris Metro and other studies in the literature were used along with the measurement results to develop a basis for projecting the

expected groundborne noise at locations along the Washington, D.C. Metro routes to determine whether or not mitigation was needed. This same procedure was used for subsequent evaluations and projections with a continuing growth of the database as new systems went into operation providing opportunities for additional measurements.

The initial assessments indicated several locations along the WMATA route where mitigation beyond that which could be provided with resilient rail fasteners was necessary. Initially, the planners and consultants for the system thought that a floating slab track type of mitigation would be needed at stations, but not in other locations. An objective analysis showed that there were many locations requiring added mitigation but only a few instances where track through stations needed the mitigation.

Identifying the need for mitigation at the WMATA system subways motivated the development of the initial light weight loading slab configuration. There had previously been a successful floating slab type of installation at the Barbican Scheme site in the City of London where residential development, an Arts Center and several buildings sensitive to noise were located close to an underground railway. When the railway was realigned, a slab bridge deck type of design was developed, a design which required substantial increase in depth of the subway tunnel, along with the installation of a complex system of crossbeams on rubber bearings under the ends of 10 m length concrete bridge decks with a damping layer and ballasted track on top. The design incorporated lateral bearings for lateral restraint without reduction of the isolation affect. The stiffness of the natural rubber bearings was tuned to about 6 Hz, considering the mass of the bridge deck and the ballasted track. A similar system was installed some years later on the London Heathrow transit line. This type of design was very complex and expensive so that there was strong motivation to develop an alternative design which would be effective and of much lower cost, including minimum depth to minimize additional cost in excavating the subway tunnel.

One of the factors which had discouraged prior development of a light weight floating track slab system was the perception that damping was needed to prevent amplification of the wheel/rail interface vibration forces at the natural frequency of the floating slab on the resilient bearings. The Barbican and Heathrow slabs had heavy damping layers in addition to the ballast to accomplish damping of the floating track assembly.

After an analysis of the type of forces applied by a moving rail vehicle to the trackbed and the supporting structure, it was identified that the forces are random impact-like forces and moving or non-stationary relative to the support system. Therefore, it was concluded that the response would be more similar to the response of a spring mass system to an impulse or impact force than that due to steady-state excitation, which is the more familiar type of analysis. This conclusion led to the

estimate of 2 to 3 dB amplification factor for a lightly damped floating slab track system rather than the 15 to 20 dB amplification that would be expected for steady-state excitation of the same system.

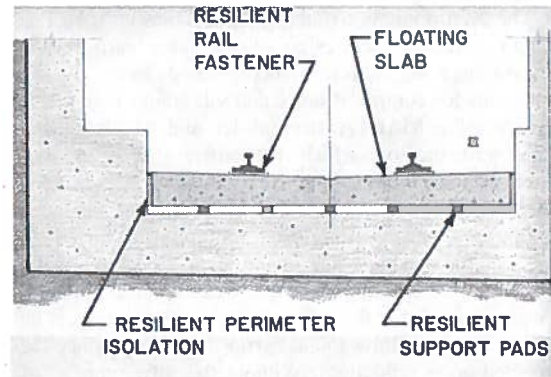


Figure 6 Cross-section of continuous floating slab design developed for WMATA

Figure 6 presents a cross-section of the light weight floating slab design developed from the analysis which indicated that the moving random excitation would create the effect of a damped single-degree-of-freedom system. For the WMATA system continuous cast-in-place floating slabs using a sheet metal form or shutter left in place were constructed. Stationary steady-state tests of an initial installation did indicate an amplification factor of 15 to 17 dB at the design resonance frequency, but that for frequencies of concern in the groundborne noise there was substantial reduction.

This design did achieve the goal of low profile while retaining enough mass to achieve the 15 to 20 dB of groundborne noise reduction needed at some locations. The added depth for box-section tunnels was small, 300 mm, and the design was adaptable to round tunnels without increasing the tunnel diameter.

A significant part of the development of the design was the determination of the appropriate elastomer for the floating slab. To this end there were several requirements that limited the design. One was an imposed limit of 3 mm for rail deflection. Another was a limit of 300 mm for the total depth of the slab and resilient pads, at least for the initial installations. A third limit was the need to have natural frequency low enough to provide the groundborne noise reduction required and low enough to avoid interaction with the vehicle bogie primarily resonance frequency. These requirements taken together indicated that natural rubber was the best selection for the elastomer. With natural rubber the ratio of dynamic-to-static stiffness is the minimum, allowing for a ratio less than 1.4. Most synthetic elastomers, including Neoprene, have a ratio of 2.0 to 2.5, resulting in substantially greater rail deflection for a given resonance frequency. Natural rubber was also known and demonstrated to have a long service life and can be

formulated to have very low creep under compressive load.

Through correspondence in 1972 with the Malaysian Rubber Bureau in the U.K., a formulation specifically tailored for floating slab track was developed and has subsequently been used as the specified elastomer with great success. Some of the earliest installations have been in service for nearly 30 years and show no signs of deterioration or change in mechanical properties. There are many older installations of natural rubber bearings used for vibration isolation applications or other purposes which demonstrate the expectation of very long life. One of the oldest is the Victorian Railway's viaduct between the Flinders Street and Spencer Street Stations in Melbourne where the installation completed in 1891 is still in service. The rubber isolation pads between the viaduct structure and the supporting piers are still in excellent condition and functioning to minimize vibration transmitted from the trains to the stone and brick piers.

With the selection of elastomer, the design of the WMATA floating slabs was determined, including the decision to cast-in-situ continuous slabs with pinned moment connections between individual sections as the concrete was poured. While these floating slabs were successful in reducing the groundborne noise and vibration, they also radiated airborne noise due to bending waves in the continuous slabs. For standard track the low frequency radiated noise was a barely noticeable addition to the noise generated by the train propulsion equipment. However, at special trackwork, the noise was thunderous, audible in the cars and at station platforms where a crossover was located near the station. The main problem encountered was that for some sections the contractors were allowed to substitute polyurethane elastomer pads for the natural rubber pads. The polyurethane pads turned out to be hydroscopic and lost their mechanical stiffness when exposed to water. The failed pads had to be replaced, a process which was difficult and expensive due to the continuous poured-in-place slab configuration.

In 1974 the TTC opened a new Yonge Street Extension with only the resilient rail fasteners for mitigation. This line went further into residential areas than previous lines and resulted in a huge amount of complaints about groundborne noise and vibration. This led to extensive research and development programs both to improve the existing new line and to identify better mitigation for future new subway lines. One of the TTC track engineers proposed precast concrete sections as a lower cost alternative to the continuous floating slab. The configuration proposed also provided for access and easy replacement of the isolation pads. With revisions to optimize the acoustical performance, the design was developed into what is known as the double-tie or discontinuous floating slab track.

Figure 7 is a plan view showing the typical 1.5 m length segments for the floating slab. The side pads and end pads provide for complete isolation with mechanical retention and to accommodate lateral loadings. Figure 8

is a photo of the double-tie floating slab system before installation of the rail fasteners and rail. This configuration essentially eliminates the airborne noise radiated from the slab as an addition to train noise heard by the patrons, provided that the resilient rail fastener has sufficient resilience to control transmission of higher frequency vibration from the rail to the slab. At the TTC system, the noise radiated from the slabs is at or below the train noise level at the same frequencies and is not noticeable either on station platforms or in the cars. At some other more recent installations where the rail fastening is too stiff, there is noticeable noise radiation from the slabs. In one instance, the rail was fastened directly to the slabs, resulting in very high noise level radiated into the cars and very poor groundborne noise control performance.

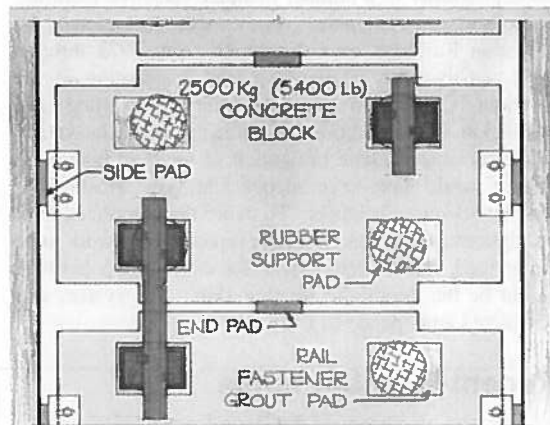


Figure 7 TTC double-tie discontinuous floating slab design - 1500 mm length precast concrete blocks



Figure 8 Photo of TTC double-tie system in subway - before installation of the rail fasteners and rail.

The earliest installations in Toronto, with the natural rubber bearing pads as specified, have now been in service for 28 years without any evidence of deterioration of the rubber pads. Further, there has been no added or special maintenance required or created by the floating slabs. The success of the design has led to the adoption by a number of rail transit facilities where mitigation of groundborne noise has been necessary. These include the MARTA system in Atlanta and the transit facilities in Los Angeles, Buffalo and recent extensions of the BART system. Other notable applications are at the Hong Kong Mass Transit Railway and at the Canary Wharf in London, U.K.

Another early installation of the double tie concept floating slab was at the Melbourne Underground Loop, MURLA, subway. The four lines of the Loop are in close proximity to a number of noise sensitive facilities. Therefore, an extensive study was completed by Victorian Railways over the period from 1973 through 1978. This study included a trial installation at the Jolimont Cutting to provide in-service testing and evaluation of the proposed floating slab track system. While the intermediate mitigation of resilient booted tie system would have been adequate at some locations, it was not adequate at others. To avoid the complication of multiple transitions and multiple types of trackwork to be maintained, it was determined the entire Loop network would be the double-tie floating slab. The system was completed and opened in 1981.

Recent Developments

The new extensions of the Hong Kong MTRC and the new line constructed for the Kowloon Canton Railway Corporation, KCRC, have required creative combinations of structure-borne noise control and sound barrier technology. The environmental requirements for these new facilities are among the most restrictive in the world. At first it was thought that achieving the design goal of 64 dBA at 25 m for a train at 140 km/hr would require a covered viaduct with floating slab track. However, using the floating slab track design principles developed and refined from experience with each new system combined with a new approach to sound barrier wall design enabled creating an overall design achieving the low wayside noise level without a complete cover over the guideway.

The overall design approach for the 21 km KCRC viaduct was the use of concrete guideway and girders, floating slab track to minimize structure-borne noise radiation from the guideway and integral sound barriers, soft rail fasteners to minimize noise radiation from the floating track slabs, sound barrier walls with sound absorption and an undercar/under-walkway sound absorptive plenum to supplement the sound barrier walls. The overall design also required low noise performance for the vehicle propulsion and auxiliary equipment. For example, a typical roof-mounted air conditioner could by itself exceed the overall wayside noise allowance, since

the AC unit noise would not be mitigated by a sound barrier wall.

Figure 9 is a representation of the KCRC viaduct final design showing the elements included for control of wayside noise, the all-concrete structure, the floating slab track, the sound barrier wall with absorption and the under-walkway plenum with absorption to minimize noise transmitted to the walkway-to-car gap to the sound barrier wall and thence to the wayside. Figure 10 is a photo of the completed viaduct and Figure 11 is a close-up photo showing the floating slab segments with the soft Cologne Egg type rail fastener. Trains began running on this facility in 2004 and the wayside noise measured was 64 dBA L_{eqmax} at 25 m for an 8-car train at 140 km/hr.

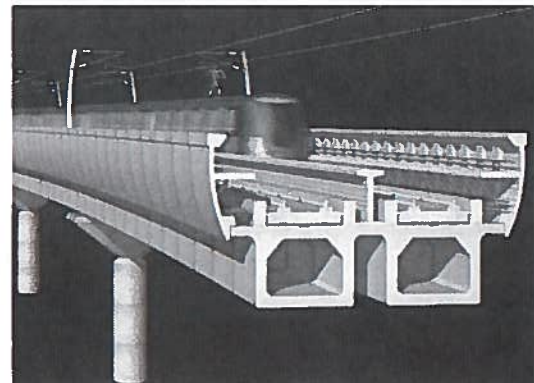


Figure 9 KCRC viaduct with floating slab track, absorptive sound barrier wall and under walkway absorptive plenum



Figure 10 Photo of KCRC viaduct completed

The fact that the new KCRC viaduct was designed and constructed to successfully control the wayside noise without need for complete cover over the trackway demonstrates that the principles, procedures and materials which have been developed do accomplish the acoustical design goals. The design represented in Figure 9 was based entirely on empirical and analytical

design analysis without construction of a test track or test section to demonstrate the performance.

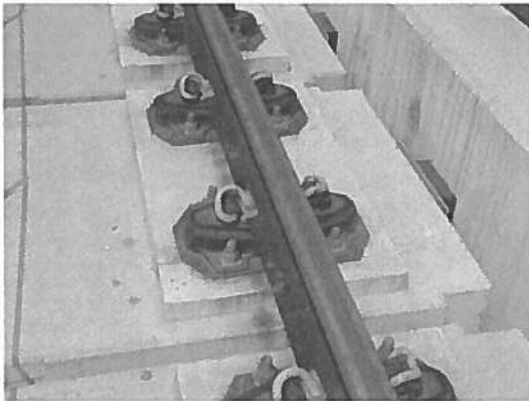


Figure 11 Close-up view of KCRC viaduct floating slabs with low stiffness rail fasteners

Summary

Through the application of simple vibration isolation design principles with careful attention to the entire complex system affected by individual noise and vibration control features, it has been found possible to greatly reduce both the wayside airborne noise from viaduct structures and the groundborne noise and vibration from subway and at-grade rail installations. The principles applied to viaducts can also, of course, be applied to bridges. With attention to the design factors which affect structure-radiated noise, it has been possible to reduce the unmitigated wayside noise from the range of 84 to 87 L_{Aeqmax} at 15 m for 130 km/hr train on a concrete viaduct structure to 65-67 L_{Aeqmax} for the same conditions but with mitigation.

Through development of light weight, undamped floating slab systems which take into account the vehicle bogie dynamics, the trackway or subway structure mass and the surrounding geology characteristics, it is now possible to install new rail systems in very close proximity to noise sensitive land uses without the impact of low frequency rumbling noise which has traditionally been associated with rail system subway trains. For example, initial operations of the TTC Spadina line, which opened in 1978, resulted in complaints from only two houses and it turned out these were due to problems with flat wheels during the initial operations. After the flat wheel problems were corrected, there were no further complaints and it was reported that trains in a tunnel only 3 m from houses were only occasionally audible.

With the technology and materials now available for rail system noise and vibration control, it is possible to install new facilities in locations or along alignments which in the past would have been considered unfavorable because of the noise and vibration impacts. Even with the more restrictive standards now imposed by

many jurisdictions, the transit system planners and designers have less limitations regarding selection of alignments for new transit facilities. Of course, there still remains the problem of convincing the neighbors of a potential new facility that the wayside noise and vibration will be satisfactory and acceptable in the community.

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**ANNEX III: COMPARISON OF
COVERAGE OF BOGIES
FROM DIFFERENT MODERN
ROLLING
STOCK EQUIPMENT on page 165**

DIRECTORATE-GENERAL FOR INTERNAL POLICIES

**POLICY DEPARTMENT B
STRUCTURAL AND COHESION POLICIES**

Agriculture and Rural Development



Culture and Education



Fisheries



Regional Development



Transport and Tourism



**REDUCING
RAILWAY NOISE
POLLUTION**

STUDY



DIRECTORATE GENERAL FOR INTERNAL POLICIES
POLICY DEPARTMENT B: STRUCTURAL AND COHESION POLICIES

TRANSPORT AND TOURISM

REDUCING RAILWAY NOISE POLLUTION

STUDY

This document was requested by the European Parliament's Committee on Transport and Tourism.

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DIRECTORATE GENERAL FOR INTERNAL POLICIES
POLICY DEPARTMENT B: STRUCTURAL AND COHESION POLICIES

TRANSPORT AND TOURISM

REDUCING RAILWAY NOISE POLLUTION

STUDY

Abstract

12 million EU inhabitants are affected by railway noise during the day and 9 million during the night. This study lists measures, funding and regulations to reduce it. The introduction of modern rolling stock will lower noise most significantly. In the short run, the replacement of cast iron by composite brake blocks on rail freight cars is most important. Developing a regulation scheme for a staged process towards low-noise rolling stock is the heart of a rail noise abatement strategy.

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LIST OF ABBREVIATIONS

AEA	AEA Technology Rail BV, Netherlands
BIMSchV	Bundes-Immissions-Schutz-Verordnung (Traffic Noise Ordinance of Germany)
BMVIT	Bundesministerium für Verkehr, Innovation und Technologie (Federal Minister for Transport, Innovation and Technology of Austria)
BS	British Standard
BVU	Beratergruppe Verkehr + Umwelt (Consultants for Transport + Environment)
CER	Community of European Railway and Infrastructure Companies
DB	German Rail (Deutsche Bahn)
DEFRA	Department for Environment, Food and Rural Affairs of UK
DG	Directorate-General of the European Commission
DG ENTR	Directorate-General Enterprise and Industry
DG ENV	Directorate-General Environment
DG Research	Directorate-General Research
DG TREN	Directorate-General Transport and Energy
DIR	Directive
EC	European Council
ECML	East Coast Main Line
EEA	European Environment Agency
EMU	Electric multiple unit
EP	European Parliament
ERFA	European Rail Freight Association
ETC LUSI	European Topic Centre on Land Use and Spatial Information
EU	European Union
FM	Friction modifier
FS	National railway of Italy - Trenitalia (former Ferrovia dello Stato)
K-block	Composite brake block

L_{DAY}	Average Noise Level Index day time
L_{DEN}	Average Noise Level Index total day
LL-block	Low-low brake block
L_{NIGHT}	Average Noise Level Index night time
NDTAC	Noise Depending Track Access Charge
ÖBB	Österreichische Bundesbahn (Federal Railway of Austria)
PPG	Planning Policy Guidance
RENFE	Spanish Railways (Red Nacional de Ferrocarriles Españoles)
RFI	Italian railway infrastructure management company - (Rete Ferroviaria Italiana)
SBB	Swiss Federal Railway (Schweizer Bundesbahn)
STIB	Municipal Public transportation company of Brussels (Société des transports intercommunaux de Bruxelles)
TAC	Track Access Charge
TOC	Train Operating Company
TOR	Top of Rail
TSI	Technical Specification for Interoperability
UIC	International Union of Railways (Union Internationale des Chemins de Fer)
UIP	International Union of Private Wagons (Union Internationale des Wagons Privés)
UIRR	International Union of combined Road-Rail transport companies (Union internationale des sociétés de transport combiné Rail-Route)
UITP	International Association of Public Transport
UNIFE	Association of the European Rail Industry
VDV	Association of German Transport Companies (Verband Deutscher Verkehrsunternehmen)
VPI	German Association of private wagon owners (Vereinigung der Privatgüterwagen-Interessenten)
WCML	West Coast Main Line
WHO	World Health Organisation

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EXECUTIVE SUMMARY

According to Member State reports compiled by the European Environment Agency (EEA) in 2010, railway noise affects about 12 million EU inhabitants at day time, with a noise exposure above 55 dB(A), and about 9 million at night time, with a noise exposure above 50 dB(A). In fact, the real figures are undoubtedly higher since the EEA's European noise mapping initiative concentrates on agglomerations with over 250,000 inhabitants and on main railway lines with over 60,000 trains per year. The railway noise problem is concentrated in central Europe, where the majority of the affected citizens live and the volume of rail freight transport is highest (primarily Germany, Italy and Switzerland, but traffic density is high also in Poland, Austria, the Netherlands and France, and noise mapping indicates that significant population is affected in Belgium and Luxembourg).

Noise is an annoying phenomenon, contaminating the environment and adversely affecting the health of people exposed to high ambient noise levels above 70 dB(A) – or even less. The discussion about railway noise has become very important in several European countries as railway transport increases and plays a more important role in greening transportation. For implementing the sustainability goals formulated in the EC 2011 Transport White Paper and the Greening of Transport package, the environmental impact (carbon, energy, noise, etc.) of railway operations needs to be minimised to maintain rail's position as a green transport mode – and thereby promote a modal shift to rail, to reduce the environmental impact of transport overall.

In order to analyse the noise situation in Europe, following current EC legislation, the Member States have to provide noise maps and noise action plans. Noise action plans describe the measures taken to lower environmental noise for identified affected inhabitants. However, legal conditions differ widely across Europe as Member States have different limits or threshold limits for environmental noise emissions, and usually these limits are tested only when building new infrastructure or during major redevelopment.

In general, three different sources of railway noise are identified:

- Engine noise
- Rolling noise
- Aerodynamic noise.

Railway noise is largely a problem of freight trains and trains containing older wagons or engines, and is a particularly severe problem during the night. Rolling noise is generally higher from poorly maintained rail vehicles, and from trains running on poorly maintained infrastructure. Aerodynamic noise is particularly relevant for high speed lines where, in most cases, noise limiting measures like noise barriers are implemented; noise barriers reduce the impact of rolling noise, but are usually too low to have any effect on noise originating at the pantograph. Engine noise is most relevant at lower speeds up to about 30 km/h, rolling noise above 30 km/h and aerodynamic noise dominates above 200 km/h. The most important noise source is rolling noise, which affects all kinds of train.

To reduce railway noise pollution, passive measures at the place of disturbance can be distinguished from active measures at the noise source. The most important passive methods used to reduce the impact of railway noise on the environment are noise protection walls and insulating windows, and for the most part action plans and

investments of the Member States concentrate on these methods. However, they are only locally effective, requiring huge investments to protect wider parts of railway networks.

In contrast, source-driven measures lower noise across the whole railway system if they are widely introduced. As an example, the problem of noisy rail freight cars can be reduced by the replacement of cast iron brake blocks by composite brake blocks. This is currently being investigated by the railway industry and would affect about 370,000 old freight wagons. Also, wheel absorbers, aerodynamic design of pantographs and noise insulation of traction equipment (e.g., locomotive engines) are measures to reduce noise at source. According to the current Technical Standard for Interoperability (TSI Noise), rolling stock which was introduced since the year 2000 (including engines and passenger coaches or passenger power cars) are required to lower noise emissions by about 10 dB(A) compared to the equipment of the 1960s and 1970s.

In the authors' opinion, noise should ideally be reduced at the source because these measures have a network-wide effect. Where track infrastructure causes increased noise levels (e.g., structure-radiated noise from viaducts or curve squeal in narrow radius curves), or where the local environment is particularly sensitive to noise (e.g., areas of natural beauty or urban environments with residences very close to the railway line) then additional trackside noise mitigation measures may be necessary. Such measures include friction modifiers, rail dampers, floating (or isolated) slab tracks and of course noise bunds and barriers in various heights. Vehicles and track should all be maintained to eliminate unnecessary sources of noise, e.g., corrugation.

Retrofitting of existing rail freight cars with composite K- or (if approved) LL-brake blocks is the most cost-effective measure on the vehicle side. Additional measures on the vehicle side are wheel absorbers, vehicle-mounted friction modifiers (most effective in urban or sub-urban networks) and (for high-speed trains) aerodynamically optimised pantographs (e.g., shielding or coating). These measures are effective network-wide. Additional research could be made for modified wheel constructions as they are very effective but experiences with accidents lead to reluctance to use new wheel constructions replacing mono block types.

On the infrastructure side, friction modifiers, rail dampers and slab track are cost-effective measures for reducing noise. In densely populated environments and highly trafficked railway sections, the use of noise barriers or coverings cannot be avoided. However, if there is a wide introduction of vehicle-related measures, the number of noise barriers or covers can shrink significantly.

Additionally, wheels and rails need frequent monitoring and maintenance to reduce noise. The surface quality of wheels and rails is a key factor determining rolling noise and deteriorates naturally over time; severely damaged surfaces (out of round wheels or corrugated tracks) are a major noise source.

The European Parliament and European Commission try to encourage the Member States to take more action to reduce railway noise, e.g., by introducing noise-dependent track pricing schemes. Such economic incentives (rail track charging differentiated according to noise emissions) can help to:

- stimulate the use of low-noise technology for the rolling stock;
- foster the use of routes which avoid hot spots for noise;
- foster noise-reducing operational routines and speeds in sensitive areas.

On the regulative side, the Japanese top-runner scheme¹ is an example to come to a long term reduction of noise. The TSI Noise is an appropriate basis for noise regulation in the medium and long term. Presently, the standards for noise emissions are valid for new or modified vehicles only. In the medium and long-term view the TSI can become compulsory for all vehicles. The noise levels in TSI Noise should also be lowered from time to time according to technical development similar to the Japanese example.

In principle, there are three approaches to a noise-dependent track pricing, and each can be configured as a mix of bonus and penalty components:

1. The train-related noise emissions can be measured at critical points in densely populated areas and/or low distances to residential zones and then allocated to the trains causing the noise. The noise mark-up for the track charge then would vary with the local noise level and eventually with the noise exposure of the residential population.
2. The wagons can be classified into noise categories and charged with a noise mark-up or granted with a bonus according to the noise category. The train operator would pay the charge to, or get the bonus from, the infrastructure manager, and pass the bill or grant the bonus to the car owner or operator.
3. Trains can be classified on the basis of the rail car types from which they are composed. In the case of freight trains, the emission category of a train could vary with every change of the train composition in marshalling yards.

The first approach would directly correspond to the polluter-pays principle, but causes high transaction costs for implementation and control. The second approach is the most simple and easy to implement, but neglects the nature of rail noise; a high percentage of noise-reduced cars is required in order to achieve a substantial reduction of train-related emissions. The third approach does not require a sophisticated payment system but needs a functioning (eventually international) information system for wagon control.

The charging schemes can be embedded into appropriate legislative regulations to set a clear framework for long-term activities to reduce railway noise. The following instruments for regulation are possible:

- Limits for stationary and pass-by noise for freight wagons and locomotives;
- Operation and maintenance rules;
- Noise-limiting technology for new rolling stock according to the Japanese top-runner scheme. This scheme aims at reducing energy consumption and climate impact by dynamic setting of emission targets on the basis of current best practice ("top runners' performance");
- Retrofitting programmes for vehicles currently in service (phased obligation schedule).

¹ This scheme aims at reducing energy consumption and climate impact by dynamic setting of emission targets on the basis of current best practice ("top runners' performance").

Noise depending track access charges (NDTAC) should be introduced to encourage the vehicle owners to invest in noise reduction measures. At the first stage they should focus on rail freight wagons but the scheme can include other vehicles or measures later or focus on noise limits without regard to measure to reach the limit.

Importantly, NDTAC should be realised so that no burdens for competitiveness for the rail sector appear. Investment and higher operational costs should be covered. NDTAC should be harmonised in the Member States and each vehicle operating in a national network should be included (also foreign vehicles). To meet the fact that significant noise reductions are only to be achieved if trains are completely equipped with low noise equipment, the NDTAC should favour trains which are nearly fully equipped with these vehicles. To avoid losses in competitiveness lower TAC for low noise vehicles a substantial part should be financed by the Member States. To motivate an early switch to low noise vehicles or retrofitting of existing freight cars also direct funding of investments should be considered for a few years.

Summary of recommendations

As rail freight wagons commonly travel across wider international distances, it is essential to harmonise noise legislation policies across Europe. As a result the authors recommend focusing on the following actions:

- Retrofitting the existing freight wagon fleet with low noise braking systems especially by replacing the cast iron by composite brake blocks as the most important and effective first step of source related noise reduction measures.
- Establishing funding schemes to cover the retrofitting and additional operating costs of the new noise reduction technologies to avoid a reduction of the rail sector's competitiveness; a substantial part of costs should be covered by the Member States, since quieter trains will reduce the need for, and therefore the cost of, infrastructure noise mitigation measures.
- Introducing rail track charging systems which differentiate the train charges according to the noise category of a train. The noise classification of a train should be determined by the wagon with the highest noise emission level.
- Making activities concerning NDTAC or noise limit regulation depending on the same actions in road transport to avoid losses of competitiveness for the rail sector.
- Making noise limits by TSI Noise ([TSI Noise 2011] also compulsory for existing rolling stock 10 or 12 years after introduction of funding schemes and noise limits for new rolling stock.
- Adjusting limits of TSI Noise in a phased process for a medium and long-run future to foster the development of new noise reduction technologies.
- Monitoring and maintenance of noise development due to abrasion to assure low noise levels also during operation over long periods.

1. DEFINITIONS AND EFFECTS OF NOISE

KEY FINDINGS

- Noise is **sound which is unwelcome** but the annoyingness depends on the individual.
- Noise can be **harmful**.
- The **noise pressure level** is measured in **dB(A)** (deci Bel) with a logarithmic scale.
- **10 dB(A)** increase of noise represents a **ten-fold increase** of noise pressure.
- A change of **3 dB(A)** is **detectable by the human ear**, with it representing a **doubling of noise pressure**.
- Local **resistance against railway noise increases** especially in Central Europe where most rail freight transport is realised.
- The majority of rail transport is realised in **France, Germany and Poland**.

1.1. Noise and railway noise

Noise is sound that is unwelcome, because of its volume or structure, and can be harmful. Since not everyone responds equally to sounds and the perception is dependent on constitution and mood, noise also contains a subjective component. Therefore, there is no fixed value at which a sound is perceived as noise.

Rail noise is sound emissions arising from the operation of trains and trams. There are a wide variety of sources and causes of rail noise, such as locomotives accelerating, freight wagons braking, squeal noise in curves, vibration from rail corrugation and out-of-round wheels, vehicle coupling in shunting yards, and even the pantographs of high-speed trains.

1.2. Measurement of noise

Sound is vibrations in the air around us causing our eardrum to vibrate. The human ear is sensitive to frequencies in the range 20 Hz – 20 kHz. These vibrations in the air cause pressure changes, and the change in pressure is called sound pressure. Sound, and therefore noise, is measured by measuring the sound pressure. How loud we perceive the sound depends on sound pressure level and duration, but also on frequency and bandwidth. Psychology also affects our perception and tolerance of sound. Besides sound pressure level, the duration of the sound, the time of day, the composition and frequency of the sound must be considered in the assessment of noise. Also, the tonality ("squeak") and impulsiveness ("hammer") play a role.

The measurement of sound pressure level, usually referred to as volume, has the physical unit Bel. Normally the term decibel (dB) (i.e., one tenth of a Bel) is used. The additive (A)

behind the unit dB expresses that the noise measurement is A-weighted (a filter defined by IEC 61672:2003 norm), i.e., tuned to the perception of the human ear.

While the human ear can perceive an increase in sound volume as sound energy increases, the relationship is logarithmic. If two identical 10 dB noise sources are placed together, the perceived increase is not a doubling of the volume but rather a 3 dB increase. If ten such noise sources were placed together, the increase would be 10 dB – multiplying the sound energy (and thus the real exposure) by a factor of ten, multiplies the perceived sound volume by a factor of two.

As such, a sound level increase from 45 dB to 55 dB may not look like much on paper, but it represents a ten-fold increase in sound energy and its impact on human health. Humans are usually able to sense a change of 3 dB in sound level, which corresponds to a factor-of-two change in sound energy, but that is about the limit of sensitivity. Measures to reduce noise levels by less than 3 dB would, by themselves, be of no real value.

Sound can also be transmitted as vibration through the ground and directly into the body, and this is also a form of noise pollution.

Three standard measures of average sound pressure level, defined by ISO 1996-2:1987, are L_{day} , L_{evening} and L_{night} , where day is typically 07.00 – 19.00, evening is 19.00 – 23.00, and night is 23.00 – 07.00; these are long-term average A-weighted measurements of all days, evenings and nights, respectively, over the course of a year. L_{den} is a weighted average of these three, adding 5 dB(A) to L_{evening} and 10 dB(A) to L_{night} ; this is defined in Annex 1 of European Commission Directive 2002/49/EC. The UK uses also $L_{\text{Aeq},16\text{h}}$ which is an average of L_{day} and L_{evening} .

1.3. Effects of noise

The faintest audible sound is at 0 dB(A); the pain threshold is about 120 dB(A). If it is louder than 120 dB(A), there is a risk of injury. At a detonated blast of 150 dB(A) the eardrum can rupture.

Noise exposure during sleep such as night flight noise is regarded as particularly critical. So night noise causes health hazards already at individual levels below 45 dB(A), if the difference between the individual level and the background noise is more than 3 dB.

Noise above 55 dB(A) is considered as noise pollution. If noise above this level lasts for an extended period of time, the efficiency and well-being of a person will be reduced. Noise in the range 65 to 75 dB(A) causes stress to the body. This can lead to arterial hypertension (high blood pressure), cardiovascular disease and myocardial infarction (heart attack). Noise can also provide for a reduction of gastric secretion and be the cause of stomach ulcers [WHO JRC 2011].

In the workplace, above 85 dB(A), a contractor is responsible to ensure his employees have suitable hearing protection available. If the noise level is over 90 dB(A), employees must wear hearing protection.

1.4. Results of noise mapping

According to Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise, all Member States have to provide noise maps and noise action plans (for details see section 2.2 on page 29).

The report on the implementation of Directive 2002/49/EC [EC 2011] summarises the number of affected people by environmental noise in the first round of strategic noise mapping (see Table 1).

Table 1: Affected people by environmental noise according to first round of noise mapping

SECTION	NUMBER OF AFFECTED PEOPLE BY NOISE LEVELS ABOVE 55 DB(A) L_{DEN} [MILLION]	NUMBER OF AFFECTED PEOPLE BY NOISE LEVELS ABOVE 50 DB(A) L_{NIGHT} [MILLION]
Agglomerations > 250,000 inhabitants		
All roads	55.8	40.1
All railways	6.3	4.5
Industrial zones	3.3	1.8
Important infrastructures outside agglomerations		
Main roads	34	25.4
Main railways	5.4	4.5
Main airports	1	0.3

Source: EC 2011, Table 2.

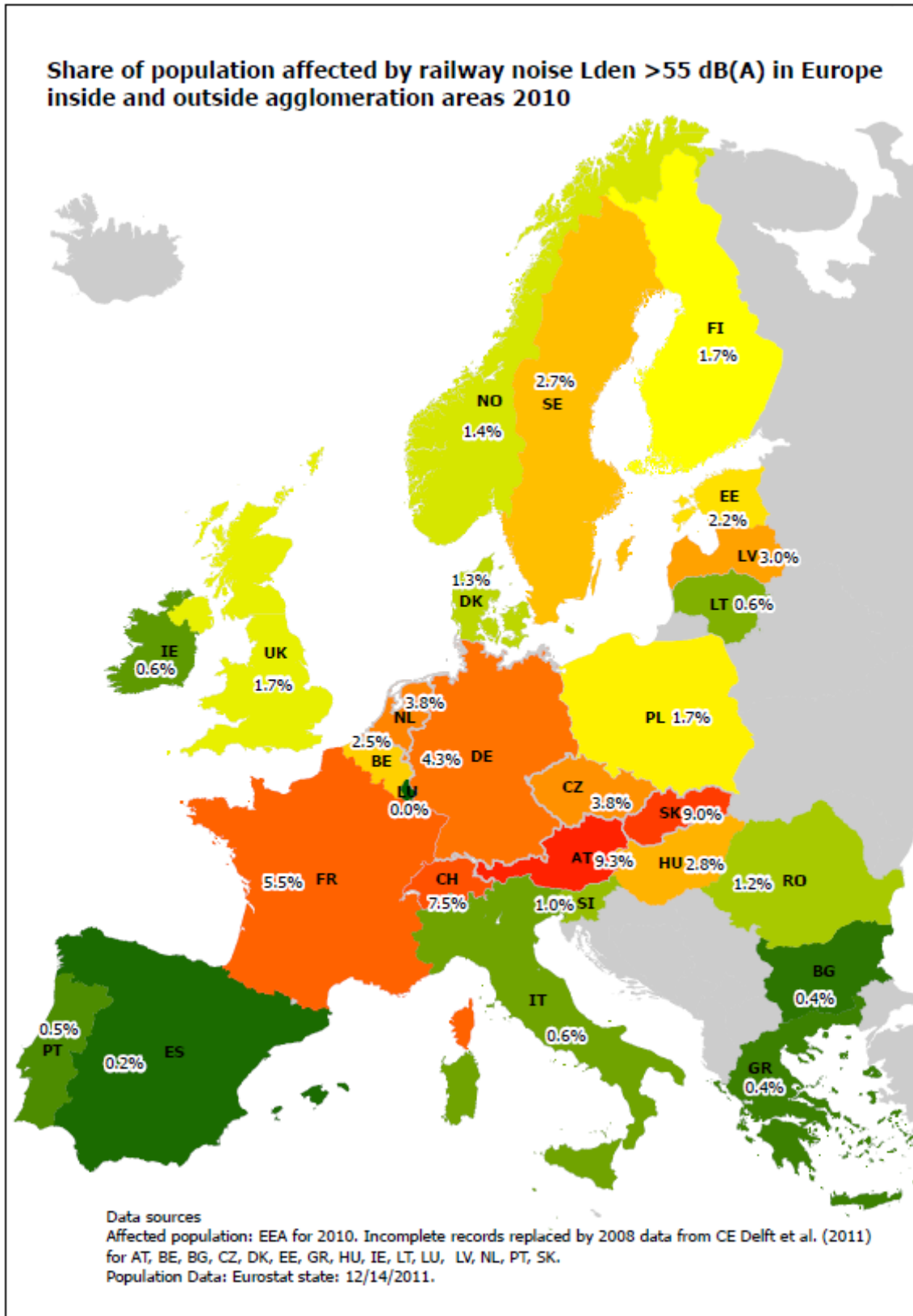
The European Environment Agency (EEA) and the European Topic Centre on Land Use and Spatial Information (ETC LUSI) publishes noise maps on the internet according to Directive 2002/49/EG. The maps are available at [NOISE 2011]. The maps present the population in each country affected by rail noise (distinguishing agglomerations from main lines outside agglomerations). Also, affected population by industry, main road traffic and aviation can be identified. A spreadsheet² shows detailed and aggregated figures according to data sent until 30 June 2010. In Annex I of this study (pages 120 - 121) the results of noise mapping for the rail sector are shown for all countries inside and outside agglomerations.

According to EEA data, the following states in Europe are mostly affected by railway noise according to the share of their population that is affected by railway noise with more than 55 dB(A) L_{DEN} : Austria (9.3%), Slovakia (9.0%), Switzerland (7.5%), France (5.5%), Germany (4.3%), Czech Republic (3.8%), the Netherlands (3.8%) and Latvia (3.0%) (see Figure 1).

The following Figure 1 shows the share of affected people in each European country according to the figures delivered by the states to fulfil the requirements of Directive 2002/49/EC.

² Summary of noise exposure data – file name is "END_DF4_Results_101005_ETCLUSI_inclBG&SW.xls"

Figure 1: Share of people affected by railway noise in each European country according to EEA data



Source: Figure elaborated by the authors with EEA data.

Analysing the figures in Annex I, it can be seen that about 85% of people affected by railway noise (over 55 dB(A) L_{DEN} or 50 dB(A) L_{NIGHT}) are located in the following six countries in Europe: Germany, France, UK, Austria, Poland and Switzerland. About 60% are located in Germany and France.

If only areas outside agglomerations are considered the figures change significantly. In this case the six countries mentioned above represent 89% of affected people. The share of people affected in agglomerations and outside agglomerations differ very much between the countries. In Germany about 75% of affected people live outside agglomerations whereas in Poland this share is 0 (Switzerland: 15%, Austria: 59%, the UK: 17%, France: 44%).

Although the number of people affected by rail noise is about eight times smaller than that affected by road transport noise, the total number remains high. In total 11.8 million inhabitants are affected by railway noise during the day (L_{DEN}) and 9 million are affected at night time (L_{NIGHT}). The limit in noise mapping remains much higher than the recommendations from WHO (see Table 2 page 24).

1.5. Environmental groups and affected inhabitants

On 7 May 2011, about 1,000 protesters came together in Rüdesheim to protest against the rail noise in their hometowns along the middle Rhine Valley. They carried banners demanding a speed limit of 50 km/h in settlement areas and a ban on night trains, word-playing with the "Deutsche Bahn" as "TaliBahn" and blocking the railway line for 40 minutes. The protests were organised not only by a number of local initiatives, but also by communities and district administrations.

The main discussion is currently about freight trains as they are identified as the main source of noise, and they mostly operate at night.

A recent survey [Schreckenberget al. 2011] showed that 45% of the inhabitants along the middle Rhine region are highly annoyed by rail noise, compared to only 13% by road noise. The reason is easy to understand: The topography forces the trains to pass through a narrow valley between Koblenz and Bingen. Four tracks, two on either side of the Rhine, cause unbearable noise disturbances in the ears of the inhabitants. Noise maps published recently show noise levels (L_{DEN}) above 65 and 70 dB(A). These extremes are caused by 400 trains per day, oncoming trains, old infrastructure, and noise reflections on the steep valley and on the water. Additionally, the EU plans for a European freight corridor from Rotterdam to Basel will double the number of freight trains of presently 150 per day to 300 per day. Further protests are expected. Further details concerning the Rhine axis will be elaborated in Section 4.2.1, page 85.

Figure 2: Protests in Rudesheim May 2011, noise map Loreley L_{DEN}



This is not the only protest at the Rhine against rail noise. The plans to increase capacities on the upper Rhine valley caused massive protests from Offenburg to Basel, where presently around 10 local action groups are active. In Offenburg, 45,840 objections were made against the infrastructure plans of Deutsche Bahn, and finally the planning was not approved by the regional administration. As a result, DB started negotiations about a rail tunnel under Offenburg and an alignment with the motorway. In other towns, groups protest against the visual impact of “ugly noise protection barriers” and demand a covered deep-level track near settlements.

The local action groups are supported by a number of environmental NGOs that operate on a national or international level. The wide range of demands concerning rail noise may be summarised as follows:

- Freight trains should bypass settlement areas or be guided through deep-level tracks, tunnels or fully enclosed tracks.
- Equal priorities for noise reduction on existing tracks and new construction projects are required.
- Regarding the legal framework, the equivalent continuous sound pressure level should be complemented by a maximum level measurement combined with frequencies (in other words, peak sound levels and noise frequencies should be considered, not just averaged sound levels).
- Set noise emissions ceilings on railway tracks, in relation to land use and population density. Reduction of the permitted night time noise level to 45 dB(A).
- Introduce protection against vibrations into relevant laws and regulations.
- Set a speed limit of 50 km/h for trains in settlement areas.
- Revise the noise standards for new railway rolling stock (TSI Noise).
- Establish a binding framework for the use of market-based instruments to ensure the polluters pay for their noise costs, including road charges and a framework for rail track access charges which will create an incentive for fast and prioritised retrofitting of rail wagons with quiet brake blocks.

Figure 3: Upper Rhine Valley: Plans for Weil am Rhein and protests in Offenburg

Analyses of transportation data from EUROSTAT show that in 2009 almost 27% of the total rail transportation volume in Europe affected Germany. This underlines the importance of central Europe as a transit region as well as an industrial region and presents the reason why the discussion, or even the battle, concerning noise is the strongest in Germany. Poland in the second place has a share of rail freight volume of 12% and France in the third place has 9%. Concerning passenger transport, Germany has a 20% share and France 21%.

Analyses of the noise mapping results show that the problem is most severe in France, Belgium, Luxembourg, the Netherlands, Austria and Switzerland.

These two aspects are the reason why data, comments, available studies and national policy activities concentrate mostly on central Europe and, there, especially on the German speaking countries and the Netherlands. Regarding the main rail transportation axes in Europe, Germany, Austria and Switzerland are affected by a large volume of transit transportation. This will even rise according to transportation volume forecasts.

The future development of rail freight transport will potentially extend noise problems to other countries through which the TEN-T Corridors pass and which will see rising rail transportation volumes. However, the measures to reduce railway noise which are proposed in this study can help to prevent problems in corridors where transportation will rise in future.

2. LEGAL FRAMEWORK

KEY FINDINGS

- WHO recommends **environmental noise limits between 32 and 42 dB(A) at night** to avoid risks for health.
- About **1 million years of healthy life** are lost every year in the EU due to noise reasons.
- National noise **limits or thresholds differ very much** between the Member States and exceed the WHO recommendations.
- Noise limits are mostly **only binding for new build infrastructure**.
- **Directive 2002/49/EC** requests the Member States to provide **noise maps and noise action plans**. This has been fulfilled for the first round of noise mapping which covers main railways, roads, airports and agglomerations. The second round (realised until 30 June 2012) will include smaller railways, roads, airports and agglomerations.
- **12 million** inhabitants are affected by railway noise above 55 dB(A) at day time and **9 million** inhabitants are affected by railway noise above 50 dB(A) at night time (major infrastructure and agglomerations).
- The **Recast** of the first railway package will request the Member States to **introduce noise depending track access charges** to compensate investments for noise reduction measures for railway operating companies.
- The **TSI Noise** sets noise limits for new rolling stock.

The reader can find an overview about all identified and analysed regulation schemes in Annex IV.

2.1. General recommendations, limits and thresholds for environmental noise

In this section some recommendations and thresholds for environmental noise will be introduced.

2.1.1. WHO recommendations on environmental noise

WHO published in 2011 a study about the burdens of disease from environmental noise [WHO JRC 2011]. The study used a quantitative risk assessment approach for the estimation. One result of the study is that, about 1 million years of healthy life are lost in the EU every year due to noise reasons.

Already in 2009 the WHO working group for preparing guidelines for exposure to noise during sleep published recommendations for thresholds of environmental noise levels [WHO 2009]. The recommendations are shown in Table 2.

Table 2: Thresholds for environmental noise at night time to avoid health risks according to WHO recommendation

EFFECT		INDICATOR	THRESHOLD [DB(A)]
Biological effects	Change in cardiovascular activity	see footnote 3 ³	see footnote 3
	EEG awakening	$L_{Amax,inside}$	35
	Motility, onset of motility	$L_{Amax,inside}$	32
	Changes in duration of various, in sleep structure and fragmentation of sleep	$L_{Amax,inside}$	35
Sleep quality	Waking up in the night and/or too early in the morning	$L_{Amax,inside}$	42
	Prolongation of the sleep inception period, difficulty getting to sleep	see footnote 3	see footnote 3
	Sleep fragmentation, reduced sleeping time	see footnote 3	see footnote 3
	Increased average motility when sleeping	$L_{Amax,inside}$	42
Well-being	Self-reported sleep disturbance	$L_{Amax,inside}$	42
	Use of sleeping pills, etc.	$L_{Amax,inside}$	40
Medical conditions	Environmental insomnia ⁴	$L_{Amax,inside}$	42

Source: WHO 2009, page XII.

According to the recent UIC study [CE Delft et al. 2011], the social costs of transportation noise are estimated at about 35 billion Euro across the EU plus Switzerland and Norway in 2008, of which about 90% are related to passenger cars and trucks. The costs of rail noise amounts to 953 million Euro or 6% of total noise costs and distributes rather evenly to passenger and freight traffic.

2.1.2. Limits or recommendations for maximum noise limits in the Member States

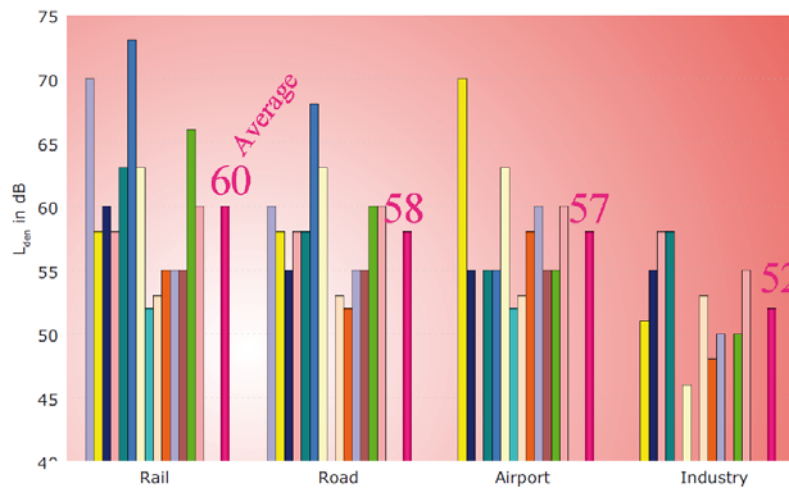
The European Environment Agency published a comparison of L_{DEN} limits of 14 Member States⁵ in November 2010 [EEA 11/2010].

³ Although the effect has been shown to occur or a plausible biological pathway could be constructed, indicators or threshold levels could not be determined.

⁴ Note that "environmental insomnia" is the result of diagnosis by a medical professional whilst "self-reported sleep disturbance" is essentially the same, but reported in the context of a social survey. Number of questions and exact wording may differ.

⁵ The EEA report does not specify which 14 Member States provided the information.

Figure 4: L_{DEN} planning values for residential area (as reported by 14 Member States)



Source: EEA 11/2010, page 22.

A standardisation might be useful in order to avoid health risks at the same level in every Member State and to balance competitiveness of all industrial sectors (including transport) as all Member States have to meet the same conditions.

The figures required as well as recommended by Member States are often much higher than the recommendations of the WHO. Some national limits or recommendations for environmental noise are introduced as examples below.

Table 3 shows recommendations for values of threshold for action plans for environmental noise reduction according to the German Federal Environment Agency (Umweltbundesamt) (2006). These figures are not obligations so that the residents cannot claim any specific mitigation measures from these recommendations, if they are affected by environmental noise above these limits. Introduction of measures is a voluntary measure by public bodies.

Table 3: German Federal Environment Agency recommendations of thresholds for action planning

TARGET OF ACTION	PERIOD	L_{DEN}	L_{NIGHT}
Avoiding health risks	Short-term	65 dB(A)	55 dB(A)
Lowering of large disturbances	Middle-term	60 dB(A)	50 dB(A)
Avoiding of large disturbances	Long-term	55 dB(A)	45 dB(A)

Source: 16. BImSchV 2006.

On the other hand, the levels introduced by German Federal Emission Regulation (Bundesimmissionsschutzverordnung) are required for new built or modified transportation infrastructures; environmental noise levels have to fall below the values mentioned in [16. BImSchV 2006].

Table 4: German maximum environmental noise levels for new built or modified transportation infrastructures

	L_{DEN}	L_{NIGHT}
Near hospitals, schools, sanatoriums	57 dB(A)	47 dB(A)
Pure residential areas and small colonies	59 dB(A)	49 dB(A)
In central areas, villages or mixed areas	64 dB(A)	54 dB(A)
In industrial areas	69 dB(A)	59 dB(A)

Source: 16. BIMSchV 2006.

In comparison to the German legislation the following table presents the Austrian limits or thresholds for noise reduction action planning.

Table 5: Austrian values of thresholds for action planning

TARGET OF ACTION	L_{DEN}	L_{NIGHT}
Road traffic	60 dB	50 dB
Air traffic	65 dB	55 dB
Rail traffic	70 dB	60 dB
Industrial areas	55 dB	50 dB

Source: Bundes-LärmV 2006.

Finally, the British Standard 8233:1999 "Sound insulation and noise reduction for buildings – Code of practice" [BS 8233:1999] states noise limits in the UK for indoor noise caused by environmental noise.

Table 6: UK values of thresholds for indoor noise caused by environmental noise

CRITERION	TYPICAL SITUATION	DESIGN RANGE	
		Good noise level	Reasonable noise level
Reasonable industrial working conditions	Heavy engineering	70 dB(A)	80 dB(A)
	Light engineering	65 dB(A)	75 dB(A)
	Garages, warehouses	65 dB(A)	75 dB(A)
Reasonable speech or telephone communications	Department store	50 dB(A)	55 dB(A)
	Cafeteria, canteen, kitchen	50 dB(A)	55 dB(A)
	Wash-room, toilet	45 dB(A)	55 dB(A)
	Corridor	45 dB(A)	55 dB(A)
Reasonable conditions for	Library, cellular office, museum	40 dB(A)	50 dB(A)

study and work requiring concentration	Staff room	35 dB(A)	45 dB(A)
	Meeting room, executive office	35 dB(A)	40 dB(A)
Reasonable listening conditions	Classroom	35 dB(A)	40 dB(A)
	Church, lecture theatre, cinema	30 dB(A)	35 dB(A)
	Concert hall, theatre	25 dB(A)	30 dB(A)
	Recording studio	20 dB(A)	25 dB(A)
Reasonable resting/sleeping conditions	Living rooms	30 dB(A)	40 dB(A)
	Bedrooms	30 dB(A)	35 dB(A)

Source: BS 8233:1999, page 19.

British standards give acceptable noise levels for properties, and requirements for noise insulation. However, there are no relevant formal limit values in force in England with regard to environmental noise from railways. The Noise Insulation Regulations, defined in British Standard; Sound insulation and noise reduction for buildings [BS 8233:1999], define a threshold level as part of the eligibility criteria. Furthermore, there are guideline levels to be found in Planning Policy Guidance that provides guidance on land use with respect to noise from railways.

Environmental impact is considered as part of the planning permission process for construction, etc., in the UK. Planning Policy Guidance 24 [PPG 24 2006]: "Planning and Noise" provides guidance to local authorities in England on how to minimise noise impact (The Scottish Office issues Planning Advice Note 56 "Planning and Noise" with similar categorisation of noise levels.). [PPG 24 2006] defines exposure categories for residential development. These categories define action depending on noise level categories.

Table 7: Noise exposure categories for dwellings

CATEGORY	DESCRIPTION
A	Noise need not be considered as a determining factor in granting planning permission, although the noise level at the high end of the category should not be regarded as a desirable level.
B	Noise should be taken into account when determining planning applications and, where appropriate, conditions imposed to ensure an adequate level of protection against noise.
C	Planning permission should not normally be granted. Where it is considered that permission should be given, for example because there are no alternative quieter sites available, conditions should be imposed to ensure a commensurate level of protection against noise.
D	Planning permission should normally be refused.

Source: PPG 24 2006, Annex 1.

Noise levels corresponding to the categories are shown in Table 8.

Table 8: Noise levels corresponding to exposure categories for dwellings

NOISE SOURCE	NOISE EXPOSURE CATEGORIES			
	A	B	C	D
Road traffic				
07.00 – 23.00	<55	55 – 63	63 – 72	>72
23.00 – 7.00	<45	45 - 57	57 - 66	>66
Rail traffic				
07.00 – 23.00	<55	55 – 66	66 – 74	>74
23.00 – 7.00	<45	45 - 59	59 - 66	>66
Air traffic ⁶				
07.00 – 23.00	<55	55 – 66	66 – 72	>72
23.00 – 7.00	<48	48 - 57	57 - 66	>66
Mixed sources				
07.00 – 23.00	<55	55 – 63	63 – 72	>72
23.00 – 7.00	<45	45 - 57	57 - 66	>66

Source: PPG 24 2006, Annex 1.

Sweden has decided long-term goals for noise limits in 1997. Indoor levels should not exceed 30 dB(A) (L_{DEN}) and 45 dB(A) L_{NIGHT} . Outdoor levels should not exceed 55 dB(A) L_{DEN} and 70 dB(A) as a maximum on a patio [Blidberg 2011].

According to Royal Decree 1367/2007 in Spain, noise action plans are to be made according to the following table [Sierra 2011].

Table 9: Spanish values of thresholds for action planning

TIME FOR ACTION	Situation	L_{DAY}	$L_{EVENING}$	L_{NIGHT}	L_{MAX}
Up to 2020	Existing	65	65	55	-
Now	New	60	60	50	85

Source: Sierra 2011.

Bedrooms in houses located in the 60/60/50 noise contour have to meet 40 dB(A) L_{DAY} , 40 dB(A) $L_{EVENING}$ and 30dB(A) L_{NIGHT} .

Thresholds for noise action planning differ between countries. The differences are even in classifying noise protection areas. In Germany, action plans which lead to a maximum level of noise in defined areas are only required for new built and modified infrastructures.

⁶ Aircraft noise: daytime values accord with the contour values adopted by the Department for Transport which relate to levels measured 1.2m above open ground. For the same amount of noise energy, contour values can be up to 2 dB(A) higher than those of other sources because of ground reflection effects.

Austria requires noise action planning for certain environmental noise levels, depending on the source of noise. UK recommendations do not require any action, except in the workplace or for new built and modified infrastructures, and levels depend on use of the rooms; local authorities have a number of legislative powers to control noise emission. Mostly the obliged figures are based on the highest level of the German Federal Environment Agency recommendations.

These examples of legislation rules or national recommendations differ from the WHO recommendation and are often only relevant for new or modified infrastructure.

The result of this comparison shows that reducing environmental noise is a very important action for the environment/health of the population. Many people are affected by rail noise that exceeds the lowest level the WHO Recommendation according to [WHO 2009] demands.

2.2. Environmental Noise Directive 2002/49/EC

The Environmental Noise Directive [Dir. 2002/49/EC] has the following aim⁷:

- "Monitoring the environmental problem; by requiring competent authorities in Member States to draw up "strategic noise maps" for major roads, railways, airports and agglomerations, using harmonised noise indicators L_{DEN} (day-evening-night equivalent level) and L_{NIGHT} (night equivalent level). These maps will be used to assess the number of people annoyed and sleep-disturbed respectively throughout Europe"
- "Informing and consulting the public about noise exposure, its effects, and the measures considered to address noise, in line with the principles of the [UNECE Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters](#), known as the Aarhus Convention, and signed on June 25, 1998.
- "Addressing local noise issues by requiring competent authorities to draw up action plans to reduce noise where necessary and maintain environmental noise quality where it is good. The Directive does not set any limit value, nor does it prescribe the measures to be used in the action plans, which remain at the discretion of the competent authorities."
- "Developing a long-term EU strategy, which includes objectives to reduce the number of people affected by noise in the longer term, and provides a framework for developing existing Community policy on noise reduction from source. With this respect, the Commission has made a declaration concerning the provisions laid down in article 1.2 with regard to the preparation of legislation relating to sources of noise."

According to the Directive 2002/49/EG, all Member States have to provide noise maps and action plans for noise reduction.

The Report from the Commission to the European Parliament and the Council on the implementation of the Directive on environmental noise in accordance with Article 11 of

⁷ Expressions coming from <http://ec.europa.eu/environment/noise/directive.htm>, last visited 14 September 2011.

Directive 2002/49/EC from 1 June 2011 [EC 2011] shows the current status of implementation of the Directive in the Member States.

2.2.1. Status of implementation of Directive 2002/49/EG

The Directive is implemented in all Member States since October 2007 according to [EC 2011]. The 14⁸ Member States which did not transpose by 18 July 2004 achieved that by October 2007. According to the EEA Study "Laying the foundations for greener transport" [EEA 7/2011] the data provided is 96% complete in mid 2011. In fact [EEA 7/2011] confirms many aspects concerning limits and the potential risks and limits to avoid risks as the WHO did in its two studies [WHO 2009] and [WHO JRC 2011]. The road map of the Directive is represented in [EC 2011] as follows.

Table 10: Road map for implementation of Directive 2002/49/EG

IMPLEMENTATION DEADLINE	ISSUE	REFERENCE DIRECTIVE 2002/49/EC	UPDATES
30 June 2005	Information on major roads, major railways, major airports and agglomerations according to the upper thresholds, designated by MS and concerned by 1st round of mapping	Art. 7-1	Mandatory every 5 years
18 July 2005	Establishment of competent bodies for strategic noise maps, action plans and data collection	Art. 4-2	Possible at any time
18 July 2005	Noise limit values in force or planned and associated information	Art. 5-4	Possible at any time
30 June 2007	Strategic noise maps for major roads, railways, airports and agglomerations according to the upper thresholds ⁹	Art. 7-1	
18 July 2008	Action plans for major roads, railways, airports and agglomerations	Art. 8-1	Mandatory every 5 years
31 December 2008	Information on major roads, major railways, major airports and agglomerations according to the lower thresholds, designated by MS and concerned by 2nd round of mapping	Art. 7-2	Possible at any time
30 June 2012	Strategic noise maps for major roads, railways, airports and agglomerations according to the lower thresholds ¹⁰	Art. 7-2	Mandatory every 5 years

Source: EC 2011, page 4.

⁸ AT, BE, CZ, DE, EL, FI, FR, IE, IT, LU, PT, SE, SL, UK.

⁹ Upper thresholds are agglomerations > 250.000 inhabitants, roads > 6 millions of vehicles per year and railways > 60.000 trains per year.

¹⁰ Lower thresholds are all agglomerations > 100.000 inhabitants, roads > 3 millions of vehicles per year and railways > 30.000 trains per year.

Additional to the information shown in Table 10 according to [EC 2011] the Directive 2002/49/EC [Dir. 2002/49/EC] defines one more step.

In the first round of noise mapping and action plans only big agglomerations and intensive frequented transportation infrastructure is concerned. The second round also concerns smaller agglomerations and transportation infrastructures.

Table 11: Additional steps in noise mapping according to [Dir. 2002/49/EC]

IMPLEMENTATION DEADLINE	ISSUE	REFERENCE	UPDATES
18 July 2013	Action plans for all roads, railways, airports and agglomerations where limits are exceeded	Art. 8-2	Mandatory every 5 years

Source: Dir. 2002/49/EC.

Concerning noise mapping the following table shows details for the first and second rounds of noise mapping.

Table 12: Schedule for noise mapping and noise reduction planning

ACTION	AGGLOMERATIONS > 250.000 INHABITANTS AND MAIN RAIL LINES > 60.000 TRAINS / YEAR	AGGLOMERATIONS AND MAIN RAIL LINES > 30.000 TRAINS / YEAR
Announcement of railway lines and agglomerations which belong to categories mentioned	June, 30 th 2005 (must be updated every 5 years)	December, 31 st 2008 (must be updated every 5 years)
Elaboration of noise maps	June, 30 th 2007	June 30 th 2012 (must be updated every 5 years)
Action plans for noise reduction	July, 18 th 2008	July, 18 th 2013 (must be updated every 5 years)

Source: Dir. 2002/49/EC.

Table 13 shows the details of the current status of implementation.

Table 13: Status of implementation of Directive 2002/49/EG

CASE	DESCRIPTION	FULL IMPLEMENTATION	PART IMPLEMENTATION
Indication of noise indices and limits	Member States shall indicate their national legal environmental noise limits or recommendations. A European wide noise level was not introduced.	Limits by 19 Member States (AT, BG, BE, CZ, DK, EE, ES, FR, DE, EL, IT, LV, LT, LU, NL, PL, PT, SL, SI); currently reviewed in 3 Member States (LT, LV, RO); recommendations by 4 Member States (FI, IE, SE, UK)	
Strategic noise maps	The Member States have to provide noise maps for main transport infrastructure and agglomerations. They must be updated frequently (5 years) and the update shall indicate the situation in the year before the update.	12 Member States (BG, CZ, EE, HU, IE, LT, LV, LU, PL, PT, SI, UK)	11 Member States reported completely with a few omissions (AT, BE, CY, DK, FI, DE, NL, RO, ES, SE, SK) 3 Member States reported only for part of the sources of noise (FR, EL, IT) 1 Member State did not report (MT)

Source: EC 2011

The range of limits and recommendations for environmental noise differ very much between the Member States. Only four of them considered health care orientated limits (EE, LU, PT, SL and the administration of Brussels in BE).

2.2.2. Noise action plans

Several studies by UIC (see [UIC 2010]) and CER together with UIC (see [CER UIC 2007]) and additional surveys by the authors lead to an overview of the existing noise abatement actions in the Member States and also in other European countries. All data available are presented in Table 14.

Table 14: Actions by European Countries for noise abatement on railways where data are available

COUNTRY	ACTIONS	SOURCE
Austria	<ul style="list-style-type: none"> • Very important topic in particular in urban and mountainous areas • Noise maps since 1993; environmental noise plans implementing DIR 2002/49/EC (www.laerminfo.at) • 250,000 people exposed to excessive rail noise • Complex national and state legislation • 1.7 million sq. m [m²] noise barriers constructed along 803 track-km, 2/3 of the planned construction works are completed • Most of the highly affected inhabitants are protected against noise, annually some 10-15,000 new protected citizens • Financial means amount to €16 – 25 million p.a.; 50% of the costs are covered by ÖBB and 50% by the federal states and the community; equipment of new tracks 100% funding by ÖBB • Equipment of 4,500 out of 31,000 wagons from Rail Cargo Austria and Rail Cargo Hungary with K-block brakes through new units. Retrofitting and noise related access charges are not foreseen • Participation at UIC-Project EuropeTrain for testing LL-block brakes 	Interviews with country representatives in September 2011
	<ul style="list-style-type: none"> • Until 2009 450 km of noise barriers for € 355 million 	[UIC 2010]
	<ul style="list-style-type: none"> • Critique to noise action plans: lag of new ways to deal with noise, no concrete specification 	[Justice and Environment 2009a]
Belgium	<ul style="list-style-type: none"> • Regional noise legislation, no national legislation existent • Flanders, Brussels: noise limits • Wallonia: no limits • No programme by SNCB; however protection for new or upgraded lines 	[CER UIC 2007]
Bulgaria	<ul style="list-style-type: none"> • Only interest in composite brake blocks for noise reduction 	Interview with Bulgarian railway operator (BDZEAD) in September 2011
Cyprus	<ul style="list-style-type: none"> • Since 1951 there is no railway line in Cyprus in effect. So rail noise is no problem for Cyprus 	http://en.wikipedia.org/wiki/Cyprus_Government_Railway

COUNTRY	ACTIONS	SOURCE
Czech Republic	<ul style="list-style-type: none"> Noise abatement compulsory for new railway lines Upgrading of existing lines with noise barriers Action plans for END (Directive 2002/49/EC) will form framework of noise abatement programmes Pilot project with LL brake blocks 	[CER UIC 2007]
	<ul style="list-style-type: none"> Until 2010 about 115 km of noise barriers 	[UIC 2010]
	<ul style="list-style-type: none"> Critique to noise action plans: merely containing only measures which have been planned anyway; no estimate of costs and deadlines 	[Justice and Environment 2009a]
Denmark	<ul style="list-style-type: none"> Few noise barriers in Denmark: 58 km Passive noise abatement strategy, mostly done at houses 	[CER UIC 2007]
	<ul style="list-style-type: none"> Research and Testing programmes for optimisation of track construction, acoustic rail grinding, noise partnership with the inhabitants and noise communication management Until 2009 46 km noise barriers, windows in 8,300 houses, total costs 65 million € 	[UIC 2010]
	<ul style="list-style-type: none"> Up to 2013 22,100 dwellings will be protected by noise screens and/or offered grant to improved sound insulation Offer of grant to improved sound insulation of 17,700 dwellings, of which 4.650 dwellings (~26%) have got improved sound insulation. Intensified grinding of rails on all main railway sections (2009 –2014) Target: Less fluctuation in rail smoothness and reduced noise Tests of rail dampers on a short section - effect 2,7 dB(2007) Project Optimized Railway Superstructure (2009 –2014): Survey on influence of different rail pads on noise and vibration at Holmstrup (2010-2011) 	[Blumensaadt 2011]
Estonia	<ul style="list-style-type: none"> TSI Noise is transformed into national law. Noise action plans for the City of Tallinn (May 2009) and for major road links (Dec. 2008) have been established. These are not legally binding and are not referring to rail transport. Road measures including noise barriers only. Provisions by the Tallinn noise action plan to be taken until 2013: <ul style="list-style-type: none"> Technical measures at noise sources Selection of quieter sources Reduction of sound transmission (e.g. tramway speed reduction) 	<p>[Justice and Environment 2009a]</p> <p>[Justice and Environment 2009b]</p>

COUNTRY	ACTIONS	SOURCE
	<ul style="list-style-type: none"> Estonian legislation has delayed the deadline for preparing noise maps beyond 30.6.2007 and action plans. This constitutes a conflict with EC legal provisions 	
France	<ul style="list-style-type: none"> Noise protection for new or upgraded lines implement noise control at hot spots <ul style="list-style-type: none"> – mostly noise barriers and noise protection windows – track absorbers homologated research projects 	[CER UIC 2007]
	<ul style="list-style-type: none"> Combined optimisation of rail and wheel dampers. Homologation of wheel dampers (STARDAMP project) Noise plan with € 193 million for noise barriers and rail dampers 	[UIC 2010]
Finland	<ul style="list-style-type: none"> Noise abatement package being considered by parliament, no retrofitting Problem of noisy Russian freight wagons 	[CER UIC 2007]
	<ul style="list-style-type: none"> Some noise barriers 	[UIC 2010]
	<ul style="list-style-type: none"> For the 7 agglomerations, Finnish Transport Agency (FTA) has contracted with the city authorities to include the main roads and railways in their assessments, paying a part of their costs The total cost for FTA will be about € 800,000, about € 1.50 per probable noise zone inhabitant (cost with roads!) Experiences with low height barrier come to a reduction of about 10 dB(A) 	[Pokolainen 2011]
Germany	<ul style="list-style-type: none"> Strong political pressure from citizen's groups and associations Long-term goal of German railway DB: cut rail noise emissions 2000 -2020 by half, i.e., a noise reduction of 10 dB(A). Costs: € 2.3 m, with € 100 m p.a. duration of programme expected at 25 years Noise differentiated track access charges will be introduced in December 2012. Wagon holders will receive a bonus financed by 50% through government. The bonus will be paid through a fund that is financed equally by increased track charges and the Noise Protection Programme of the German government 180,000 wagons are eligible to be retrofitted with new brakes. Costs amount to € 300 m. Number of wagons presently retrofitted: 6,350 Programme "Quiet Rhine" started that will retrofit 1,150 wagons with new brakes Voluntary noise remediation programme for existing tracks of the federal railways Research project "silent train on real track" 	Interviews with representatives from DB and national authorities in September 2011

COUNTRY	ACTIONS	SOURCE
	<ul style="list-style-type: none"> testing innovative vehicle-side technologies Research programme "silent track" testing track dampers and low noise barriers with funding from the Economic Stimulus Package II Acoustic rail grinding programme on-going 	
	<ul style="list-style-type: none"> Testing innovative infrastructure measures: Rail dampers, friction modifiers, low height barriers, absorbers for steel bridges, under sleeper pads Work on realistic rail/wheel contact: improvement of wheel/rail contact, wheel vibrations and acoustic optimisation of pavement € 100 million per year, total costs of 2.3 billion until 2030 including noise barriers and windows Most activities are related to infrastructure side measures Retrofitting up to 5,000 freight wagons with K- and LL-blocks up from the year 2009 Definition of a practical approach for the use of LL-blocks Definition and pre-evaluation of noise differentiated track access charging models 	[UIC 2010]
	<ul style="list-style-type: none"> In fact, Germany currently invests significant money in noise protection walls in the Konjunkturpaket 2¹¹ 	Additional information by the authors
Hungary	<ul style="list-style-type: none"> The national law obligates noise protection on new or modernised railways 	[CER UIC 2007]
	<ul style="list-style-type: none"> Action plans are not binding and have no implication for national budget rules Good public involvement in action plan design by establishment of noise committees 	[Justice and Environment 2009a]
Greece	<ul style="list-style-type: none"> The density of railway lines in Greece is very small. 60% of all railway kilometres belong to one single connection between Thessaloniki and Athens (1565 km). A very small percentage of all Greece inhabitants is affected by railway noise 	http://www.griechenland-travel.com/eisenbahn.htm
Ireland	In the Dublin area traffic is the major noise source, but railways do not have a major impact on overall noise levels. Major measures: Promoting walking, cycling, public transport and quieter motor vehicles	[Dublin City 2008]
	Outside agglomerations 23 km of track are above 60,000 passages p.a., but without affecting	[King et al. 2009]

¹¹ « Konjunkturpaket 2 » (Economic Stimulus Package II) is an extra investment programme of the German government following the recent economic crisis 2008/2009 to support the building industry.

COUNTRY	ACTIONS	SOURCE
	population with $L_{DEN} > 55$ dB(A)	
Italy	<ul style="list-style-type: none"> • Strict noise legislation including existing lines • action plans • implementation until 2020 • measures to be considered on about 8000 km • costs about € 6.8 billion • legislation does not allow retrofitting 	[CER UIC 2007]
	<ul style="list-style-type: none"> • Measurements of all assets (rolling stock) for noise emissions – example: modification of software of the ETR 500 High Speed trains to lower ventilation and cooling noise • Most measures indeed concentrate on noise barriers and insulating windows • Development of cast iron brake blocks for freight wagons 	Answer from Trenitalia (FS) on authors survey in September 2011
	<ul style="list-style-type: none"> • For the next 15 years on about 3,675 km of existing lines noise barriers and building insulation is foreseen with a budget of about 8.31 billion € (9,025 single actions) 	Answer from RFI on authors survey in September 2011
Latvia	<ul style="list-style-type: none"> • Strategic Noise Mapping was completed in 2008 including only major road sections. It can thus be concluded that rail noise does not play a significant role in Latvia 	[EIONET 2011]
Lithuania	<ul style="list-style-type: none"> • Detailed information on noise action plans have not been available; Communications from the Ministry for Transport and Communications only mention noise reduction programmes for road and air transport • But modal shifts to rail by a cooperation between Lithuanian Railways (JSC) and CargoBeamer (Germany) on combined transport is expected to reduce noise pollution from road haulage 	[SUMIN 2011]
Luxembourg	Luxemburg has submitted a draft Noise Action Plan to the EC, which is not accessible to the public	[EIONET 2011]
Malta	<ul style="list-style-type: none"> • Since 1931 there is no railway line in Malta in effect. So rail noise is no problem for Malta 	http://de.wikipedia.org/wiki/Schienerverkehr_auf_Malta
Netherlands	<ul style="list-style-type: none"> • Noise abatement legislation since 1987 • Introduction of noise differentiated track access charges in 2008. The bonus is fixed at € 0.04/ wagon-km and is applied to both passenger and freight vehicles with a maximum of € 4,800 over two years. The bonus is granted on a system of self-declaration • Noise Innovation Programme: Launching of numerous studies and pilot projects to test composite brake blocks • Noisy trains will be prohibited starting in 2015 	[CER UIC 2007]

COUNTRY	ACTIONS	SOURCE
	<ul style="list-style-type: none"> Target noise reduction: 10 – 12 dB(A) Also measures for shunting yards are planned 	
	<ul style="list-style-type: none"> € 430 million for noise barriers, windows and rail dampers Lubrication, removing of rail joints, noise barriers and window insulation in shunting yards Research projects for friction modifiers against curve squeal, influencing rail roughness Monitoring noise ceilings and capacity management 	[UIC 2010]
Norway	<ul style="list-style-type: none"> Rail grinding planned but not yet implemented, noise from freight terminals, tonal noise from accelerating and decelerating trains Passive noise abatement strategy, mostly done at houses 	[UIC 2010] [CER UIC 2007]
Romania ¹²	<ul style="list-style-type: none"> National noise action plans in preparation since 2008 	[CER UIC 2007]
Poland	<ul style="list-style-type: none"> Environmental law includes noise abatement track grinding noise barriers (50 km), noise protection windows on new and upgraded lines 	[CER UIC 2007]
Portugal	<ul style="list-style-type: none"> Noise protection is obligated on all railway lines Nearly all freight cars are equipped with LL-blocks (no need of admittance of these cars in other countries as Portugal has broad gauge track and so there is no exchange of wagons with the other European countries) More than 50 km of noise protection walls and in future more are planned 	[CER UIC 2007]
Slovak Republic	Action plans are considered very vague and general and not binding and have no implication for national budget rules	[Justice and Environment 2009a]
	To date only Action Plans for road transport have been submitted to the EC	[EIONET 2011]
Slovenia	Action plans are considered very vague and general and not binding and have no implication for national budget rules	[Justice and Environment 2009a]
Spain	<ul style="list-style-type: none"> Directive 2002/49/EC is completely implemented in national legislation and for major railway lines and agglomerations noise maps are existing, second phase of noise 	Interview with the RENFE in December 2011

¹² According to an Interview with the Romanian Railway Authority there are no problems with noise in this country.

COUNTRY	ACTIONS	SOURCE
	<p>mapping will be fulfilled in 2013</p> <ul style="list-style-type: none"> • Currently 62% of rail freight transport is done with low noise wagons (equipped with composite brake blocks) • 32% of all freight wagons are already equipped with composite brake blocks (30,58% K- and 1,37% LL-blocks, as well as Portugal Spain has broad gauge) • Equipment of freight wagons with K- or LL-blocks goes on (600 expected for 2012) • 95% of passenger rolling stock is already equipped with disc brakes and new rolling stock will only have disc brakes 	
Sweden	<ul style="list-style-type: none"> • According to Sweden ´s noise mapping: problems also outside of mapping areas; noise mitigation measures such as rail grinding, rail dampers and low height barriers are being studied • Passive noise abatement strategy, mostly done at houses 	[CER UIC 2007]
	<ul style="list-style-type: none"> • Noise abatement programme including insulated windows and local barriers for good acoustic indoor environment and noise protected patio area 	[UIC 2010]
	<ul style="list-style-type: none"> • Sweden also favors retrofitting braking systems of existing rail cars but serious problems are still not solved concerning the braking performance in severe winter conditions 	[Blidberg 2011]
Switzerland	<ul style="list-style-type: none"> • Noise legislation enacted 1987 • Noise differentiated track access charges introduced in 2010 using a bonus system for low-noise wagons • railway noise abatement largely financed through road traffic • specific legislation for railway noise: <ul style="list-style-type: none"> – retrofitting of all Swiss rolling stock until 2014 (direct subsidies) – noise barriers with cost-benefit restriction – noise protection windows 	[CER UIC 2007]
	<ul style="list-style-type: none"> • The total national freight wagon fleet will be equipped with composite breaks which lower rolling noise (for details see Section 3.3). The programme is financed by the government which shifts earning from road pricing to the rail sector. Also a noise-dependent track price system has already been introduced and is currently in discussion for enhancements • A cost benefit analysis should show which additional measures will be taken: rail grinding, stand by noise, rail dampers and 	[UIC 2010]

COUNTRY	ACTIONS	SOURCE
	<p>steel bridges are among the issues studied</p> <ul style="list-style-type: none"> • By 2009 111 km of noise barriers and windows, and by 2015 300 km of noise barriers are planned for € 1 billion • Switzerland publishes very detailed information about the status of rail noise abatement and the approach for private persons to gather funding for noise insulating windows for instance (see www.laerm-sbb.ch) 	
United Kingdom	<ul style="list-style-type: none"> • Strict planning policy requires new railway developments to consider noise impact during construction and operation 	[CER UIC 2007]
	<ul style="list-style-type: none"> • British Standards give acceptable noise levels for properties and requirements for noise insulation • Most (approximately 75%) of UK freight wagons have disc brakes or composite brake blocks • The UK uses a variety of noise mitigating technologies including noise barriers, rail lubricators and friction modifiers, rail absorbers, and, usually in tunnels, resilient baseplates and floating slab track • DEFRA (Department for Environment, Food and Rural Affairs) is responsible for the UK's noise mapping and noise action plans • The UK has identified a number of Important Areas for the relevant transport authorities to focus on, as well as a subset of First Priority Locations and a timeline for implementation 	Interviews held by partners in September 2011
	<ul style="list-style-type: none"> • Long-term strategy: Framework for noise abatement incorporating infrastructure provider (NetworkRail) and train operators • Concentration on night time noise and integration of transport and land use planning 	[AEA et al. 2004]

Source: Different sources; see column SOURCE.

Reports have been suspended for Greece, Malta and Cyprus due to marginality or non-existence of rail networks.

Switzerland and Norway are mentioned as non-member countries as they are also members of UIC as the concerned railway organisation.

UIC (in [UIC 2010]) also mentions an initiative by the group of **The Netherlands, Germany, Switzerland and Italy** ([UIC 2010], page 25). In the Rotterdam - Genoa project, the governments of the states mentioned analysed possibilities to promote retrofitting of freight cars with low noise equipment (particularly composite brakes). The study finally recommended harmonised solutions for bonus systems (not only along the corridors) and to avoid penalty systems.

By the end of 2005, in Europe 1,000 km of noise barriers have been built and approximately 60,000 buildings have been endowed with noise protection windows. The measures resulted in noise protection for about 1,250,000 citizens. The measures comprised annual investments of 150–200 million Euros. The estimated total costs for infrastructure measures are estimated at up to € 10 billion.

Most national activities and investments so far concentrate on infrastructure: noise barriers, rail damping and friction modifiers. Many countries and projects also concentrate or integrate source driven measures like wheel dampers or composite brake blocks.

Interviews conducted with rail industry representatives from DB and ÖBB suggest that noise bonus regulations shall be unique across Europe to increase the incentives for wagon owners and operators to retrofit old rolling stock and to minimise market distortions among rail transportation companies.

2.3. Recast of the First Railway Package

The First Railway Package consists of Directives 2001/12/EC (amending Council Directive 91/440/EEC on the development of the Community's railways), 2001/13/EC (amending Council Directive 95/18/EC on the licensing of railway undertakings) and 2001/14/EC (on the allocation of railway infrastructure capacity and the levying of charges for the use of railway infrastructure and safety certification). This was designed to open the international freight market by setting out the conditions for licensing freight operators in Europe, to define the roles of the infrastructure managers and railway undertakings, and to set out a policy for capacity allocation and infrastructure charging.

The Second Railway Package includes the Railway Safety Directive (Directives 2004/49/EC and 2008/110/EC) and EC Regulations 881/2004 and 1335/2008 which required the establishment of national safety authorities and investigatory bodies who report to the European Railway Agency, responsible for rail safety and interoperability as well as drafting legislation for a harmonised European rail system. The Second Package also includes the Interoperability Directive (2008/57/EC) which defines how the Technical Standards for Interoperability (TSIs) should be developed, e.g., TSI Noise relating to "rolling stock – noise" of the trans-European conventional rail system", Commission Decision 2011/229/EU (see Section 2.4, page 42).

The Third Railway Package focuses on opening up international passenger services to competition within Europe, and includes Directive 2007/58/EC (amending Council Directive 91/440/EEC on the development of the Community's railways and Directive 2001/14/EC on

the allocation of railway infrastructure capacity and the levying of charges for the use of railway infrastructure).

On September 17th 2010, the European Commission delivered a proposal for a Recast of the First Railway Package [COM(2010) 475]. Article 7 of Dir. 2001/14/EC covers "Principles of charging". Noise is not mentioned explicitly in Dir. 2001/14/EC, but the directive allows infrastructure charges to be modified based on environmental impact. This enables Member States to introduce noise-dependent track access charges if this is introduced also for competitive transportation modes or the total turnaround for infrastructure companies does not rise. Article 31 of the proposed Recast, based on Article 7 of Dir. 2001/14/EC, explicitly allows differentiation of track access charges based on the noise emission characteristics of the rolling stock if the same is introduced for road transport.

2.4. TSI Noise

The basis for all subsystems (infrastructure, energy, control-command and signalling, operation and traffic management, telematics applications, rolling stock and maintenance) of the railway system are the "European Railway Technical Specifications for Interoperability (TSIs)". The elaboration of TSIs is introduced in Directive 2008/57/EC. The European Railway Agency (ERA) is responsible for the coordination of development of the TSIs. For this, ERA organises working groups for the different subsystems which consist of experts and authorities. The ERA pays attention that all relevant stakeholders are represented in the working groups.

All TSIs are directly valid for each Member State for new build or modified subsystems. If exceptions must be made, the Member States have to declare this precisely. General exceptions are only possible for underground, tram and regional rail systems; infrastructures / networks which are separate from the rail network and are only used for local and urban transport; private rail infrastructure and vehicles which are only used on the private infrastructure which is only used for freight transport for the owner; infrastructures and vehicles which are only for local use or historical and touristic uses.

The new European Railway Technical Specification for Interoperability (TSI) for Noise (TSI Noise), document No. 2011/229/EU (published on April, 4th 2011) defines maximum noise levels for rolling stock [TSI Noise 2011]. This TSI is part of the subsystem rolling stock. It replaces the version of 2006 [TSI Noise 2006]. Maximum noise levels are defined for stationary and for pass-by noise on defined rail reference tracks and at defined speed. For engines, starting noise levels and interior noise within the driver's cab are also defined where applicable. Interior noise within the driver's cab is not relevant for this study. Details are presented in Annex II. According to Directive 2008/57/EG these limits are directly valid for new build vehicles.

Pass-by noise is defined at a distance of 7.5 metres from track centre line and 1.2 metres above upper surface of the rail. Details about the reference track are to be found in the TSI Noise. The reference track is defined by its roughness and its dynamic behaviour (described by the vertical and lateral track decay rates).

In Commission Decision of 30 May 2002 concerning the technical specification for interoperability relating to the rolling stock subsystem of the trans-European high-speed rail system referred to in Article 6(1) of Directive 96/48/EC (2002/735/EC) noise limits were set to rolling stock of high speed trains [Com 2002/735/C].

2.5. Measuring and computing of railway noise

2.5.1. Legislation according to Environmental Noise Directive

The EU Directive 2002/49/EC demands in its Annex 1 the following formula to calculate the relevant day-evening-night level (on the basis of measured noise levels):

$$L_{den} = 10 \lg \frac{1}{24} \left(12 * 10^{\frac{L_{day}}{10}} + 4 * 10^{\frac{L_{evening} + 5}{10}} + 8 * 10^{\frac{L_{night} + 10}{10}} \right)$$

in which:

- L_{day} is the A-weighted long-term average sound level as defined in [ISO 1996-2: 1987], determined over all the day periods of a year,
- $L_{evening}$ is the A-weighted long-term average sound level as defined in [ISO 1996-2: 1987], determined over all the evening periods of a year,
- L_{night} is the A-weighted long-term average sound level as defined in [ISO 1996-2: 1987], determined over all the night periods of a year,
- L_{den} is the average noise level for a period of 24 hours (day, evening and night)

and in which:

- the day is 12 hours, the evening four hours and the night eight hours. The Member States may shorten the evening period by one or two hours and lengthen the day and/or the night period accordingly, provided that this choice is the same for all the sources and that they provide the Commission with information on any systematic difference from the default option,
- the start of the day (and consequently the start of the evening and the start of the night) shall be chosen by the Member State (that choice shall be the same for noise from all sources); the default values are 07.00 to 19.00, 19.00 to 23.00 and 23.00 to 07.00 local time,
- a year is a relevant year as regards the emission of sound and an average year as regards the meteorological circumstances; and in which: the incident sound is considered, which means that no account is taken of the sound that is reflected at the façade of the dwelling under consideration (as a general rule, this implies a 3 dB correction in case of measurement) (see [EC 2002], Annex I).

Noise indicators can also be computed (necessary for predictions). Directive 2009/49/EG defines in its Annex II computing methods which have to be used if the Member States have no own legislative computing method which is adapted to Annex I of the directive. For railway noise the calculation method of the Netherlands is prescribed ("Reken- en Meetvoorschrift Railverkeerslawai '96, Ministerie Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, 20th November 1996") [ReMR 1996].

The calculation scheme defines nine train categories where noise levels for pass by of one of these trains are indicated. Together with the total number of trains of one type, the averages L_{DEN} and L_{NIGHT} level can be calculated. Supplement factors are indicated for different types of bridges.

Germany for example has its own calculation scheme. They use the "Preliminary calculation method for the environmental noise at railways" (Vorläufige Berechnungsmethode für den Umgebungslärm an Schienenwegen) – VBUSch 2006" [VBUSch 2006] for calculations for noise mapping.

All calculations schemes are very complex and exceed the scope of this study, but all schemes classify trains into classes. For each class an emission factor must be calculated and the addition of all factors is done with a logarithmic function.

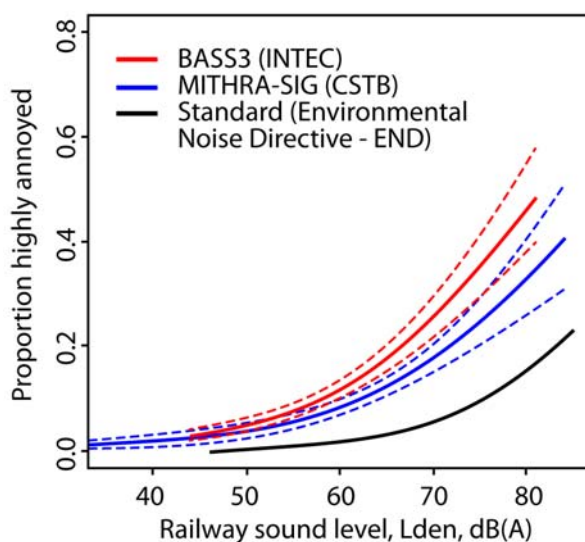
There are currently two main discussions about the calculation schemes - the different results of different schemes and the rail bonus in calculation. Both aspects will be discussed in the following sections.

2.5.2. Different results of different computing schemes

The Dutch scheme uses nine train type categories where the indicators mentioned in the German scheme are already integrated in general calculation factors for the train category.

The calculation in Germany has a common factor for all train types, modified by individual bonus or penalty factors according to indicators, whereas the Dutch calculation scheme has already defined global calculation factors for train categories. So calculation results can differ according to the scheme used; Lercher elaborated an example of these differences in ALPNAP project [ALPNAP 2007-2]. Figure 5 which comes from the ALPNAP project [ALPNAP 2007-2] shows an example of the result of different calculation methods for people annoyed by railway noise. The figure compares BASS3 (INTEC)¹³, the MITHRA-SIG¹⁴ and the Standard set by the Environmental Noise Directive.

Figure 5: Comparison of noise calculation methods in ALPNAP project



Source: ALPNAP 2007-2, page 124.

Clearly there would be value in a European calculation (and measuring) standard to make noise effects on the population more comparable.

¹³ BASS3 is an implementation of ISO 9613 (acoustics - Attenuation of sound during propagation outdoors) by INTEC-University of Gent.

¹⁴ MITHRA-SIG is an implementation of the French standard method NMPB (Méthode de Prevision du Bruit des Routes).

2.5.3. Rail noise bonus discussion

In former, and in some current, calculation or measuring methods (see German Schall 03, for example) a general bonus for rail noise is included. These incentives transfer measured or calculated environmental noise emissions into a balanced value. Railway noise is often seen as less annoying than other noise sources. Amongst others this is accounted due to more times without noise emissions at all. The general discount is between 3 and 10 dB in different countries [ZEUS Möhler 2010].

Recently, several studies analysed whether this discount is suitable and eligible. The study "Lärmbonus bei der Bahn?" (Noise bonus for rail?) [ZEUS Möhler 2010] by Möhler + Partner München; ZEUS GmbH, Hagen, analysed several studies for the German Federal Environment Agency (Umweltbundesamt).

The following table shows the suitability of railway noise incentives according to analysed studies:

Table 15: Analysis of studies about the eligibility of rail noise incentives

ELIGIBILITY OF RAIL NOISE DISCOUNT	TYPE OF STUDY		
	Case studies	Laboratory studies	Total
Yes for a general rail noise bonus	2	6	8
Different kinds of bonus or penalty	6	0	6
No for a general rail noise bonus	0	5	5
Neutral concerning rail noise bonus	1	1	2
Total	9	12	21

Source: Zeus Möhler 2010, page 49.

About 8 out of 21 studies came to the result that a rail noise bonus is eligible. 11 of the 21 studies came to the result that either the incentives have to be variable (for example depending on time, area influenced, noise level; even a penalty should be included), or the rail noise bonus is not eligible. 2 of the studies remain neutral. If only case studies are considered, only 2 of 9 studies agreed that a general rail noise bonus was acceptable, whereas 6 studies suggested a variable noise bonus/penalty system was necessary. The authors of that study also identified mistakes in the studies considered. The rail noise bonus/penalty must be further elaborated, especially considering the current modal split in transportation and the effects of noise at night (interruption of quiet phases), or different noise levels, for instance.

ZEUS GmbH and Möhler+Partner published an article about a census concerning the annoyance by rail and road noise at different times of day (Daytime-related harassment by road and rail traffic noise – Method and empirical results / Tageszeitsbezogene Belästigung durch Straßen- und Schienenverkehrslärm - Methode und empirische Ergebnisse) [ZEUS Möhler 2005]. The authors questioned people about their feeling of harassment from railway and road noise. The most important result is that during the evening and night the noise coming from railways harassed more than at during the day. This would justify a rail noise penalty at evening and night time.

As a result of the ALPNAP¹⁵ project, Lercher et al. studied the use of sleeping pills by people affected by rail noise [Lercher et al. 2007]:

- Use of sleeping pills is increasing already at low levels of railway noise from 50 dB(A) upwards.
- The environment noise level of 60 dB(A) at night which leads to the necessity of action plans is considerably too high.

This leads to the general result that a rail noise bonus is not justifiable both at evening and night time but only eligible during the day and not in the night.

¹⁵ ALPNAP = Monitoring and Minimisation of Traffic-Induced Noise and Air Pollution Along Major Alpine Transport Routes, see <http://www.alpnap.org> (last visit June, 30th 2011).

3. RAIL NOISE – SOURCES AND PREVENTION MEASURES

KEY FINDINGS

- **Main source** of railway noise is **rolling noise** coming from rail freight wagons.
- **Of minor importance** is engine noise (at lower speeds) and aerodynamic noise (high speed trains).
- Locally also squeal noise can be important.
- Rolling stock which is introduced from the year 2000 on is about **10 dB(A) less noisy** than rolling stock from the 1960s and 1970s.
- Against each source of noise an **enormous number of measures** has been developed in the last years.
- **Rolling noise and wheel noise** can be reduced by **composite brake blocks** (freight wagons), **resilient wheels** or **wheel dampers**.
- **Rail noise** can be reduced by rail dampers, resilient track pads and combinations with noise barriers of different heights.
- Track side or vehicle side **lubrication systems can avoid squeal noise** and are well introduced in tram way systems.
- **The most efficient measure to achieve network wide noise reduction is the retrofitting of freight cars with composite brake blocks.**

This chapter will identify the main sources of railway noise and measures to prevent or to protect from it.

3.1. Sources of railway noise

Many studies and publications exist concerning sources of rail noise. The Working Group Railway Noise of the European Commission published its Position Paper on the European strategies and priorities for railway noise abatement in 2003 [EC 2003]. The International Union of Railways (UIC) published its "Environmental Noise Directive Development of Action Plans for Railways" in April 2008 [UIC 2008].

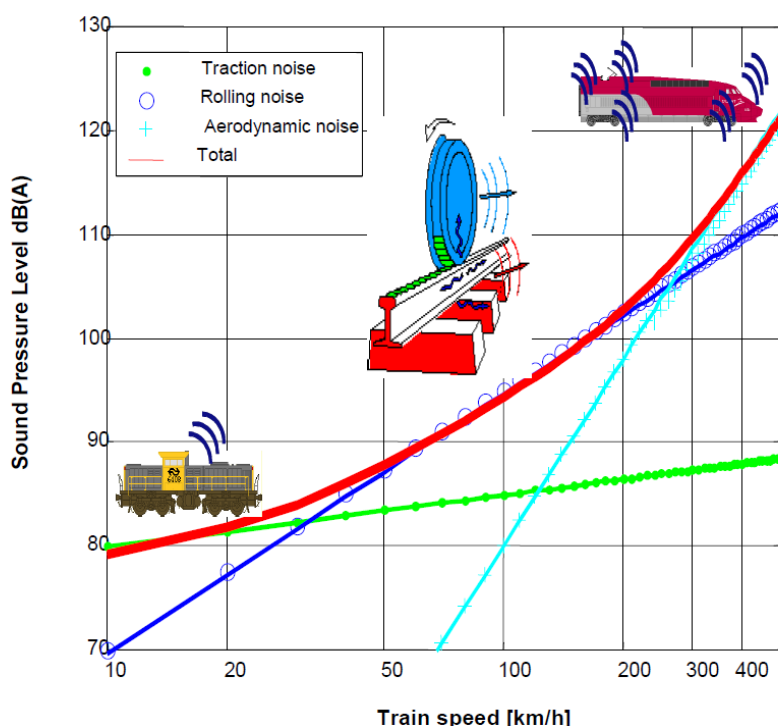
Both studies (and others, see, e.g., the comprehensive review given by [Thompson and Gautier 2006]) identify the following sources for railway noise:

- Rolling noise
- Power equipment noise
- Aerodynamic noise.

The severity and relative proportions of these noise sources depend on train speed. At low speed, power equipment noise is the dominant source, whereas at medium speed the

dominant source is rolling noise. Only at very high speed does the aerodynamic noise become an important factor. This effect is illustrated in the following figure.

Figure 6: Sources of railway noise according to train speed



This figure shows that between 30 and 200 km/h rolling noise is the dominant source. This is also the speed range which affects most people living near railway tracks. Low speed is only to be found in shunting yards, near stations or on factory railways. Speeds of more than 200 km per hour are only to be found on high speed lines.

The range between 30 and 200 km/h applies to most other railway lines. Mostly these are older lines built in a time where noise protection was not obligatory. Currently these lines have the right of continuance. There is mostly no obligation to invest in noise protection measures but according to Directive 2002/49/EC, many states in Europe already introduce actions to lower environmental railway noise. The speed range between 30 and 200 km/h is also the speed where freight trains operate (about 100 km/h). Many sources identify freight trains as the noisiest trains and they mostly operate outside high-speed lines. The following table shows the importance of noise sources, depending on train type.

Table 16: Importance of noise sources

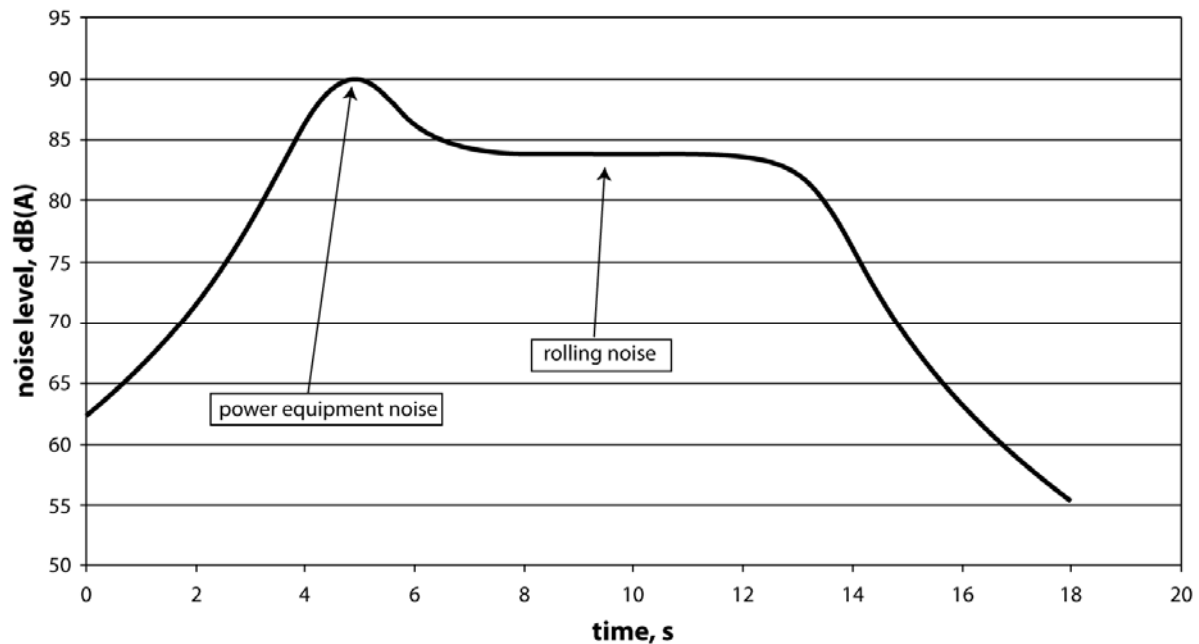
ACTION	ROLLING NOISE	POWER EQUIPMENT NOISE	AERODYNAMIC NOISE
Freight trains	++	+	Not relevant
High speed trains	++	+	++
Intercity or other long distance trains	++	+	Not relevant
City railways (tram)	++	+	Not relevant

Source: EC 2003, page 18.

The table confirms the importance of rolling noise. [EC 2003] considers that passenger trains are already quieter as they are equipped with disc brakes. This measure was not introduced for noise reduction but to enhance performance at speeds above 140 km/h.

The following figure shows the effect of power equipment noise (here a diesel hydraulic engine, built 1968 to 1979, German type 218), when a train passes. The engine noise has a large influence at the beginning of the train passage, but after a few seconds the main influence is the rolling noise.

Figure 7: Development of noise sources while train passing



Source: UIC 2008, page 13.

Concerning shunting yards: there were no reports identified which elaborate this aspect in detail. However, noise sources from shunting yards include:

- Engine noise from shunting engines
especially many acceleration and braking phases must be considered
- Rolling noise from the wagons
(especially in the train splitting siding zone behind the hump)
- Brake noise
 - Incoming trains
 - Braking of shunting engines
 - Braking of wagons by hump retarders (one of the loudest noise sources)
 - Testing of brakes of ready trains
- Noise from shunting impacts

Most shunting yards are located outside housing areas and their number has dropped over the years. Single wagon transport has even been abandoned in some countries. On the other hand, single wagon transport is still important and may play an important role in modal shift. There was no literature found concerning noise from shunting yards. Other shunting areas are mostly industrial railways where industrial noise protection rules must be met. Here railway noise is treated together with other noise aspects and is part of the total noise measurement or calculation for industrial plants.

Engine noise is relevant at lower speeds and so mostly near stations. This concerns especially acceleration noise when engines (especially diesel engines) work at high power drain (high motor speed, high inverter and converter noise).

Summary:

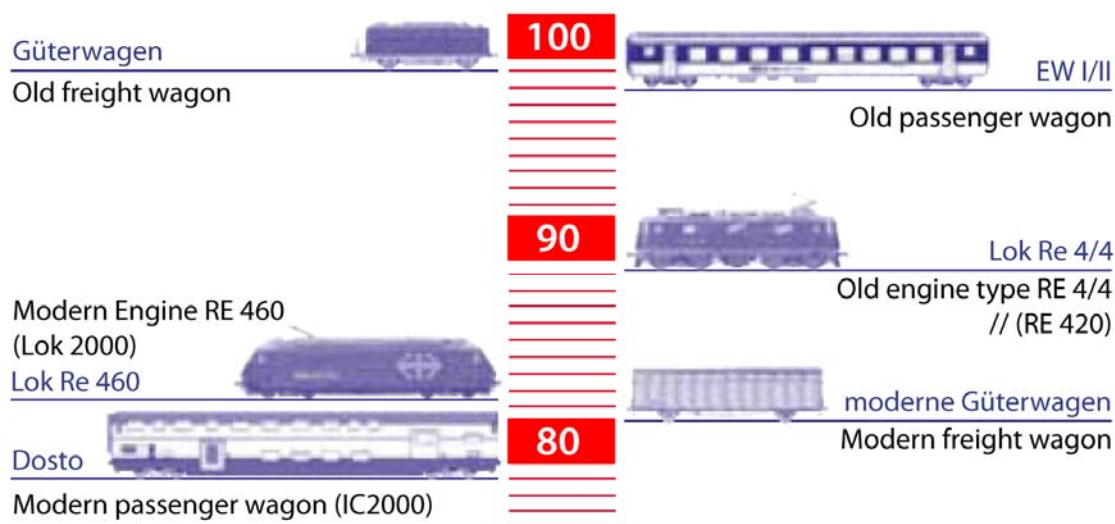
- **The most important source of noise is rolling noise, as this is relevant for both freight and passenger trains.**
- **Aerodynamic noise, especially from pantographs, is very important for high-speed trains.**

3.2. Noise emissions in relation to rolling stock

For existing wagons and engines no changes need to be made according to TSI Noise [TSI 2011]. Only in the case of renewal or upgrading of the wagon or engine is there the need for a new authorisation (to be defined by the national authority); the noise levels must be met with the new authorisation.

The following examples show the development of noise emissions concerning engines and wagons in the past. Since the year 2000, many new vehicles have been introduced all over Europe in freight and in passenger transport. In its brochure "Ruhe bitte" (silent please) [SBB 2011], Schweizer Bundesbahn (SBB – Swiss Federal Railway) showed how pass-by noise differs between old and new rolling stock. The following figure shows the changes between old stock (designed in the 1970s, or earlier) and new rolling stock (designed at the end of the 1990s). For each of the vehicle types, the noise emission measured according to TSI Noise is shown.

Figure 8: Noise emission development of Swiss rolling stock



Source: SBB 2011.

The engine Re 460 (also known as Lok 2000) is still one of the quietest engines and was the quietest vehicle of all trains until the introduction of the IC2000 passenger double deck coaches. Detailed photographs of the modern Swiss rolling stock show that the bogies are well covered by the whole engine body (Annex III).

The TSI Noise demands a maximum pass-by level of 85 dB(A) for electric engines and of 80 dB(A) for passenger wagons at 80 km/h. The Swiss examples are already below the noise level of current European legislation. This is even more interesting as the Lok 2000 was introduced in 1991 and the IC 2000 passenger cars were introduced in 1997.

[Mather 2006] presented an analysis of sources of noise in comparison with the TSI Noise. This shows the current performance of rail vehicles in comparison with the demands of the TSI. The results are shown in the following tables.

Table 17: Maximum and realised noise emissions of existing high speed trains

SPEED	MAXIMUM NOISE EMISSION ACCORDING TSI NOISE	CURRENT EMISSION OF GERMAN HIGH SPEED TRAINS	DIFFERENCE
250 km/h	87 dB(A)	87 – 94 dB(A)	0 – 7 dB(A)
300 km/h	91 dB(A)	91 – 95 dB(A)	0 – 4 dB(A)
320 km/h	92 dB(A)	92 – 96 dB(A)	0 – 4 dB(A)

Source: Mather 2006.

Table 18: Maximum and realised noise emissions of new freight wagons

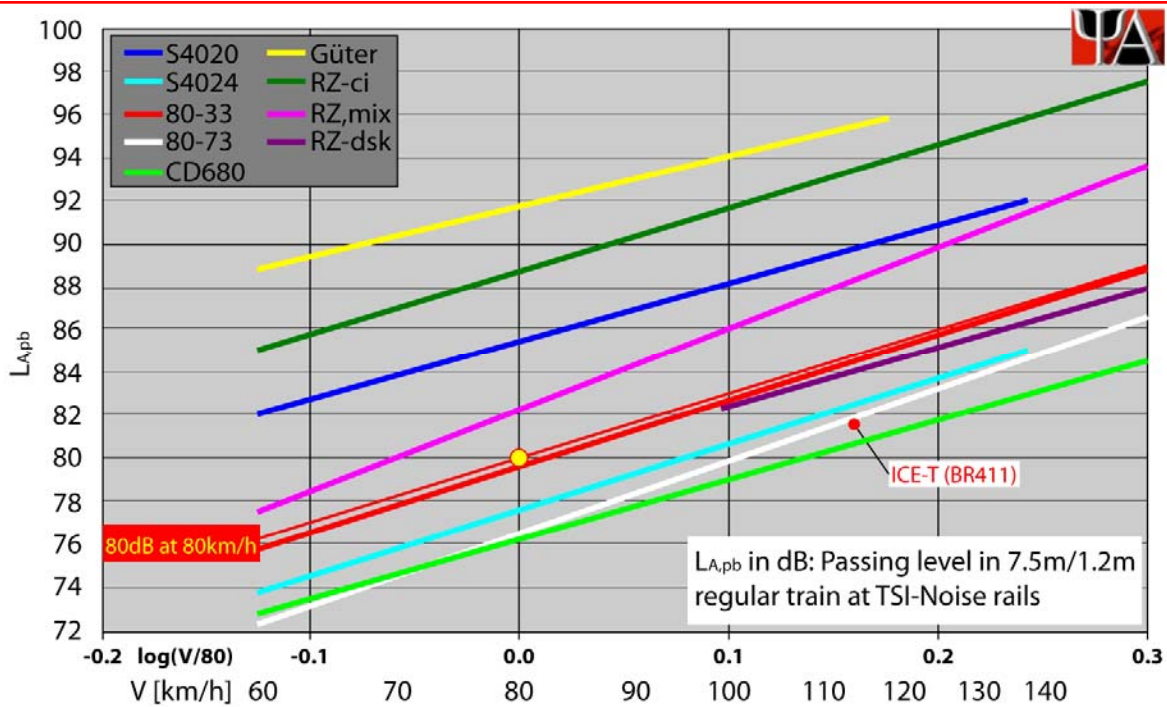
AXLES PER WAGON LENGTH	MAXIMUM NOISE EMISSION ACCORDING TSI	CURRENT EMISSION OF WAGONS	DIFFERENCE
0.15 axles per metre (new car / retrofit car)	82 dB(A) – 84 dB(A)	92 / 94 dB(A)	8 – 12 dB(A)
0.15 – 0.275 (new car / retrofit car)	83 dB(A) – 85 dB(A)	91 – 95 dB(A)	6 – 12 dB(A)
> 0.275 axles per metre (new car / retrofit car)	85 – 87 dB(A)	92 – 96 dB(A)	5 – 11 dB(A)

Source: Mather 2006.

The result is that most actions are still to realise at rail freight wagons and less on passenger trains and modern engines.

Bukovnik, in a presentation about development and measures in rail noise abatement, gives a comparison of old and new rolling stock [Bukovnik 2010]. The following figure shows the effect of new self-propelled vehicles for suburban railways. The vehicle type 4020, built between 1978 and 1987, is - at all speeds - about 8 – 10 dB(A) noisier than the type 4024 (Bombardier electric Talent) built since 2006. At 80 km/h, type 4024 meets or goes below TSI recommendations.

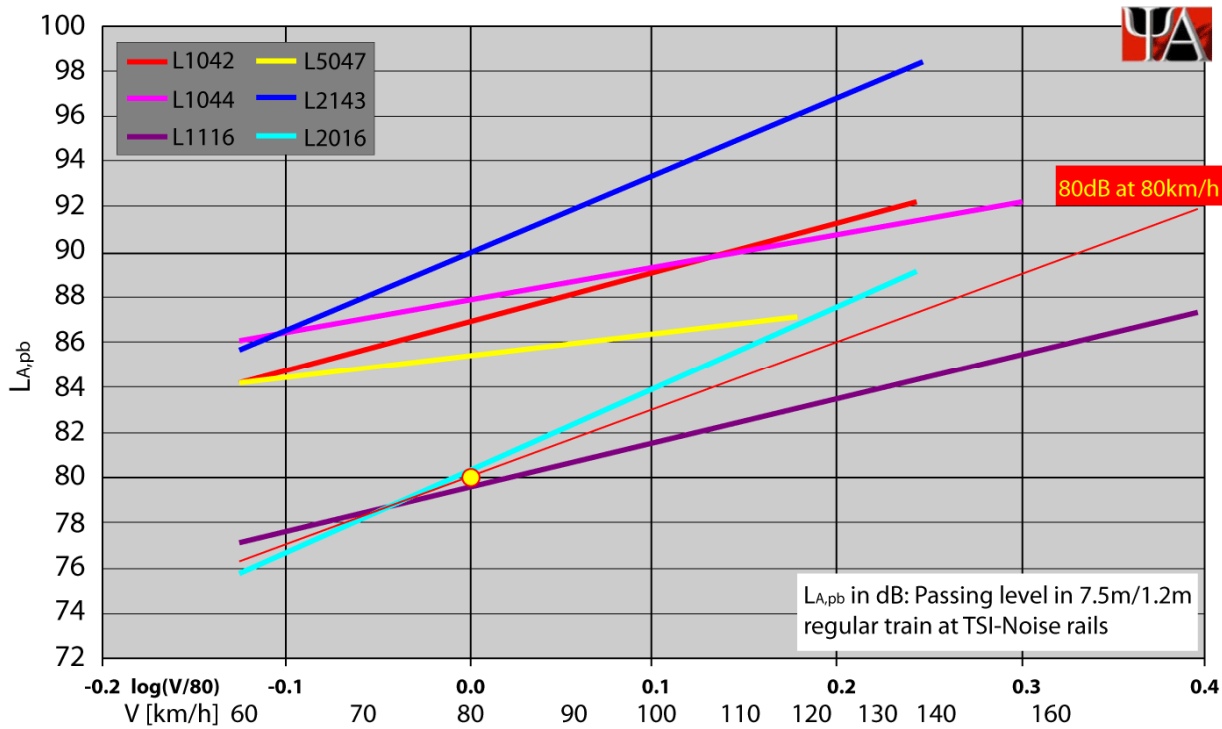
Figure 9: Noise levels of Austrian self-propelled rail vehicles



Source: Bukovnik 2010.

Similar to self-propelled passenger trains, the following figures show pass-by noise emissions of diesel and electric engines. Red lines show electric and blue lines show diesel engines.

Figure 10: Noise levels of Austrian rail engines



Source: Bukovnik 2010.

L1042 and L1044 are old electric engines, designed between 1963 and 1995. L1116 (Taurus) is a new electric engine built since 2000. L2123 is an old diesel engine built between 1964 and 1977; L2016 (Eurorunner) is a new diesel engine built since 2002. A reduction of about 8-10 dB(A) has been realised. With 80 dB(A) at a speed of 80 km/h the new engines are much below the TSI recommendation of 85 B(A).

This shows that the introduction of new rolling stock can lower noise in a big range. Halving of noise was realised since the 1960s and 1970s. Nevertheless there are also negative examples of new rolling stock that may even be noisier than the old equipment. Many sources recognise the modern Class 66 engine as well as the Blue Tiger engine as being as noisy as engines from the 1960s. Both engines were constructed in the 1990s and built since 1998. The great breakthrough to lower noise of engines came according to this since the beginning of the 21st century.

Nevertheless the noise emissions of about 80 dB(A) for new and modernised rolling stock do not lead to a reduction of noise below the WHO levels. Also the levels of the example countries cannot be met with the new rolling stock. But the reduction at the source can lower the additional needs for local noise protection as they can be less extensive or avoided in regions where people live far away from railway lines. There quieter rolling stock can lower the noise measured at far distance to an applicable level.

Summary:

- **Rolling stock introduced since the year 2000 is about 10 dB(A) less noisy in comparison with equipment from the 1960s and 1970s.**
- **So the replacement of old equipment with new ones helps to reduce rail noise.**

3.3. Measures to avoid railway noise

Sources of railway noise can be divided into the following aspects:

- Roughness-Induced Rolling Noise
- Wheel Noise
- Rail Noise
- Squeal Noise
- High Speed Trains
- Other Sources of Noise

The mitigation methods studied or already realised in demonstrators or practice will be introduced with the source of noise.

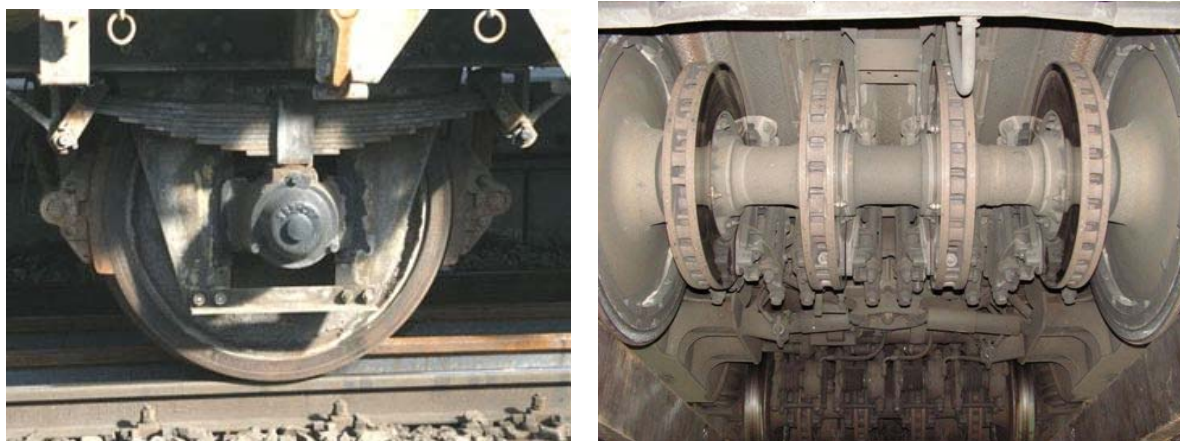
3.3.1. Roughness-Induced Rolling Noise

A major, unavoidable source of noise is wheel and rail roughness. Rail corrugation (which causes intense ground vibration and can increase noise level by 20 dB [CER UIC 2007]) and wheel flats (regular thuds) are extreme versions of this, but poor rail or wheel surface condition should be avoided. Regular grinding of rails and turning of wheels helps to minimise noise. Special 'acoustic' grinding can reduce noise levels by about 3 dB [Thompson 2008-1]; grinding strategies to reduce noise levels were studied in the MONA project [Thompson and Gautier 2006].

Both Speno and Schweerbau offer general purpose grinding, which can reduce noise levels by 10-12 dB, and special acoustic grinding, which can achieve a further 3-4 dB reduction [Licitra 2006]. UIC's 2007 report on the state of the art [CER UIC 2007] states that poorly maintained track increases noise levels, so that track renewal can achieve about 10 dB noise reduction, and acoustic grinding can achieve a further 1-3 dB.

Cast iron tread brakes, which are very common in European freight vehicles, tend to induce a corrugation in the wheels which increases noise levels significantly [Thompson and Gautier 2006]. By contrast, disc brakes, which are prevalent in passenger vehicles, are typically about 8 dB quieter [Hemsworth 2006]. The difference between tread brakes and disc brakes is shown in Figure 11. With tread brakes, the brake blocks press against the wheel directly on the running surface (the tread), i.e., the wheel surface which is in contact with the rail; whereas with disc brakes an extra disc is placed on the axle and brake blocks press against this to brake the vehicle. Because tread brakes, particularly with cast iron blocks, damage the wheel, the running surface becomes rough and can develop out-of-roundness, increasing the rolling noise.

Figure 11: Comparison of tread and disc brakes



Source: Hemsworth 2006.

Disc brakes are very expensive and can only be introduced with new freight wagons or expensive retrofitting of existing wagons (the whole bogie needs to be changed). The EU Project EuroSabot (1996-1999) looked into possibilities for retrofitting vehicles with a low-noise replacement for cast iron brake blocks [EUROSABOT 2011], [Hemsworth 2006], [Thompson and Gautier 2006]. This started the quest for composite brake blocks with friction characteristics similar to cast iron brake blocks, and suitable for retrofit; these are called 'LL-blocks'. 'K-blocks' are composite brake blocks used in new vehicle designs.

The advantage of LL-blocks is that the braking system of the wagon does not need to be modified, whereas for K-blocks there is additional effort necessary besides changing the blocks. This is because LL-blocks have similar friction characteristics to conventional cast-iron blocks, whereas K-blocks have a higher coefficient (2.5 times higher).

Both types (K- and LL-blocks) reduce noise levels by 8-10 dB; life cycle costs for K-blocks are similar to life cycle costs for cast iron brake blocks; life cycle costs for LL-blocks are still to be determined [CER UIC 2007] concerning operation costs. Concerning K-blocks, some manufacturers or wagon owners recently detected higher costs due to higher wheel wear [Gilliam 2008] and [Saabel 2011].

The EU Project Euro Rolling Silently (2002-2005) developed three prototype LL-blocks. By 2009, two LL-block types (IB 116* and Jurid 777) were reportedly safe for use in Europe [Dörsch 2009]. ICER Brakes S.A. sell organic LL-blocks which reduce noise by 8 dB compared to cast iron brake blocks [Licitra 2006]; organic LL-blocks are also produced by the Federal-Mogul Corporation.

However, although the new composite LL-blocks are effective at reducing noise, there are still problems to be solved before they can be implemented across Europe. In tests with LL-blocks, the wheels' equivalent conicity increases over time, affecting the dynamic stability of the vehicles. To address this, a consortium of brake manufacturers and vehicle operators has established the EuropeTrain project ([EuropeTrain]) which is using a real train travelling around Europe to speed up testing of LL-blocks.

If the LL-block could be introduced and certified the migration would be relatively easy, simply replacing the existing cast iron blocks by LL-blocks. Concerning the accreditation of LL blocks, Mr Lochman from CER expects certification by the end of the year 2011 and the beginning of introduction mid-2012, whereas Mr Pennekamp, Mr Fleckstein, Mr Mather and Mr Theis from DB expect certification sometime during 2012.¹⁶ As a result, the authors of this study expect certification by the end of 2012, which is more practical.

In addition to EuropeTrain, the following two composite brake projects are being conducted in Europe: Leiser Rhein includes the retrofitting of vehicles, especially in the Rhine Valley, and L&Giv develops improved K-and LL-blocks.

Summary:

- **Roughness of rails and wheels, especially corrugation in rails and out-of-round wheels, is a major cause of rail noise and needs to be monitored and controlled. Infrastructure managers and train operators already have maintenance programmes to control rail and wheel quality, and infrastructure managers use axle load checkpoints to monitor passing traffic and detect severely damaged wheels. Tolerances may need to be tightened to improve quality and reduce noise, requiring additional maintenance.**
- **The use of composite brake blocks rather than cast iron brake blocks will significantly improve the wheel running contact surface and reduce noise levels. Retrofitting existing wagons with composite brake blocks is possible, and the use of LL-blocks in particular (requiring the least effort and cost to retrofit) is currently being investigated by UIC's EuropeTrain consortium. There are still questions about the long-term degradation and the life cycle costs of the new LL-blocks that are holding up widespread implementation.**

3.3.2. Wheel Noise

The EU Project Silent Freight (1996-1999) looked at possibilities of reducing noise emission from wheels [Dörsch 2009], [Hemsworth 2006], [Thompson and Gautier 2006]:

- ring dampers reduce noise by 6 dB;

¹⁶ These statements are the results of interviews held by the project team in July 2011.

- perforation of the wheel is ineffective;
- wheel-tuned absorbers reduce noise by up to 7 dB;
- wheel web shields reduce noise by up to 9 dB.

The following figures illustrate the systems.

Figure 12: Ring damped and perforated wheel



Source: Hemsworth 2006.

Figure 13: Wheel-tuned absorbers



Source: Hemsworth 2006.

Figure 14: Wheel web shields



Source: Hemsworth 2006.

Further noise reduction can be achieved through the use of a bogie shroud [Hemsworth 2006].

Fundamental redesign of the wheel to reduce noise is difficult due to the need to fit with existing tread braking systems and the need to dissipate the heat generated during braking. Reducing the wheel diameter makes the wheel more susceptible to wheel-rail roughness interaction and can increase noise levels. The RONA project (wheel optimisation for high-speed lines) developed a new wheel design, JR13, which reduced noise levels by about 3 dB. The RONA project also developed a wheel, Alu4, with a thick aluminium web and wheel dampers, with a predicted noise reduction of 12 dB. However, following the Eschede derailment in 1998¹⁷, caused by a broken tyre, the industry has been wary of multi-material wheels. Other incidences with broken axles on freight wagons or ICE trains¹⁸ will make innovations of wheels and axles more difficult. The EU Project HIPERWHEEL (2000-2004) tested a constrained layer damping treatment on the ETR500 high speed train in Italy and measured a noise reduction of 4-5 dB between 200 and 300 km/h (see [Thompson and Gautier 2006]).

Lucchini¹⁹ offers a range of special low-noise damped wheels. *Syope* is a constrained layer damping treatment; *Galene* uses tuned absorbers to reduce squeal noise for trams; *Hypno* is a friction damping steel design for tread-braked freight wagon wheels. Valdunes²⁰ also integrates damping systems into wheels, for example, using damping rings to reduce squeal noise by 10-15 dB (see [Licitra 2006]).

Heathcote Industrial Plastics offers constrained layer dampers which eliminate squeal noise and reduce under-vehicle noise by up to 30 dB. GHH offers wheel absorbers (5-15 dB noise reduction) and damping rings. VSG Vibration Absorbers offers wheel vibration absorbers (10-30 dB noise level reduction at squeal noise peak frequencies). Schrey & Veit offers wheel absorbers which almost completely eliminate squeal noise, and reduce the noise level by 8 dB if squeal does occur (see UIC Curve Squeal Project WP3 [Müller et al. 2003]).

Summary:

- **Resilient wheels can reduce noise and improve ride quality, and can be very effective at reducing squeal noise in tight curves. A variety of technologies are available and in use in high-speed and metro applications.**
- **Following the Eschede disaster in 1998, there is still a reluctance to use non-monoblock wheels in high-speed rail vehicles.**

3.3.3. Rail Noise

Rail dampers – steel masses embedded in an elastomer, fixed to the rail web – were developed in the 1990s by ERRI in the OFWHAT (Optimized Freight Wheels and Track)

¹⁷ At Eschede the broken separate tyre caused the high-speed ICE train to derail at a switch. The rear bogie of one carriage followed the turnout on to a parallel track, and the carriage subsequently hit bridge supports. The bridge collapsed onto the train and the following cars crashed into the broken bridge and cars. 101 people died and a further 88 sustained injuries. The separate tyre technique was only used with ICE trains to solve a primary damping problem with this train type whereas other high speed trains only use full monoblock wheels.

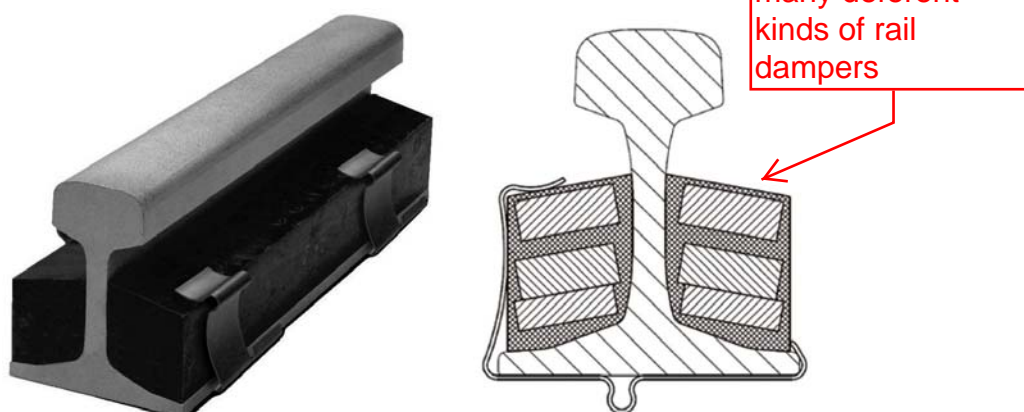
¹⁸ Breaking of an axle of an ICE3-train in Cologne on 9 July 2008; freight train derailment in Viareggio (Italy) 30 June 2009.

¹⁹ Lucchini RS [<http://www.lucchinirs.it/>] is an Italian company which produces high-speed wheelsets; this is separate from the Russian-owned steel manufacturer Lucchini.

²⁰ Valdunes [<http://www.ghh-valdunes.com/>] is a major European wheelset manufacturer based in Germany, France and Belgium.

project and SNCF in the VONA project (low-noise track designs for high-speed lines) [Thompson and Gautier 2006]. The EU Project Silent Track (1997-2000) developed these rail dampers further; the new design reduced noise by 6 dB [EUROSABOT 2011], [Hemsworth 2006], [Thompson and Gautier 2006]. The Dutch IPG project²¹ tested rail dampers and found the silent track dampers and also the Schrey and Veit (S&V) VICON-ASMA 5RQ absorber to be effective, reducing noise levels by 3 dB [Thompson 2008-2]. Further testing of rail dampers is presented by van den Dool [van den Dool 2007].

Figure 15: Tata Steel SilentTrack tuned rail dampers



Source: Tata Steel; images from product brochure.

Tata Steel offers the 'SilentTrack' tuned rail damper system (see Figure 15), with a noise reduction of 3-7 dB. The rubber at both sides of the metal rail causes the noise reduction. Over 200 km of SilentTrack are in operational use around the world, including the Netherlands, Germany and the UK.

Trackside barriers can also be used to reduce noise levels [Hemsworth 2006], [Thompson and Gautier 2006], but rail dampers can make barriers and screens unnecessary [van den Dool 2007].

The VONA project also developed optimised rail pads which reduced noise levels by 3-4 dB [Thompson and Gautier 2006]. Rail pads were also developed in the Silent Track project, reducing noise levels by 2 dB.

Saargummi and CDM offer a range of resilient rail pads designed to damp noise and vibration; CDM and Getzner Werkstoffe offer under-sleeper pads and ballast mats and a range of solutions for slab track and embedded track systems [Licitra 2006].

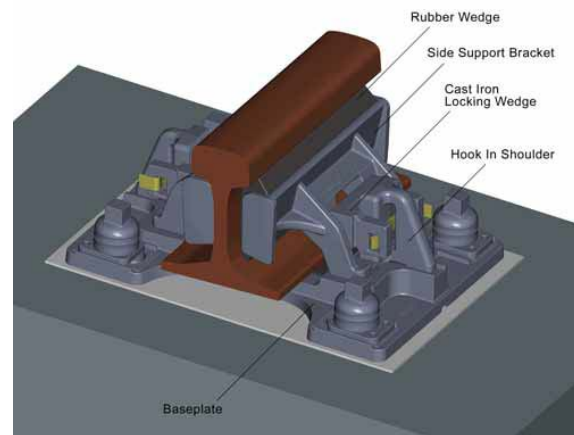
Pandrol's VANGUARD uses resilient padding to attenuate noise, but also supports the rail at the web to prevent rail roll. This system is used in the London Underground (Victoria Line) and the Channel Tunnel Rail Link, for example, and recently in the new development of Belgrade Central where vibration reduction was a key consideration. When tested in Hong Kong's MTRCL test track on plain slab track, the VANGUARD system reduced average noise levels by 7.3dB in the 20Hz-500Hz range; and by 13dB in the 40Hz-80Hz range. These tests showed even greater noise reduction was possible by using the VANGUARD on an Isolated Slab Track (IST); IST has a rubber ballast mat and is easier to install than floating slab track, but is not as effective.

²¹ Innovatieprogramma geluid (IPG) voor weg- & spoorverkeer [<http://www.innovatieprogrammangeluid.nl/>].

Figure 16: Left: Saargummi rail pad; Right: Pandrol Vanguard resilient web support



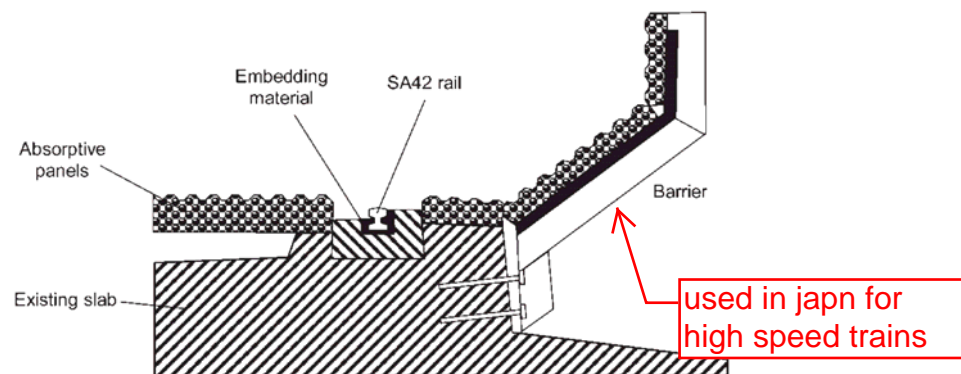
Source: Licitra 2006



Source: Pandrol Vanguard; product brochure

The Silent Track project developed a new rail section with a narrower fit, along with a new fastening system and a new twin-block sleeper design; this reduced noise levels by 3 dB. The Dutch project Quiet Rail Traffic (STV) developed a new, smaller rail section, SA42, for slab track (see Figure 17); the rail is continuously supported by a stiff embedding material, and this acts as a damping mechanism. The noise reduction compared to slab track with UIC 54 rails is 5 dB. Barriers at the side of the track, with a height of 0.7 m, further reduced noise levels by 6 dB (see [Thompson and Gautier 2006]).

Figure 17: Slab track section SA42 from Quiet Rail Traffic project



Source: Thompson and Gautier 2006.

The Edilon Corkelast embedded rail system, which provides a noise reduction of 5 dB, has been implemented in the rail steel bridge over the Arno in Pisa [Licitra 2006].

Balfour Beatty Embedded Rail System (BBERS) has been shown in a test in Medina, Spain, to reduce noise level by 2 dB or more, compared to ballasted track [InnoTrack D2.3.3].

Summary:

- Noise and ground-borne vibration are a major concern in urban areas, and bridges and underground railways require special measures. Resilient rail pads are a common solution, but for locations where a greater level of damping is required then floating or isolated slab track is a possibility, or under-sleeper pads and ballast mats for ballasted track; an alternative to

rail pads is a more advanced resilient rail support system such as VANGUARD.

- **Resilient rail support solutions interact with each other and also with resilient wheel technologies, and the whole system needs to be considered and modelled in order to minimise noise and vibration in the required frequency range.**
- **Noise barriers have a large on-going maintenance cost, have a high visual impact and create problems for track access. Rail dampers can be tuned to the local needs of the railway and left in place for the life of the track; these can be an effective alternative to noise barriers.**

3.3.4. Squeal Noise and Friction Modifiers

Squeal noise is the high pitch noise (2-4 kHz) sometimes emitted when vehicles are curving. This is caused by lateral stick-slip behaviour of the contact between the wheel and rail exciting high-frequency resonances in the rail and wheel. Many wheel and rail damper solutions target squeal noise.

Friction modifiers are used to change the interaction of wheel and rail to prevent squeal noise and corrugation. As of 2005, UIC's position on friction modifiers was that there is no optimal solution. Friction modifiers can be lubricants, e.g., greases, designed to reduce friction to 0.2 or less, and usually applied to the gauge face of the high rail in curves where the wheel flange often makes contact, creating a grinding sound and high levels of wear. Lubrication is primarily used to reduce wear, and is not desirable on the top of the railhead where high levels of friction are required for traction (train acceleration and braking). Top-of-rail (TOR) friction modifiers (FM) control friction to be in the range 0.3-0.35. To prevent squeal noise, friction modifiers need to have 'positive friction' characteristics, so that friction increases when the wheel slips. TOR FM can also be effective at reducing short-pitch corrugation (a major noise source) on the low rail in curves, and has been used successfully in the Heathrow Express to combat corrugation²².

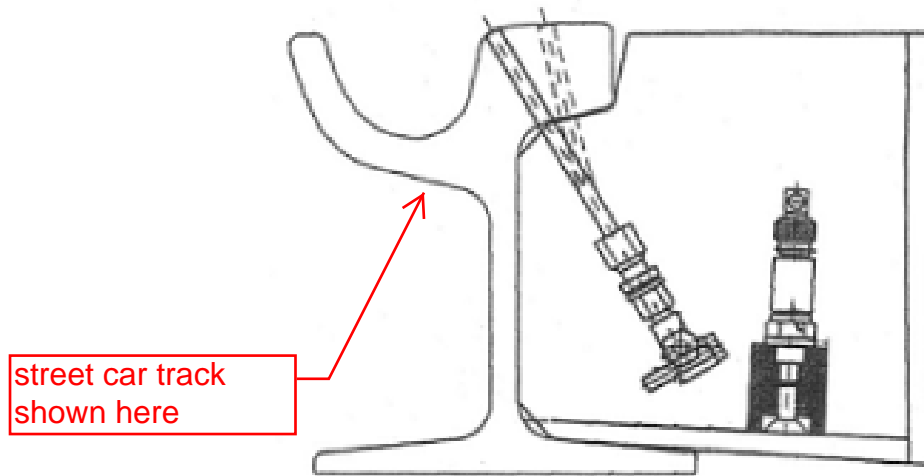
Alternatively, special asymmetric rail sections can be used to prevent squeal ('Anti-Squeal Profile'), and the track layout can be adjusted to avoid dynamic conditions of the vehicle which cause squeal noise. Special surface layers or coatings can be designed with special friction characteristics, such as Duroc AB's particle-impregnated rail surface. Based on laboratory tests, this layer has a low coefficient of friction when dry, and is also effective at reducing rail wear, and even the corresponding wheel wear is relatively smooth (see [Hiensch et al. 2007]).

The EU Project Q-City (2005-2009) tested vehicle and track lubricators for squeal noise suppression. On-board lubrication was tested in the Antwerp network and found to be effective at reducing squeal noise, and for a relatively low cost. A wayside lubrication system was tested at the STIB depot; the wayside lubrication was very effective, decreasing squeal noise by at least 16 dB. In general, electric power is required on site for wayside lubricators, and access to hydraulics for maintenance may be difficult in urban

²² M. Chestney, N. Dadkah and D. Eadie (2009) The Effect of Top of Rail Friction Control on a European Passenger System: The Heathrow Express Experience, 8th International Conference on Contact Mechanics and Wear of Rail/Wheel Systems (CM2009), Firenze, Italy. [For a summary of this, and a general look at TOR FM, see also: <http://www.therailengineer.com/railtex2011/Day-2-No-06-Kevin-Portec.pdf>].

environments (see [Q-City 2009]). These techniques, indeed, are only tested for municipal railways (light rail, underground systems).

Figure 18: Principle of way-side lubrication systems for friction modifying



Source: Q-City 2009.

The particular through-hole lubricator prototype developed by Lion Oil was found to be unreliable (see Figure 18). The figure shows the injection device to lubricate the rail-wheel-contact area. Other similar systems are on the market, and the annexes of [Q-City 2009] give quotations for: (A) Clicomatic rail through-hole grease lubrication system; (B) FluiLub rail lubrication systems (vehicle-mounted and track-based).

ELPA d.o.o. offer another through-hole wayside application for suppressing squeal noise, both in curves and during braking (particularly useful at marshalling yards) [ELPA], [Licitra 2006]. The ELPA system uses an environmentally friendly composite friction modifier.

Other track-based rail lubrication / friction management systems are: Portec trackside Friction Management System (5-15 dB noise reduction); Schreck-Mieves Electronic Rail lubrication; and KLS Lubriquip. Other on-board friction management systems: REBS (rail lubrication, 20-28 dB reduction at 2500 Hz, and wheel-flange lubrication); TracGlide (rail lubrication); Vogel AG (wheel-flange lubrication); Kelsan/Lubriquip (wheel-side, 2-7 dB reduction); Barnt Green Birmingham (water spray); SBB (water spray) (see UIC Curve Squeal Project WP 3 [Müller et al. 2003]).

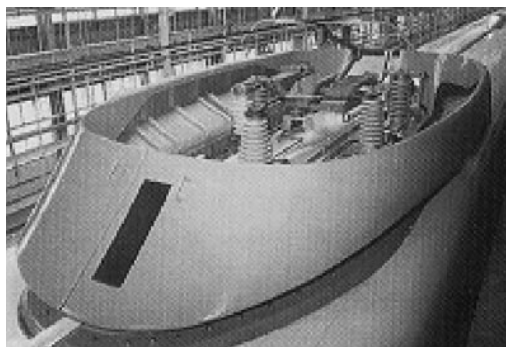
Summary:

- **Gauge-face lubrication is the traditional means for controlling wear of the high rail in narrow-radius curves, which has a secondary effect of reducing noise levels, including squeal noise in some cases. The main technological developments in this area focus on the applicators.**
- **Top-of-rail friction modifiers are a relatively new extension of this technology, and are used to prevent corrugation of low rails and squeal noise in curves, as well as brake squeal in shunting yards.**

3.3.5. High-Speed Trains

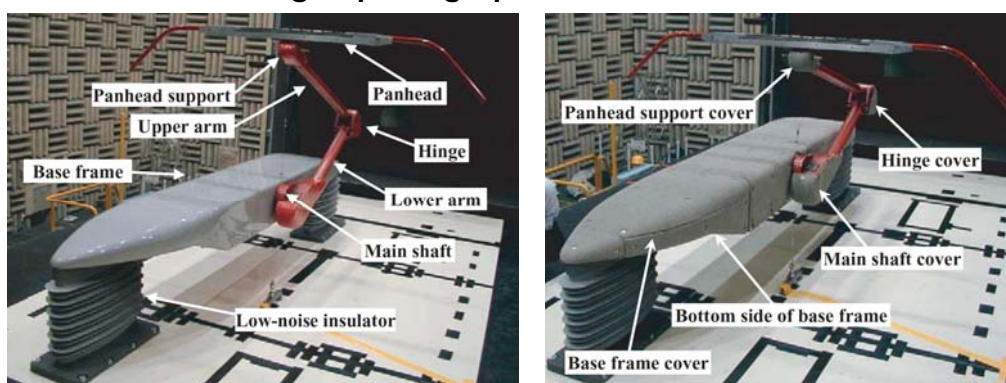
Aerodynamic noise becomes significant at high speed (over 200 km/h) reaching a noise level similar to rolling noise. For electric trains, pantograph noise is also significant at high speed. Pantographs and the leading bogie are the two main sources of aerodynamic noise. Pantographs can be shielded (see Figure 19) and/or carefully shaped, and thereby achieve noise reductions of 5-10 dB in each case (see [Talotte 2000], [Talotte et al. 2003]). [Sueki et al. 2009] have shown that porous covers can reduce aerodynamic noise of pantographs.

Figure 19: Shield of pantograph of Japanese Shinkansen Series 700



Source: Talotte 2000.

Figure 20: Porous coating of pantographs



Source: Sueki et al. 2009.

Vibrations caused by vehicle-track interaction travel through the ground at a speed that depends on the ground type; propagation is slower in softer soil. If train speed exceeds the ground vibration propagation speed, then this creates a ground-borne vibration 'boom', analogous to a sonic boom when aircraft break through the sound barrier. In practice this means there is a threshold train speed above which ground vibration increases sharply. For peat and clay soils, this critical speed can be as low as 150 km/h, but bogie spacing and axle spacing also influence the critical speed [Madshus and Kaynia 2000].

Concerning high speed trains on high speed lines, often ballast-less tracks are used. As this superstructure is a hard soil the noise can increase due to the hard concrete plate, low absorption of noise and strong transference. The normal solution is to cover the ballast-less tracks with dampers.

Summary:

- **Pantographs are generally higher than noise barriers, and for high-speed trains these are a major source of noise. Rather than making noise barriers**

even higher or all-enclosing, an alternative approach is to focus on aerodynamic design and new materials.

3.3.6. Other Sources of Noise

Other sources of noise include locomotive exhaust, traction motors, cooling fans, bridges and train horns [Talotte et al. 2003]. Resilient baseplates are effective at reducing bridge noise (the Pandrol VIPA system reduced noise by 6 dB in one study [Wang et al. 2000]). Schrey & Veit (S&V) also offer a tuned absorber system for railway steel bridges [Licitra 2006] with also approximately 6 dB noise level reduction.

It should be noted, finally, that poor or infrequent maintenance can cause increased noise levels, particularly from components with moving parts, e.g., bearings, vehicle suspension.

3.3.7. Other options to reduce noise

Other options, such as speed limits and land-use planning, are rejected in [UIC 2008]. Speed limits need to be substantial (50 km/h) to have a considerable noise impact and thus “are not compatible with the operation of a commercially competitive railway” (although the benefits of speed reduction should be considered on a case-by-case basis). Land-use planning measures are of little effect, since further than 50 metres from the source “noise level is insensitive to even medium changes in distance”.

The redirection of trains is not always suitable. In some cases there may be alternative lines, but here also people can be affected. So this solution may only be a shift of the problem. In some cases, for example the Rhine axis, there are no (realistic) alternatives.

3.4. Result for main reduction measures

The following table shows a summary of measures, effects and costs, collected from the different sources.

Table 19: Measures, effects and costs

MEASURE	AVOIDED SOURCE OF NOISE	IMPACT (LOCAL, NETWORK WIDE)	EFFECT	COSTS / UNIT ²³
K-blocks	Rolling noise	network wide	Up to 8 dB(A) – 10 dB(A)	4,000 – 10,000 € per wagon ²⁴
LL-blocks	Rolling noise	network wide	Up to 8 dB(A) – 10 dB(A)	500 – 2,000 € per wagon ²⁵
General grinding of bad track	Rolling noise	local	10 – 12 dB(A) (up to 20 dB(A) at very bad tracks)	Shall be established in normal maintenance

²³ Cost information comes from [UIC 2008] page 25.

²⁴ Retrofit, for new wagons there are no additional costs; additional operating cost still to be analysed.

²⁵ Retrofit, for new wagons there are no additional costs; additional operating cost still to be analysed.

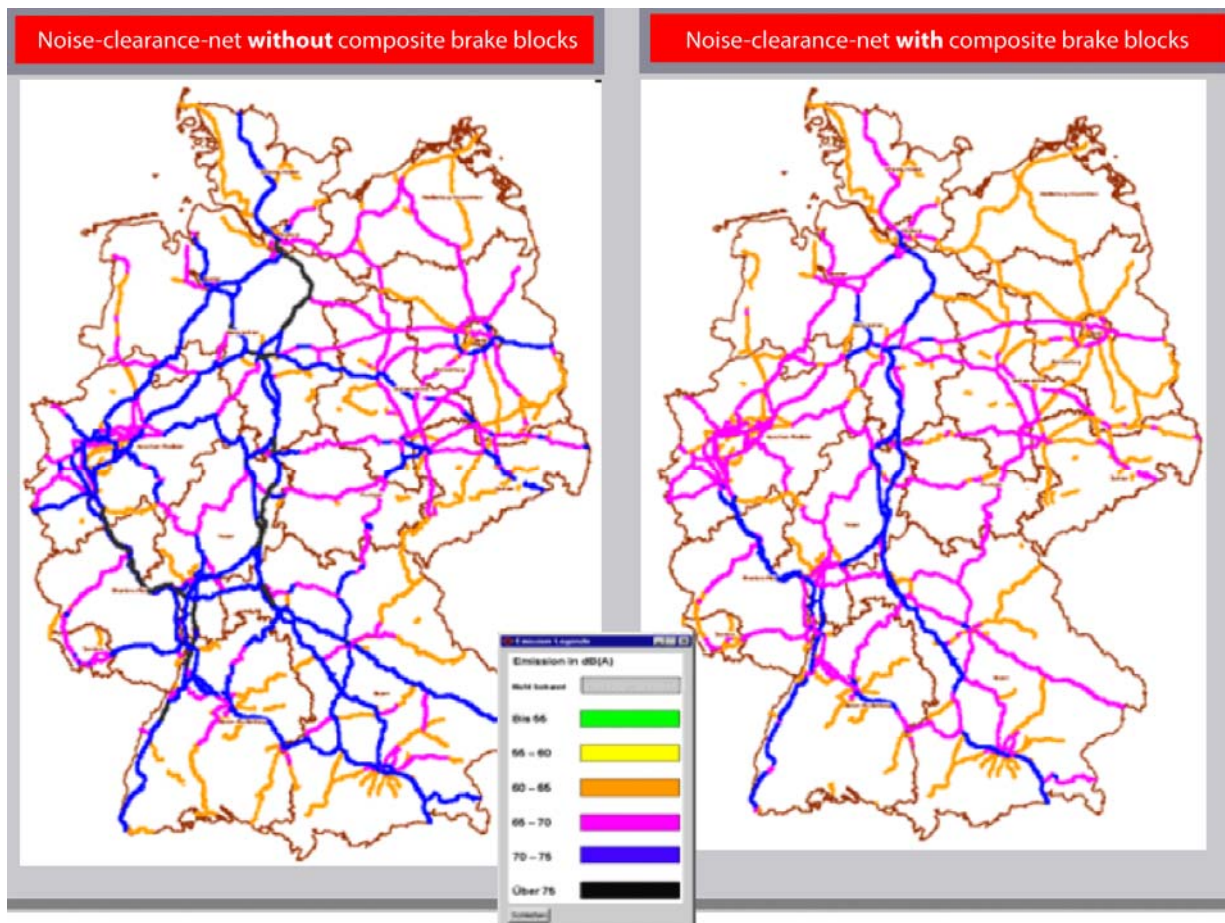
MEASURE	AVOIDED SOURCE OF NOISE	IMPACT (LOCAL, NETWORK WIDE)	EFFECT	COSTS / UNIT ²³
Special acoustic grinding	Rolling noise	local	1 – 4 dB(A) (depending on local rail roughness conditions), mostly around 2 dB(A) attended	
Disc brakes	Rolling noise	network wide	10 dB(A)	Meanwhile mostly established in passenger cars
Wheel-tuned absorbers	Wheel noise	network wide	2 – 7 dB(A)	3,000 – 8,000 € per wheel → (24,000 – 64,000 per 4-axle wagon)
Bogie Shrouds together with low height barriers	Wheel noise	local	8 – 10 dB(A)	
Rail dampers	Rail Noise	local	3 – 7 dB(A) (mostly around 3 dB(A) attended)	300 – 400 € per metre (two rails)
Slab tracks	Rail noise	local	5 dB(A)	
Rail pads	Rail Noise	local	3 – 4 dB(A)	
Different measures to lower squeal noise	Squeal noise	local	Up to 20 dB(A) depending on local conditions	
Shielding of pantographs	High speed trains	Global but only at high speed up from 200 km/h	5 – 10 dB(A)	
Barriers 2 meter high	All sources	local	10 dB(A)	1,000 €/m
Barriers 3 – 4 meter high	All sources	Local	15 dB(A)	1,350 €/m (3 metres high) 1,700 €/m (4 metres high)
Insulated windows	All sources	In house only	10 – 30 dB(A)	3,000 – 8,000 € per house (4 windows)

Source: Elaborated by the authors from different sources.

Deutsche Bahn has published two graphs in its Statement for Noise Reduction [DB 2010] Figure 21 shows, on the left, the current noise levels on German railway lines; and, on the right, the results of a simulation with the assumption that composite brake blocks for rail freight wagons have been introduced. The graphs show that the network affected by high noise emissions will shrink by introducing modified tread brake blocks. Fewer lines will be affected by noise levels between 70 – 75 dB(A) and 65 – 70 dB(A). Nevertheless, there are many lines which will remain affected by these noise levels.

However, the introduction of low noise wagons with the help of composite blocks lowers the number and length of rail sections where local (expensive) measures must be taken.

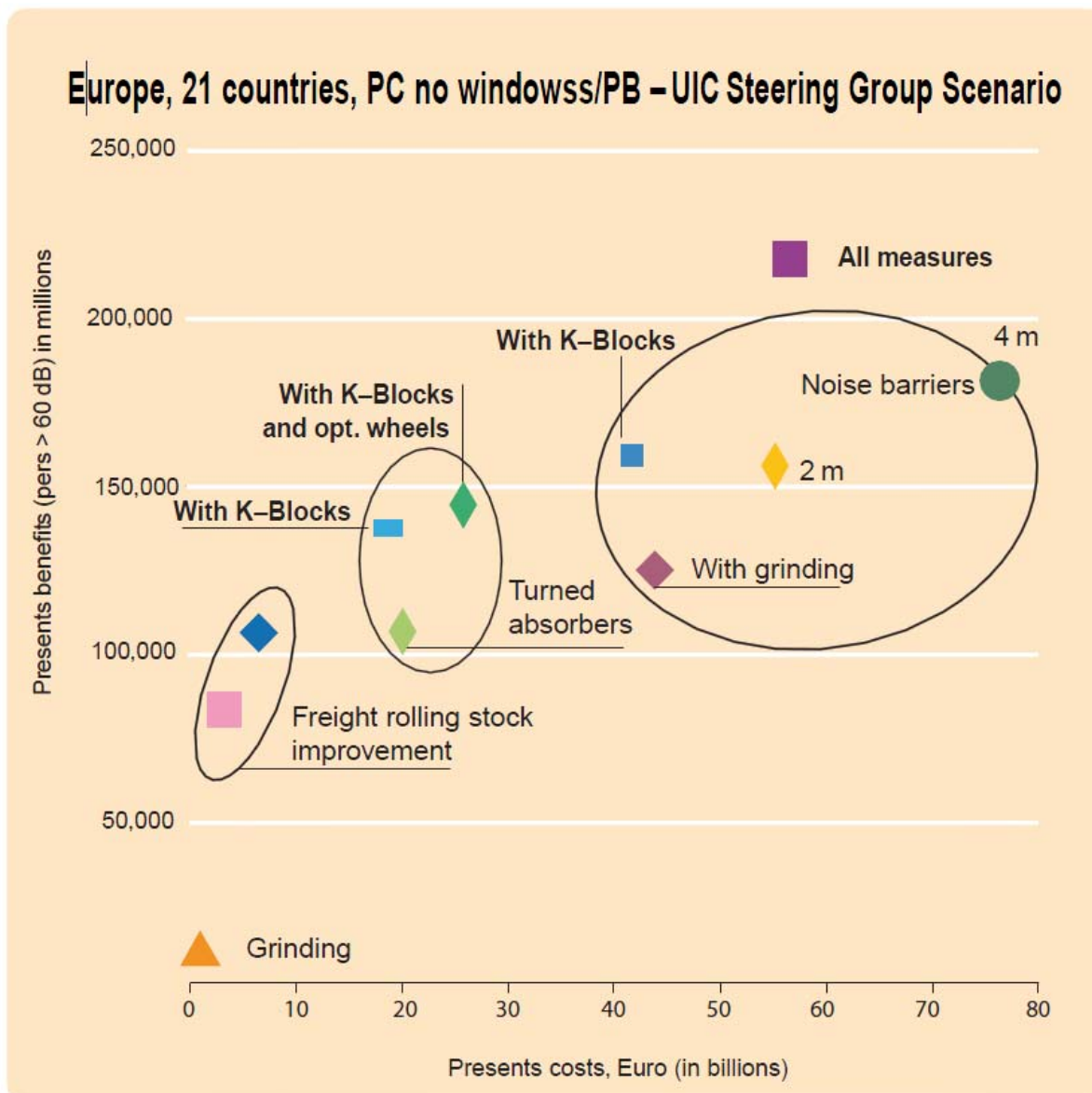
Figure 21: Shift of noise levels on German railway lines due to introduction of composite iron soles for rail freight wagons



Source: DB 2010, page 3.

The UIC published in its report "Railway Noise in Europe – A 2010 report on the state of the art" a diagram where the costs and benefits of different measures and combinations are presented [UIC 2010]. Figure 22 represents the main result of the STAIRRs Project (funded by the EU 5th Framework Programme). The graph shows that the most cost effective measure to lower railway noise is the retrofitting of freight wagons with composite blocks. It costs about 5–10 billion Euro and lowers noise for about 100 million people. The combination of composite blocks with rail-tuned absorbers will raise costs up to 20–40 million and affect 100–150 million people. In comparison, noise barriers (without any changes in vehicle technology) will cost about 80 billion Euro and affect about 180 million people. As a result, the introduction of composite brakes saves a considerable amount of money in comparison with noise abatement only realised by noise barriers.

Figure 22: Cost benefit analysis of measures to reduce noise in STAIRRS project

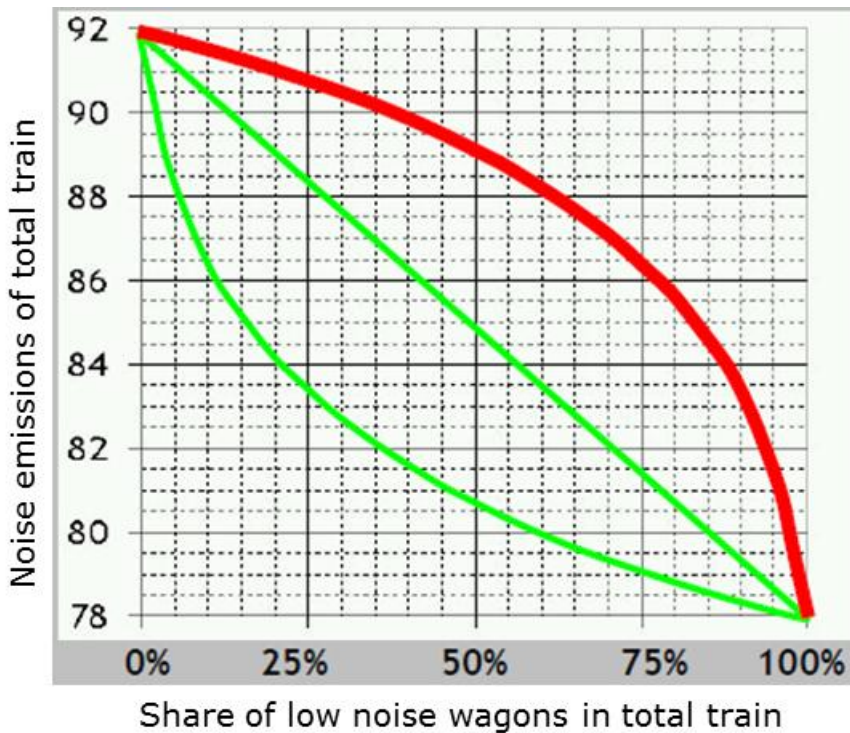


Source: UIC 2010, page 15.

Concerning the equipping of freight wagons with composite blocks: The noise reduction effect of a complete train depends in a logarithmic form on the number of wagons equipped with composite blocks. This effect is illustrated by [Bukovnik 2010].

The red line in Figure 23 is the relevant one. It shows the effect of the total noise emission (y-axis) of a train in which a certain share of wagons is equipped with low noise brakes (x-axis). The assumption for Figure 23 is that wagons equipped with composite brakes cause noise emissions of 78 dB(A), whereas the others cause emissions of 92 dB(A). The figure shows that noise reduction for a whole train follows the share of noise-reduced wagons and is disproportionately low until about 75% of the wagons have composite brakes, and after that the total noise decreases faster.

Figure 23: Effect on total noise according to share of wagons equipped with K- or LL-blocks



Source: Bukovnik 2010.

If 50% of the wagons were equipped with composite blocks the total noise would only be reduced to a noise level of 89 dB(A) (21% of total possible lowering). Only if about 98% of wagons were equipped would a total level of 80 dB(A) (86% of possible lowering) be reached. This means that the lead time until significant noise reduction is achieved will be very long if the modified wagons are introduced by normal replacing of old wagons by new ones after the normal operation time of a wagon (about 40 years).

To achieve a significant and noticeable effect, a large share of wagons has to be equipped with K- or LL-blocks as soon as possible. LL-blocks can be completely introduced according to the normal operational lives of blocks (which in some cases is less than one year as normally – operation time for cast iron blocks is about 60,000 km, whereas wagons for combined transport run about 100,000 km per year). K-blocks can be introduced in about 6–8 years providing the possibility for wagon owners to modify the braking system with the general inspection.

Conclusion:

Regarding the costs and the associated effects, and current experience of noise measures, the authors conclude that:

- Noise should ideally be reduced at the source because these measures have a network-wide effect.
- **A relatively cheap way to reduce noise on freight routes is to retrofit braking systems of rail freight wagons with composite brake blocks as quickly as possible.**
 - Freight trains are currently identified as the noisiest trains.
 - Most freight trains operate at night which is the most sensitive time of day.
 - Most passenger trains already have disc brakes due to higher speeds and enhanced comfort for passengers, so these trains are quieter than freight trains.
 - Wheel dampers are very expensive and cause additional efforts for maintenance but can significantly reduce noise emission.
- In case of high-speed trains, advanced pantograph designs should be considered, especially for routes through noise-sensitive areas where noise bunds and barriers shield against rolling noise but may not shield pantograph noise.
- Where track infrastructure causes increased noise levels (e.g., structure-radiated noise from viaducts or curve squeal in narrow radius curves), or where the local environment is particularly sensitive to noise (e.g., urban environments with residences very close to the railway line (especially agglomerations) or areas of natural beauty) then additional trackside noise mitigation measures may be necessary.
 - Rail-tuned absorbers can be effective against curve squeal and rolling noise, reducing noise levels typically by 3-7 dB(A). These can be a low-cost solution which avoids visually intrusive noise barriers.
 - Noise bunds and barriers can be effective against noise propagation, but can create problems for track access and have high on-going maintenance costs.
 - Curve squeal and corrugation of the low rail can be prevented using top-of-rail friction modifiers.
- In the long term, new wheel concepts can be introduced, but these need more research and testing before they can be introduced especially into high speed vehicles.
- In dense populated areas with high frequencies of trains, noise protection walls or insulating windows still need to be introduced. Their number could shrink in case of well introduced source related measures or modified tracks.

3.5. Number of rail freight wagons to be retrofitted

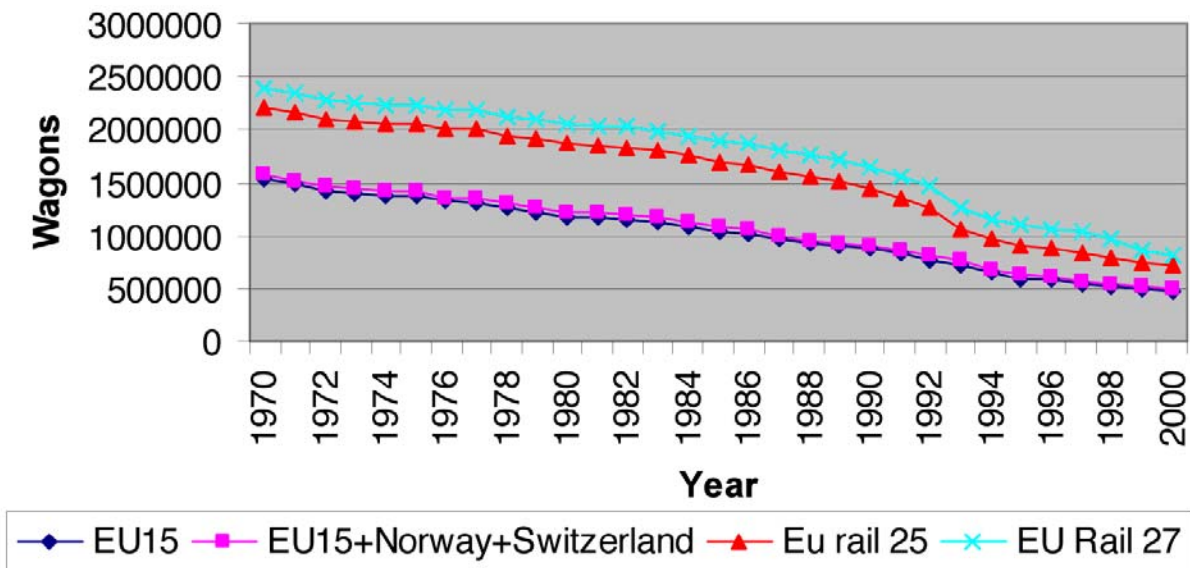
To identify the value of retrofitting freight cars with composite brake blocks, an analysis of the age structure of the fleet must be done. One question is the number of wagons it is worth retrofitting. Another is the number of wagons that will be replaced by new ones in the near future, since these are not worth retrofitting.

Unfortunately the only study available concerning the freight wagon fleet is from the year 2004 [AEA et al. 2004]. The figures from that report will be updated by some recent reports or news from European railways, wagon owners and wagon manufacturers.

The AEA study mentions on page 38, that Trenitalia has made a detailed survey of the European fleet in the year 2000. If a retrofitting programme had begun in 2005, the retrofitting would have affected 650,000 wagons out of 1.2 million.

In general, the AEA study points out that determining the size of the fleet is very difficult due to the lack of data from some countries. Also, the authors did not get data from each of the railway companies or countries because the number and age of freight cars is often confidential for competition reasons. The estimated total number of freight cars in Europe is given in Figure 24. The age structure of the total fleet of the year 2000 is presented in Table 20.

Figure 24: Estimated number of freight cars



Source: AEA et al. 2004, page 39.

Table 20: Age structure of freight wagon fleet in the year 2000

Building year	Share
Before 1970	10%
Between 1970 and 1980	46%
Between 1980 and 1990	22%
after 1990	10%

Source: AEA et al. 2004, page 42.

To update the figures given in the AEA-study, the authors have made additional analyses using other sources.

Recent documents from VDV, UIC and others indicate that in Europe 600,000 rail cars still exist or are relevant for noise reduction programmes. The UIC indicates a total number of 600,000 old wagons to be retrofitted [UIC 2009]. Also VDV together with VPI, DB Schenker

and DB Netz indicate 600,000 wagons where retrofitting must be checked [VDV et al. 2010].

For retrofitting activities the railway alliances UIC, CER, UIRR, ERFA, EIM and UIP together answered a Consultation document of the Commissions Services [UIC et al. 2007]. Their statements concerning the worth of retrofitting focus on the number of years a retrofitted wagon will be used. This is about 4–6 years (one revision cycle) but realistically 10 years. The normal durability of a freight wagon is about 40 years, so the oldest wagons to be retrofitted may be about 30 years old. According to the figures mentioned in Table 20, only 264,000 of the fleet of the year 2000 are valid for retrofitting (only the categories up from the year 1980). General figures about the total number of wagons currently operating in Europe are 600,000 or 650,000. The difference between the wagons up to 30 years and the highest number of wagons in operation makes 386,000 wagons which either have been built since the year 2000 or before 1980. Estimating that the normal life time of freight wagons is 40 years, almost 80% of wagons produced between 1970 and 1980 are still in use. That makes about 300,000 wagons. So about 86,000 wagons must have been produced since the year 2000. Together with the fleet worth retrofitting, from between the years 1980 and 2000, this makes a total of 350,000 wagons.

An interview with Mr Kerth from VDV by the authors came to an estimate of 350,000 to 370,000 wagons to be retrofitted. Also KCW indicates a total number of 370,000 freight cars to be retrofitted [KCW 2009].

Summary:

- **Although the exact number is not known, a reasonable estimate is that there are currently 370,000 freight wagons suitable for retrofitting with composite brake blocks.**

4. CASE STUDIES

KEY FINDINGS

- This section describes some general noise situations in regions and rail sections and effects of realised or proposed measures to lower / avoid noise.
- On the **Rhine Axis** the situation on the currently realised/planned upgraded line **between Karlsruhe and Basel** and the existing line in the narrow Rhine Valley between **Bingen and Koblenz** is described. A **simulation** of the introduction of noise barriers on the one hand and of composite brake blocks on the other hand is made.
- For **alpine regions** general findings from a research project on noise are represented.
- For the **Inn Valley in Austria** the current situation, development of rail transport and the intensive activities of Austria concerning the **installation of noise protection walls** are described.
- For the **Fréjus Corridor between France and Italy** the noise situation is described.
- For the **UK activities** and noise situations for the new built projects **Thameslink** and the **two High Speed Lines** are represented.

This chapter is divided into two main sections. Section 4.1 on page 71 describes selected regions or countries and includes some general local aspects of noise emission and noise spreading in mountain areas. Section 4.2 on page 83 analyses selected railway lines in more detail. The effects of sample measures which are described in Section 3.3 on page 53 are calculated.

4.1. General descriptions of environmental railway noise in selected areas or countries

4.1.1. Rhine Axis

The Rhine Axis beginning at the ARA ports and ending in Basel with the continuance via Gotthard and Lötschberg to north Italy represents one of the most important freight corridors.

The main areas where the discussions about railway noise are currently the strongest are the section between Bingen and Koblenz and the new build "Rheintalbahn" between Karlsruhe and Basel. The section Bingen – Koblenz is the narrowest section of the Rhine Axis where railway lines are located on both sides of the Rhine. The rail track follows the river with many sharp turns. The section Bingen – Koblenz will be described in Section 4.2.1 on page 84. This section focuses on the Rheintalbahn.

In 1993 the first sections of two extra tracks between Karlsruhe and Basel were introduced for operation on the "Rheintalbahn". In the following years more and more sections got into operation. They are mostly located next to the existing railway line but also some of the new sections are constructed next to the motorway A5 (example: bypass Freiburg for freight trains) or use completely new corridors (like the Rastatt tunnel or the Katzenberg tunnel). The sections between Rastatt and Offenburg are in operation. The sections Karlsruhe – Rastatt and Offenburg – Basel are still in planning or partly under construction. There are many objections against the project especially due to noise pollution reasons.

BMU and Intraplan Consult published a prediction about numbers of trains between Offenburg and Basel. The study firstly comes to the result that about 1,300,000 people are living in the affected area of the railway²⁶ line ([BVU INTRAPLAN 2008], page 11).

The following table gives the result of predicted numbers of trains for sample sections (rural and urban areas).

Table 21: Prediction of numbers of trains on Rheintalbahn

SECTION (SAMPLES)	TRAIN TYPE	2007	2015	2025
Denzlingen – Freiburg (agglomeration)	Long distance trains	66	76	78
	Regional trains	124	152	190
	Freight trains	160	286	304
	Share of freight trains	47%	56%	53%
Müllheim – Auggen (rural area)	Long distance trains	66	76	78
	Regional trains	50	76	76
	Freight trains	160	280	304
	Share of freight trains	58%	65%	66%

Source: BVU INTRAPLAN 2008, page 38.

The predictions for regional trains as well as for long distance trains come from existing planning for extensions of public transport services.

The figures show that in the corridor the number of freight trains will rise about 100% in all sections. In the Freiburg agglomeration, the number of regional trains also will rise. The share of freight and passenger trains differs between agglomeration and rural areas. In agglomerations the share of freight trains is about 50% whereas in rural areas the share will rise up to 66%. So the influence on total noise is different.

The share of trains during day and night time for 2015 is shown in the following table.

²⁶ Cities of Freiburg, Ortenaukreis, Landkreise Breisgau-Hochschwarzwald, Emmendingen and Lörrach.

Table 22: Share of numbers of trains on Rheintalbahn between day and night time

SECTION (SAMPLES)	TRAIN TYPE	DAY (6 – 22 H)	NIGHT (22 – 6 H)
Denzlingen – Freiburg (agglomeration)	Long Distance trains	60	16
	Regional trains	132	20
	Freight trains	129	155
	Share of freight trains	40%	81%
Müllheim – Auggen (rural area)	Long Distance trains	60	16
	Regional trains	64	12
	Freight trains	125	155
	Share of freight trains	50%	85%

Source: BVU INTRAPLAN 2008, page 39.

At night the share of freight trains rises from 40 / 50% up to 81 / 85%. Almost 55% of freight trains are operated at night. As night time is a period with a higher sensitivity to noise this is important.

The figures show that a concentration on measures to reduce noise at the source - for freight wagons, as the first step - is an important measure to reduce or avoid extra railway noise.

The current situation is represented by the noise action plans of the cities of Freiburg and Offenburg. In its noise action plan the city of Freiburg published the number of inhabitants affected by railway noise.

Table 23: Affected inhabitants of railway noise in Freiburg

L _{DEN}		L _{NIGHT}	
Noise level [dB(A)]	Affected inhabitants	Noise level [dB(A)]	Affected inhabitants
		> 45 – 50	32,820
> 55 – 60	22,820	> 50 – 55	19,020
> 60 – 65	8,950	> 55 – 60	7,530
> 65 – 70	4,380	> 60 – 65	3,820
> 70 – 75	2,680	> 65 – 70	2,410
> 75	2,340	> 70	1,880
Total	41,170	Total	67,480

Source: Freiburg 2009, page 5.

According to the noise action plan, Deutsche Bahn is currently installing about 9 – 10 km of noise protection walls and noise protection windows in about 1,500 apartments. The target of Deutsche Bahn is to meet the emission levels of 70/72/75 dB(A) at day time and 60/62/65 dB(A) at night time (residential zones / mixed zones / industrial zones).

In the noise action plan of the city of Offenburg [Offenburg 2009] the number of inhabitants affected by railway noise is published as follows.

Table 23: Affected inhabitants of railway noise in Offenburg

L _{DEN}		L _{NIGHT}	
Noise level [dB(A)]	Affected inhabitants	Noise level [dB(A)]	Affected inhabitants
> 55 – 60	7,150	> 50 – 55	5,890
> 60 – 65	2,910	> 55 – 60	2,310
> 65 – 70	920	> 60 – 65	770
> 70 – 75	450	> 65 – 70	410
> 75	450	> 70	410
Total	11,880	Total	9,790
Total above 70	900	Total above 60	1,590

Source: Offenburg 2009, page 6.

Actions for environmental railway noise mostly consider the building of a freight train tunnel for the next section of the new Rheintalbahn and noise action plans in special areas.

Concerning the new built areas and sections of the third and fourth track, mostly noise protection walls are foreseen. Discussions with the neighbours are often made due to different opinions of calculation about the associated noise emissions and the resulting number, length and height of noise protection walls. Especially the difference between the calculation scheme for noise mapping according to Directive 2002/49/EB [VBUSch 2006] and for new build infrastructure [Schall 2003] (for details see Section 2.5 on page 43) is currently in discussion. The rail noise bonus which is still valid for German infrastructure caused many struggles.

In Offenburg the planning foresees to build the new tracks along a new corridor through the city. Noise emissions will affect many people. Alternatives like a tunnel solution are presented by citizens' initiatives. As this solution is very expensive it is refused by the building owner. The current plans of the building owner were refused by the planning and authorisation body (Regierungspräsident Freiburg) as they were not finished and could not meet legal checks.

In Rastatt a tunnel already was planned but it was adjourned indefinitely at the beginning of 2010. Local action groups are struggling against this as noise pollution in Rastatt is expected. The Federal Ministry of Transport, Building and Urban Development argues that Rastatt is not a bottleneck and the building activities have to concentrate on the section Offenburg – Basel.

In fact, for high frequency railway lines and, especially for construction of new railways, the citizens become more and more aware of noise items. This must be kept in mind for all planning.

4.1.2. Alpine regions

4.1.2.1. General aspects

This section provides general aspects concerning railway noise in Alpine and mountain regions and presents details about two railway corridors in the Alps.

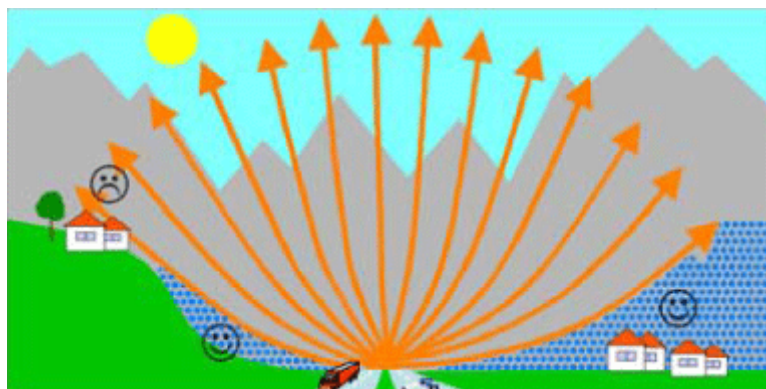
Important and interesting aspects about noise impacts in alpine regions come from the ALPNAP project.

ALPNAP has been a European research project [ALPNAP 2007-2] funded by INTERREG IIIB in ERDF Funds. The main target was to develop exact but also practical calculation methods for air and noise pollution prediction. As there is a gap between difficult scientific calculation and practical approach (easy formulas and assumption methods), the project aimed at the development of methods that were acceptable and sufficiently precise.

The project partners made many measurements for pollution and environmental noise emissions in defined areas like the Brenner corridor with Inn Valley and Edige/Etsch valley and the Fréjus corridor with Maurienne valley and Susa valley.

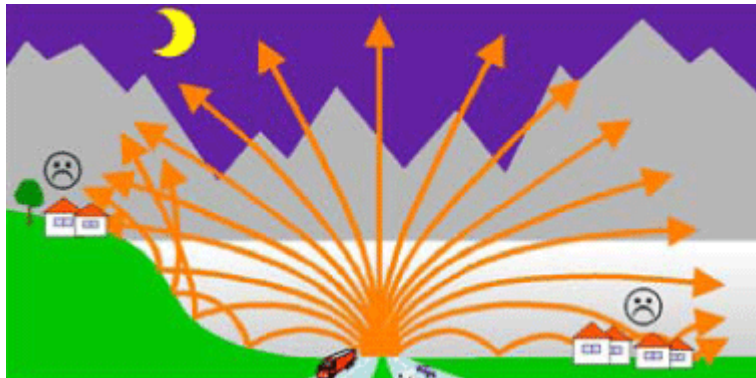
Concerning environmental noise (in general) one important result of the project is that the spread of noise depends on weather conditions and time of day. Examples are shown in the following figures.

Figure 25: Direction of sound spreading (sound rays) during day



Source: ALPNAP 2007-1, page 10.

During the day, the temperature decreases with height and the sound is refracted upward. In the dotted blue areas ("acoustical shadow zones") on the valley bottom the noise is reduced significantly because the upward refracted sound rays cannot reach there.

Figure 26: Direction of sound spreading (sound rays) during night

Source: ALPNAP 2007-1, page 10.

During the night, the temperature increases with height in an inversion layer (shown grey) and the sound is refracted downward. Acoustical shadow zones do not appear. Instead the sound is reflected at the ground.

Wind speeds and wind directions have an impact on environmental noise. Also, in valleys reflections can spread environmental noise up to high altitudes. Mostly low frequencies are spread very wide as higher frequencies are well absorbed by air.

The most severe problem for transportation and its emissions in mountain areas is that transportation infrastructure (both rail and road) as well as residential or industrial zones are concentrated in (partly narrow) valleys. So all sources of noise are located very close together.

Noise in mountain regions is even more annoying or economically harmful as the area is used for tourism which is an important employment factor.

The figures above also show one important incident for protection measures. As noise in valleys can spread up to very high altitudes where also inhabitants can be affected by noise, protection walls have a lower influence on noise reduction.

4.1.2.2. Alpine regions - The Inn Valley

The Inn Valley between Kufstein and Innsbruck is the major access line to the Brenner railway line where a tunnel has been planned for a long time. The Inn Valley was examined in the ALPNAP project and will become more important for freight trains when the Brenner tunnel is opened. An estimation of future rail traffic was made.

In the year 2005, 40 regional passenger trains, 16 long distance passenger trains, ([Kummer et al. 2006], page 24) and about 100 freight and RoLa-trains are operating on the Brenner line. Taking into account the rise of freight trains - about 4.3% per year between 1999 and 2005 - a total rise of about 52% is expected for 2015. ÖBB (Austrian Federal Railway) expects 186 freight trains in 2016 ([Kummer et al. 2006], page 25). Passenger trains will remain at about 46 regional and 26 long distance trains. This shows that freight trains have a share of 64 to 68%. So they have the majority on the Brenner line which affects the Inn Valley.

Austria may be considered as good practice regarding rail noise abatement. More than 12 years ago noise emission inventories were compiled and on this basis plans for the implementation and financing of noise abatement measures along railway lines were developed. In recent years, the annual financial means amounted to some 30 million Euros. It is expected to spend the same amount in the years to come as well. The costs are carried 50% by the Austrian railways ÖBB and the remaining 50% by the federal states and the community [ÖBB - BMVIT 2008].

Through this programme, Austria has realised considerably more protection measures as foreseen in the first phase of the EU Noise Directive 2002/49/EC. In 2008, the programme had achieved the following results:

Table 24: Results of the Austrian rail noise abatement programme

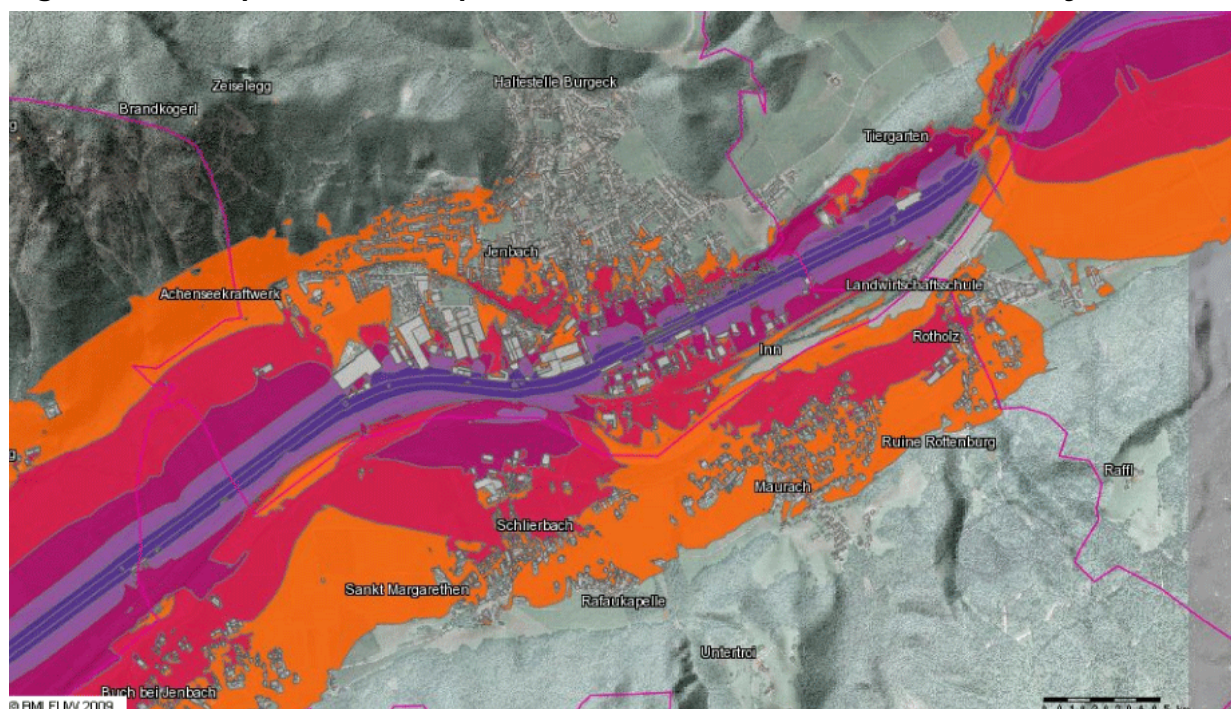
ACTION	FIGURES
Planning in communities	236
Implementation in communities	185
Inhabitants covered in plans	250,280
Inhabitants benefitting from implementation	183,603
Noise barriers [m ²]	1,263,706
Length of noise barriers [m]	413,016

Source: ÖBB – BMVIT 2008.

In 2008, 72% of the citizens covered in the plans benefited from noise protection measures. Since then, the size of the rail noise barriers has increased to some 1.7 million sq. m [m²]; in 2011 two thirds of the planned construction works are completed and most of the severely affected inhabitants are protected against noise. Through the continuation of the programme, 10–15,000 additional citizens annually will be protected against rail noise.

The effects of noise barriers in the mountainous Inn Valley can be seen on the map below, where the inhabitants of the small town of Jenbach are protected against high noise levels that show up in the unprotected outskirts of the settlement. However, the map shows as well the effects of noise reflection from the adjacent mountains.

Figure 27: Impacts of noise protection barriers in Jenbach, Inn Valley, Austria



Source: Austrian Noise mapping, <http://gis.lebensministerium.at/geoinfo>.

4.1.2.3. Alpine regions – The Fréjus line

The Fréjus line is the rail freight corridor between France and Italy. Additional to this it is part of the planned high speed and rail freight corridor between Lyon and Turin.

The Fréjus-Corridor, especially the Susa (between City of Susa and Modane) and the Maurienne Valley (between Modane and Aiguebelle), was also examined in the ALPNAP project. For the Fréjus line the numbers of daily trains on the Italian side (Susa Valley) of the total line are published in [ALPNAP 2007-2] on page 241. The table is represented below.

Table 25: Example of railway traffic data in the Susa Valley; Number of trains for an average workday

SECTION	TYPE OF TRAIN	DAY	EVENING	NIGHT	SPEED [KM/H]
Borgone Susa – Bussoleno	Regional	35	14	3	120
	International	3	3	0	130
	Freight	21	11	13	85
	Goods	49	23	29	95
Bussoleno – Susa	Regional	18	7	3	120
	International	0	0	0	130
	Freight	0	0	0	85
	Goods	0	0	0	95

SECTION	TYPE OF TRAIN	DAY	EVENING	NIGHT	SPEED [KM/H]
Bussoleno – Salbertrand	Regional	9	4	0	110
	International	2	2	0	110
	Freight	11	5	6	75
	Goods	24	12	14	85
Salbertrand – Bardonecchia	Regional	17	7	0	110
	International	3	3	0	110
	Freight	21	11	13	75
	Goods	49	23	29	85
Bardonecchia – Modane	Regional	1	0	0	75
	International	3	2	0	75
	Freight	21	11	13	70
	Goods	49	23	29	70

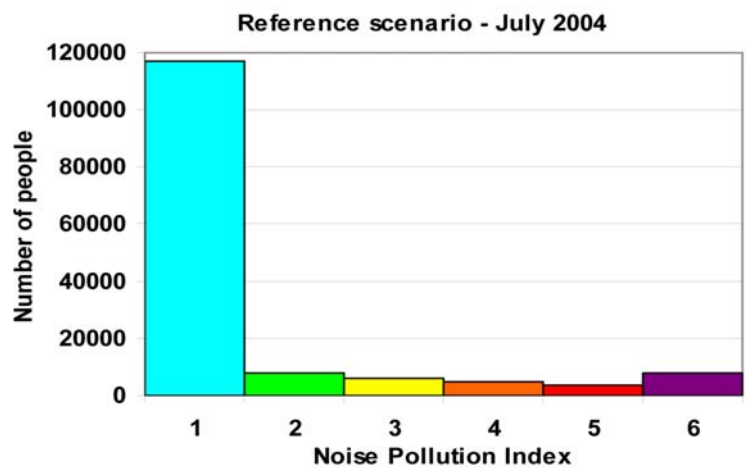
Source: ALPNAP 2007-2, page 241.

Here freight and goods trains have the majority on the main line, especially at night (as in the Inn Valley) and in the sections between Bussoleno and Modane. The share of freight trains is higher than on the Brenner line / in the Inn Valley.

The study has already shown that rolling noise is the most important environment noise source from trains at speeds between 30 and 200 km/h and that freight trains are the noisiest trains. Considering this, the most important starting point to lower noise, particularly in mountain areas, is to avoid rolling noise directly at the original source (contact zone of rail and wheel).

For the Fréjus Corridor the ALPNAP project produced a noise pollution index which shows the number of people which are affected by a certain noise pollution index (see Figure 28). The meaning of the indices is declared in Figure 29 and Figure 30.

Figure 28: Noise pollution in the Fréjus Corridor



Source: ALPNAP 2007-2, page 288.

The noise pollution index defined by ALPNAP project is represented in the following figures:

Figure 29: Noise pollution index (NPI) due to simultaneous exposure to rail and road sources

$L_{den-road}$ (dB)	$L_{den-railway}$ (dB)						
	45	50	55	60	65	70	75
45	1	1	1	2	3	4	5
50	1	1	2	2	3	4	5
55	2	2	2	2	3	4	5
60	3	3	3	3	3	4	5
65	4	4	4	4	4	4	5
70	5	5	5	5	5	5	5
75	6	6	6	6	6	6	6

Source: ALPNAP 2007-2, page 154.

Figure 30: Interpretation of the NPI values

NPI value	Exposure to noise
1	Very low
2	Low
3	Moderate
4	Pronounced
5	High
6	Very high

Source: ALPNAP 2007-2, page 154.

The NPI shows the exposure to noise in dependence of the L_{DEN} noise level caused by both road and rail traffic.

Although train traffic is high in the Fréjus-Corridor, about 30,000 out of 146,000 people (see [Alpnap 2007-2] page 286) are affected by NPI levels higher than 1.

An interesting result of the ALPNAP Study is that a modal shift from road to rail will lead to an increase of people affected by NPI 5 to NPI 6. The reason is that the motorways in the Fréjus-Corridor are already well equipped with noise protection walls in populated areas in comparison with the railway lines.

There are many protests against the project of a high speed railway line between Turin and Lyon especially concerning the affected valleys. In detail the high-speed line will consist of about 200 km new build railway lines including the new Mont-Cenis-Base-Tunnel (56 km). This tunnel will completely pass by the Susa-Valley between Modane and Susa. On the Italian side the Bussoleno-Tunnel will directly follow the Mont-Cenis-Base-Tunnel (12 km) so only a short part of the railway line will remain outside in the area of Susa. On the French side also two long tunnels (Bolledonne Tunnel, (20 km) and Chartreuse Tunnel (20km – freight trains only) are foreseen passing by big parts of the Maurienne-Valley

[Transalpine]. With all these tunnels only short parts of the new line remain uncovered in the Valleys.

Protests against this project concern air pollution (due to excavations of asbestos and uranium), general threats for the nature of the valleys and disturbances due to building works (15 – 20 years). During the building phase economic losses due to shrinking of tourism in the affected areas are expected. Noise is also mentioned in some of the publications but is not a main aspect of the protests. Most relevant are disturbances during the building phase.

4.1.3. United Kingdom

The UK uses a variety of noise mitigating technologies including noise barriers, rail lubricators and friction modifiers, rail-tuned absorbers, and, usually in tunnels, resilient base plates and floating slab track. Approximately 75% of the UK freight wagon fleet has disc brakes or composite tread brakes instead of the noisier cast-iron tread-braked wheels.

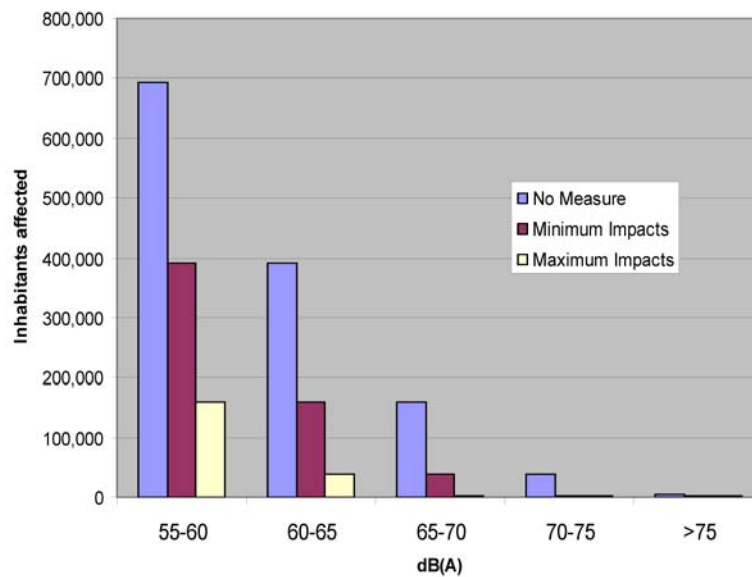
In England²⁷, 23 Noise Action Plans were designed to address the management of noise issues and effects in agglomerations. According to these plans, 1.3 million inhabitants of agglomerations are affected by rail noise; of these, 68% live in Greater London. Outside agglomerations, only 4,000 inhabitants are included in Noise Action Plans.

The theoretical study in this section estimates the potential impact of building noise barriers with 2m height along all railway lines in English agglomerations. It is assumed that noise barriers reduce the noise levels by 5–10 dB(A). Due to these rough assumptions, only the magnitude of the impact may be estimated. The number of affected inhabitants would decrease by 54–84%. This implies that in English agglomerations only 200,000 to 600,000 inhabitants would be affected by rail noise, compared to 1.3 million without noise protection measures. Figure 31 shows the range of impacts of noise barriers in English agglomerations.

The environmental cost of rail noise in English agglomerations may be estimated at 144 million Euros per year. These costs would be reduced through the implementation of noise barriers by annually 86 to 126 million Euros.

²⁷ UK not including Scotland, Wales and Northern Ireland.

Figure 31: Effects of rail noise barriers on the number of inhabitants of agglomerations in England



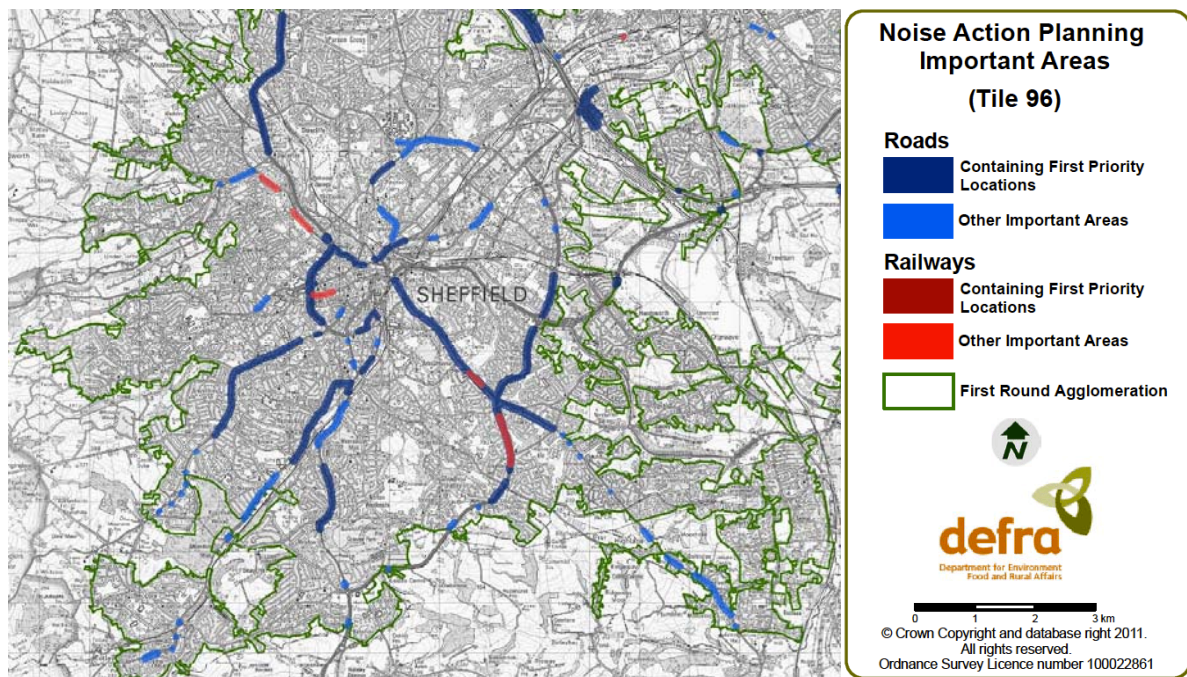
Source: Noise Action Plans in England, own calculations

Source: calculation by the authors according to Noise Action Plans in England.

For rail noise protection in England it has been decided that the important areas with respect to noise from major railways will be where the 1% of the population that are affected by the highest noise levels from major railways are located according to the results of the strategic noise mapping ("Important Areas"; see Figure 32). In addition, those locations where the $L_{Aeq,18h}$ is at least 73 dB(A) according to the results of the strategic noise mapping have been identified as "First Priority Locations". The following timeline for railways was developed:

- April 2010 – Oct 2011 Relevant rail authorities investigate Important Areas (giving priority to those that contain First Priority Locations)
- April 2011 onwards Relevant rail authorities implement any actions or secure budget for actions
- April 2012 onwards Relevant rail authorities investigate remaining Important Areas and implement any actions or secure budget for actions

An example of Important Areas arising from the English Noise Action Planning is given in Figure 32.

Figure 32: Important Areas, Noise Action Plan for Sheffield, England

Source: DEFRA 2010.

4.2. Detailed analysis of selected sections

This section describes effects of noise reduction measures for selected sections of the rail network. Assessments for effects of noise reductions are made with the use of defined measures from Section 3.3 on page 53).

The authors made a general analysis of the sections as detailed examinations in real situations were not possible. Some generalisations have been made. For example, noise barriers were assumed to be built in each location where inhabitants are affected, not taking into account if this will be technically feasible or whether installations already exist. Therefore, a range of noise impacts of the different measures had to be defined as given in Table 26. These figures were again adapted to the local conditions, i.e., used rolling stock, number of trains and share of train types (long distance, regional, freight trains). For replacement of cast iron by composite block brakes or equipment of freight cars with wheel absorbers, a 100% endowment of all relevant wagons is assumed.

Calculations were made with the actual state and the if-case (if-case = the measure is introduced completely in the section).

Table 26: Range of noise reduction

MEASURE	MIN REDUCTION	MAX REDUCTION
Composite brake blocks on freight wagons	8 dB(A)	10 dB(A)
Noise barriers (2m high)	5 dB(A)	10 dB(A)
Wheel absorbers	2 dB(A)	7 dB(A)
Rail tuned absorbers	3 dB(A)	7 dB(A)

Source: own summary according to section 3.3.

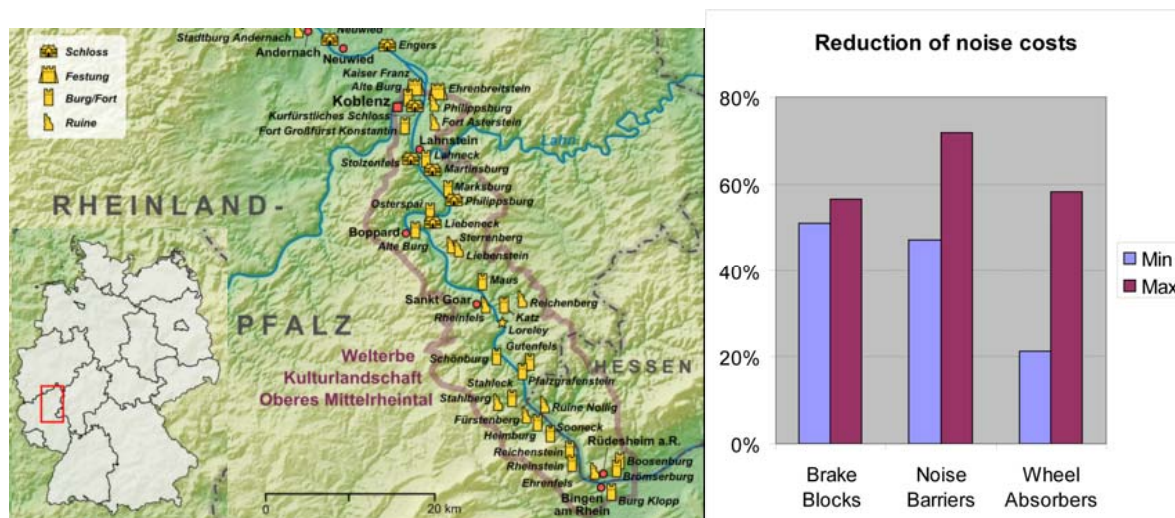
The following elaboration also includes an assumption of noise reduction effects by reduction of external rail noise costs. For cost calculation the same method was applied as the study “External Costs of Transport in Europe 2008” commissioned by the International Railway Union (UIC) in 2011 [CE Delft et al. 2011]. The study quantifies the monetary impacts of steady noise exposure of people at different levels by a review of European studies of housing prices and assesses additional medical costs by the increased risk of cardiac infarctions based on latest epidemiological research. The resulting non-linear noise exposure cost function is then applied to national statistics on noise affected inhabitants by 5 dB(A) L_{DEN} noise classes.

4.2.1. The Rhine Axis section Koblenz – Bingen

The selected section between Koblenz and Bingen represents an area in a narrow valley with high frequency railway lines on one of the main European transportation corridors (see also Section 4.1.1 on page 71).

The location of the section is given in Figure 33. The valley has four tracks, two on each river bank. The essential data and results of the assessment are given in Table 27.

Figure 33: Section Koblenz - Bingen, impacts of measures



Source: Own calculation by the authors.

In this section of the Rhine Valley, nearly 68,000 people are affected by rail noise above 55 dB(A). Rail noise causes damages in the order of 11 million Euros per year. However, these may be reduced significantly: The strongest impacts are achieved through the construction of noise barriers. If - theoretically - the whole valley were protected, only 17,000–36,000 inhabitants will still be affected afterwards and the environmental costs will be reduced by 47%–72% (Figure 33). However, this would imply considerable costs, as well as strong visual intrusions. If new brake blocks were implemented, the environmental costs could be reduced by 51-57%. The lower value is due to the fact that passenger trains are not affected by this measure. Wheel absorbers reduce environmental costs by 21-58%.

Table 27: Impacts of noise reduction measures in the Middle Rhine Valley

ITEM	VALUE
No of freight trains / day (both directions)	265
No of passenger trains / day (both directions)	157
No of remaining inhabitants affected by rail noise (>55dB(A))	
Without measures	67,550
With noise protection barriers	16,850 – 36,200
With low-noise brake blocks (K and LL)	28,985 – 32,907
With wheel noise absorbers	28,460 – 55,010
Remaining annual external rail noise costs [million €]	
Without measures	10.7
With noise protection barriers	4.4 – 8.4
With low-noise brake blocks (K and LL)	4.6 – 5.2
With wheel noise absorbers	4.4 – 8.4

Source: Own calculation by the authors.

4.2.2. United Kingdom section Thameslink near Blackfriars in London

In order to have an example about a railway line in a dense populated agglomeration with a large frequency of trains per hour, Thameslink was chosen as a case study. Rail noise of railway lines in metropolises by nature affects a lot of people. So it is very important to find good solutions for inner-city lines. Thameslink is considered to be a good example because it represents an area with dense population and a planned extension of traffic.

Thameslink runs through the heart of London, crossing the River Thames at Blackfriars Bridge, operating along a 225km route between Bedford in the north and Brighton on the south coast. The service stops at King's Cross / St Pancras International, Luton Airport and Gatwick Airport, and an offshoot (the Wimbledon Loop) passes through south-west London. An estimated 75000 people every day use Thameslink to get in and out of London.

Thameslink 2000 is a £5.5bn programme²⁸ to increase service capacity and frequency on the Thameslink route, with longer trains and eventually new rolling stock. The route from St Pancras to London Bridge is being upgraded, and Blackfriars station is being rebuilt to

²⁸ Thameslink 2000 Programme website: <http://www.thameslinkprogramme.co.uk/>.

span the river, with a new entrance on the south bank; the station will be ready for 12-car trains by December 2011, and completed in time for the 2012 Olympics. The Thameslink 2000 project was originally proposed in 1991, and, following a public inquiry in 2005, planning permission was finally granted in 2006.

As a result of the public inquiry, many of the relevant documents are available to the public through the Inquiry's website²⁹ or on request.

As part of the Environmental Impact Assessment, Temple Environmental consultants Ltd produced the 'Noise & Vibration Specialist Report' in June 2004 [Thameslink 2004], and the 'Blackfriars Noise Assessment Report' in 2005 [Thameslink 2005]. These reports include calculations and predictions of rail noise, using ISVR's NORBERT³⁰ model, and make recommendations regarding the use of noise mitigation technologies.

One of the goals of the Thameslink programme is to run 24 trains per hour, each way, between Blackfriars and St Pancras Midland Road; and 18 trains per hour, each way, between Blackfriars and London Bridge. Blackfriars Railway Bridge is a steel decked bridge across the Thames (see Figure 34 and Figure 35) with ballasted track. In 2004, the traffic across the bridge during the day was 233 Thameslink trains and 133 other trains; during the night, the traffic was 39 Thameslink trains and 11 other trains. The target is to increase this to 672 Thameslink trains and 70 other trains during the day, and 74 Thameslink trains during the night.

Figure 34: Left: View of Blackfriars Railway Bridge from the south bank. Right: First Capital Connect Class 319 EMU.



Source: Thameslink 2005.

In addition to increasing the number of trains, capacity will be further increased by replacing 8-car trains with 12-car trains during peak hours; during off-peak hours, 4-car trains will be replaced by 8-car trains. To some extent the increase in noise from the additional traffic will be offset by the introduction of quieter rolling stock. In 2004, Thameslink operated Class 319 EMUs primarily, and have since acquired all Class 319 vehicles still operational³¹. These are disc-braked; the last of the Class 421 and 423 EMUs with cast iron tread brakes were phased out during 2004. The Class 319 fleet was manufactured during 1987-90. First Capital Connect (who took over the Thameslink franchise in 2006) have recently acquired 23 Class 377/5 EMU 4-car trains (Electrostars),

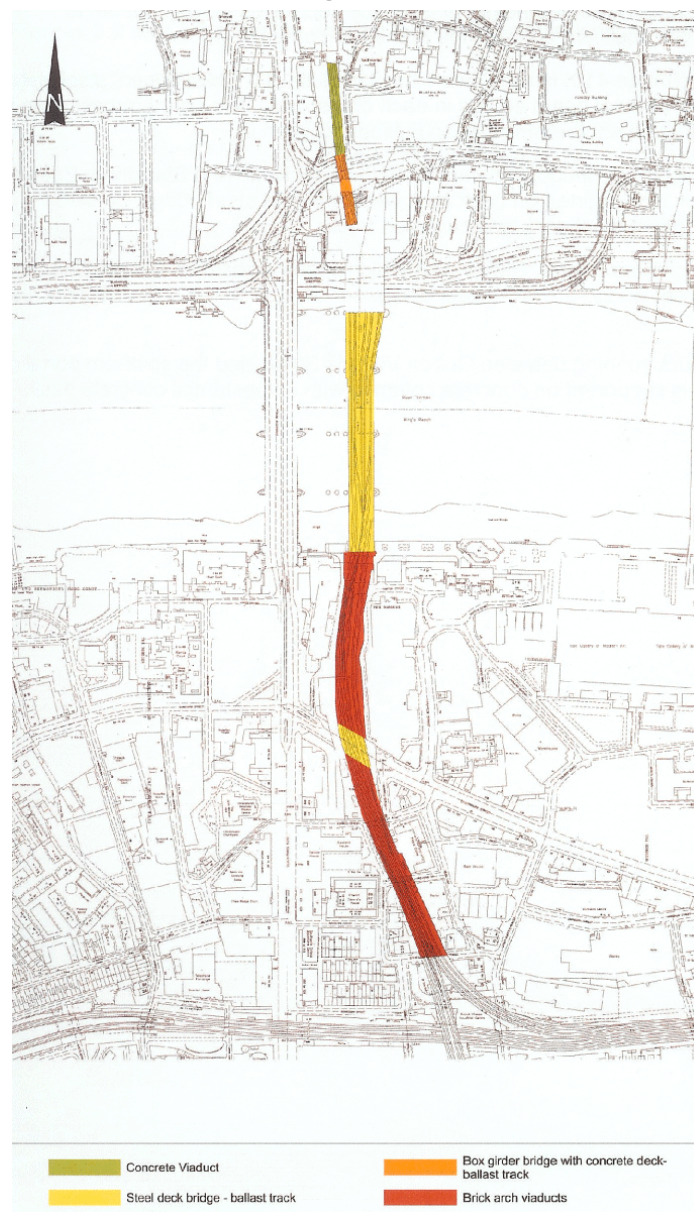
²⁹ Thameslink 2000 Public Inquiry website: <http://www.tl2000inquiry.org.uk/>.

³⁰ ISVR's NORBERT model calculates structural radiation of bridge noise using a detailed model of track and bridge structure, rail roughness and rolling stock type. (Thompson, D.J., Jones, C.J.C., Bewes, O.G., 2005, 'NORBERT – Software for Predicting the Noise of Railway Bridges and Elevated Structures, Version 2.0,' ISVR Contract Report, CR 05.12; also see David Herron, 2009, 'Vibration of railway bridges in the audible frequency range,' Thesis submitted for Engineering Doctorate, University of Southampton.)

³¹ The Class 319 is a dual-voltage EMU, and therefore able to operate both north of the River Thames, which uses a 25kV AC overhead supply, and south of the river, which uses a 750V DC third rail.

manufactured in 2008-09. The train noise correction for the Class 377/5 is 8.4 dB(A), compared to 11.3 dB(A) for the Class 319.

Figure 35: Overview of viaducts/bridges near Blackfriars station



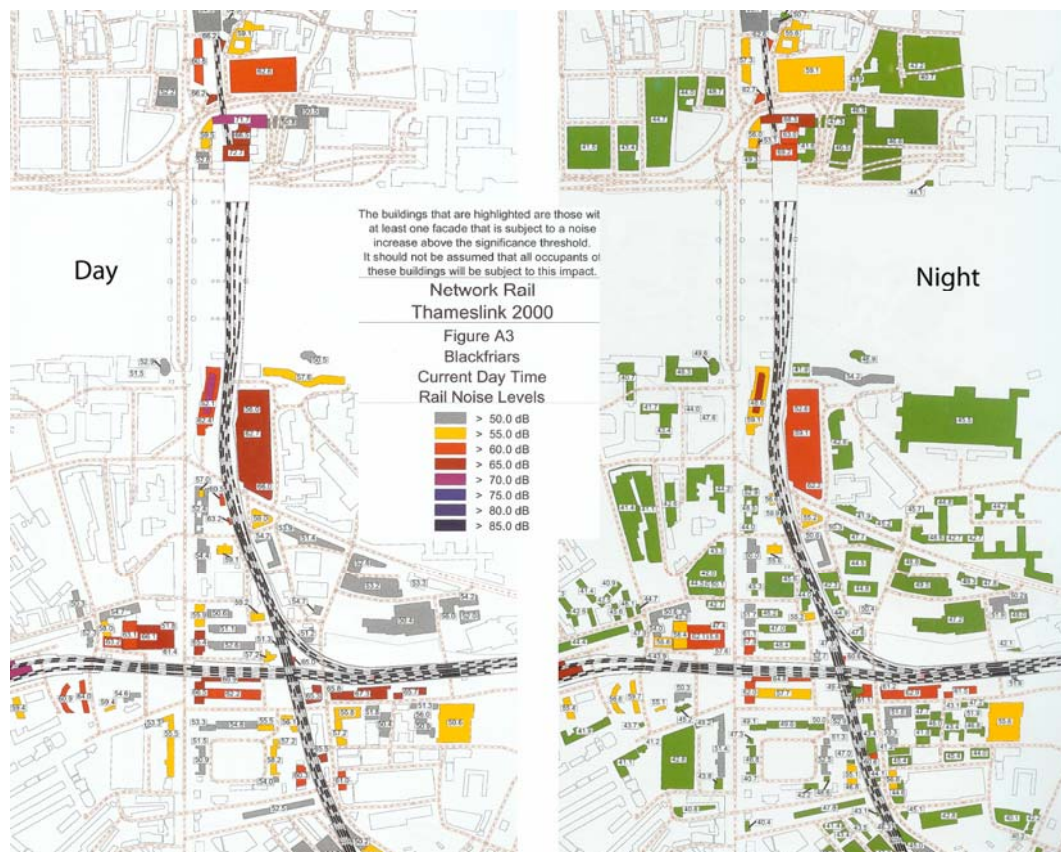
Source: Thameslink 2005.

Regarding further rolling stock noise mitigation measures:

- wheel dampers may provide a cost-effective means of reducing curve squeal and flange contact noise;
- for vehicle mounted lubricators or wheel dampers Network Rail will work with TOCs and other stakeholders to install them to the existing rolling stock where it is found that such measures are reasonably practicable.

However, the EMUs are disc-braked and there is little scope to reduce rolling noise; future design innovations in the suspension systems are not expected to reduce ground borne noise and vibration; and, in general, train speed is not an effective means of vibration reduction.

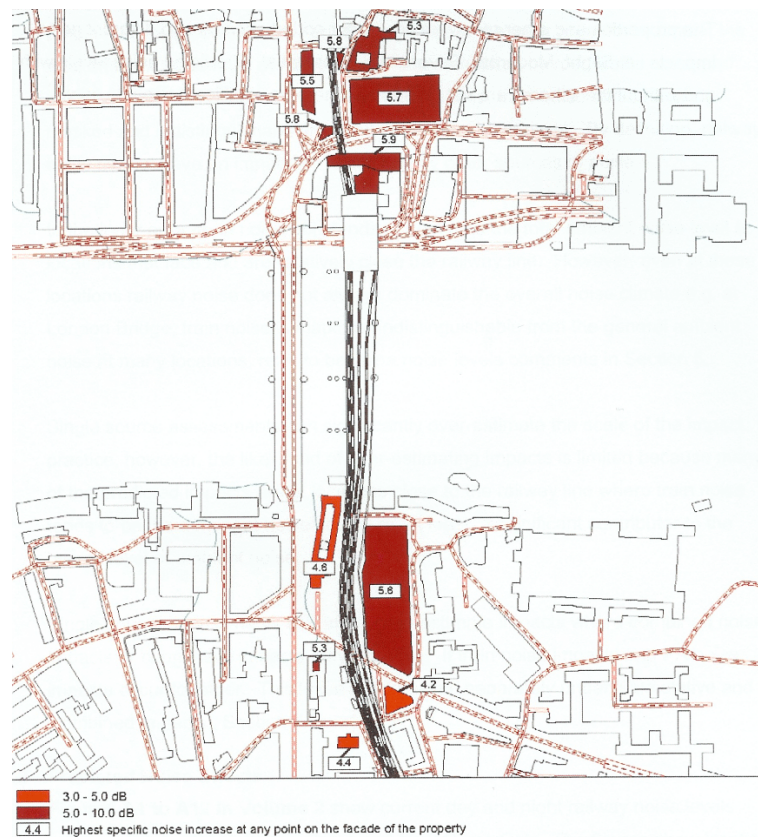
Figure 36: Measured noise levels in Blackfriars area



Source: Thameslink 2004.

Noise level projections for 2026, with or without the Thameslink upgrade, were used to assess the impact of noise on local properties. The Thameslink programme was predicted to reduce the number of affected residential properties from 44 to 24, and the number of non-residential properties from 14 to 8. In either case, the majority of these impacts are either slight or moderate. The reason why so few properties are affected is that, even close to the railway, rail noise does not dominate over the ambient noise level. Predicted noise level increases near Blackfriars Railway Bridge are shown in Figure 37.

Figure 37: Predicted noise increase by 2026 at nearby facades as a result of daytime railway operation



Source: Thameslink 2004.

One distinctive source of noise at Blackfriars is the jointed track, which gives rise to the characteristic 'pounding' noise. Removal of joints will reduce the noise level by about 3.1 dB(A), and will significantly improve the subjective impression of the bridge noise. Regarding track renewals and remodelling between Blackfriars and London Bridge:

- All jointed track will be removed as far as practical where track is renewed and replaced with Continuously Welded Rail or Long Welded Rail. Any unnecessary Switches and Crossings (S&Cs) will be removed and joints to remaining S&Cs will be welded. All new or replacement expansion joints will be scarfed.

Another source of noise, about 6 dB(A), is flange contact on the curve south of the bridge (Falcon Point). As part of the renewal programme, this section will be replaced with modern track to a high specification, avoiding sudden changes in curvature at rail joints. Where necessary, flange lubricators will be installed or replaced.

Network Rail has a regular inspection and maintenance programme, and is committed to removing any corrugation. In addition, vehicles are monitored for wheel flats. No significant benefit in noise level is expected from imposing more frequent grinding or an enhanced wheel set maintenance regime.

Where effective and safe, Network Rail is willing to use rail dampers³². However, rail damping is not effective when used with stiff rail pads. In the Blackfriars area (in 2005), the rail was supported on stiff pads or no pads at all. Rail dampers would not have affected the bridge noise component, and only a 0.8 dB(A) reduction would have been achieved in the direct rolling noise.

Noise barriers are a visual intrusion, particularly since they are a target for graffiti; they have a high cost, and cause problems for track access. Their effectiveness depends on their absorption properties, their height, and the proximity of the barrier to the noise source and/or to the receiver. At Blackfriars, noise barriers will not be particularly effective since the railway is multiple-track, and many of the affected properties overlook the track. However, the new station roof will incorporate sound absorbent material which will help to increase the noise attenuation provided by the barriers, and a new Vitreous enamel clad Bridge 412 enclosure will shield 1 Puddle Dock.

A variety of noise mitigating trackforms were considered for reducing noise levels around the Blackfriars Railway Bridge, including ballast mats (which can be problematic for maintenance and tamping), resilient baseplates, booted sleepers, and Pandrol's VANGUARD (which clamps the rail around the web and under the head, as well as under the foot) on ballasted track; and slab track with soft rail pads or baseplates. While these track designs reduce noise levels significantly when compared with the reference design, they do not provide any meaningful reduction in overall train noise levels. At Falcon Point, railway noise is expected to reduce by 3–4 dB at the upper floors closest to the Bridge. This benefit would affect some 6 dwellings. The cost will be disproportionately high in relation to the scale of the potential benefit. There is no justification to install resilient baseplates on Blackfriars Railway Bridge.

4.2.3. Noise Impact of High Speed Lines in the UK

The East Coast Mainline (ECML) operates between Edinburgh and London King's Cross and the West Coast Mainline (WCML) operates between Glasgow and London Euston. The lines are rated for 200 km/h for the most part, and even for 225 km/h in places. However, UK legislation requires in-cab signalling for train speeds over 200 km/h, which has prevented operation at 225 km/h on these lines. Currently the only line in the UK operating at speeds over 200 km/h is High Speed 1 (HS1). High Speed 2 (HS2) is currently in the early planning stages and is expected to start operation in 2025.

4.2.3.1. High speed 1 (HS1)

High Speed 1 is the route from London to the Channel Tunnel which started operation in 2007. After leaving St Pancras, the line crosses the ECML and immediately enters a tunnel which passes underneath London for 20 km (line speed for this stretch is 230 km/h, but other tunnels on the route have a speed limit of 270 km/h); the bridge across the ECML to the tunnel entrance is fully enclosed by a tube with acoustic grey cladding to shield the local environment from noise (although this is not completely effective). Pandrol's VANGUARD and a variety of other noise mitigation technologies are implemented along the route: noise bunds and barriers (including low barriers on viaducts), Sateba booted sleeper track system (Slab track SAT SB12), and GERB's floating slab track (also used in London's Docklands Light Railway).

³² Blackfriars Station will be the first site in the UK to install Tata Steel's SilentTrack noise damping system – this is scheduled for February 2012.

There is no noise map for HS1, but there are a few comments on noise in the written evidence in the Transport Committee HS2 report:

- 'experience in Kent and elsewhere shows how the noise footprint of HSR trains can be mitigated'
- 'the experience of HS1 is that fears expressed before its construction have mostly not been realised'
- 'it would appear from the lack of complaints related to HS1 operation that the noise impact can be overrated by objectors at the planning stage'
- 'HS1's impact has been masked to some extent by the route passing close to existing busy roads'

Overall, HS1 has been a positive development with very few complaints about noise.

4.2.3.2. High Speed 2 (HS2)

This section refers to the Tenth Report of Session 2010-12 of the House of Commons Transport Committee, regarding High Speed Rail (HSR), specifically High Speed 2 (HS2), and associated written evidence. HS2 is planned for 2025.

Remit:

'HS2 Ltd was established as a Government company to examine the case and develop proposals for a new high-speed railway line between London and the West Midlands, and potentially beyond. Its remit was to identify a route between London and the West Midlands with the primary aims of increasing passenger capacity on the corridor and optimising journey times. It was a requirement of the remit that the route should include an interchange between HS2, the Great Western Main Line and Crossrail, with convenient access to Heathrow.'

Proposal:

'HS2 Ltd has proposed a London – West Midlands route that avoids any significant demolition of property except for the Euston station area; about half the route would be in deep cutting or tunnel, to reduce noise and visual intrusion on adjacent areas.' The proposal focuses on 400 km/h high speed rail route. This is expected to free up capacity on the West Coast Mainline and allow greater rail freight utilisation.

Noise Issues:

No Environmental Impact Assessment has been carried out for HS2, and none is planned until after the current consultation exercise. An Appraisal of Sustainability (AoS) has been published which includes a technical report on noise and vibration.

Following England's Noise Action Plan and the Noise Insulation (Railways and Other Guided Transport Systems) Regulations, the noise measure LAeq,18h (noise averaged over the period 06.00–24.00) has been used as the primary indicator of noise level, with an imposed limit of 73 dB – since noise levels higher than this would make the route a 'First Priority Location', i.e., an immediate target for noise mitigation.

While such a strategy might be acceptable for already noisy areas, part of the proposed route runs through an Area of Natural Beauty (AONB) where the environmental impact of the railway is a major concern. Consequently, there has been fierce opposition to HS2 along this section of the route, including complaints about noise levels:

- 'Acceptable' noise levels do not follow WHO guidelines or English Planning Permission (PPG24) guidelines. The latter would limit noise levels to 66 dB, or even less considering the rural environment. The former recommends that peak noise levels be considered, not just the average, and for high speed trains the difference between these is large.
- Concern over the visual impact of noise barriers, coupled with the concern that these will not block aerodynamic noise from pantographs. In addition, in the noise prediction modelling, pantograph noise has been modelled as a noise source at rail track height, which is not appropriate and underestimates the noise impact. (The AoS assumes a 3 dB reduction in noise emissions based on improved noise control measures in future rolling stock, and notes the importance of mitigating the source of aerodynamic noise. 100 km of 2–3 metre high noise barriers are included in the model.)
- The noise impact from the ground-borne Raleigh shock wave of high-speed trains travelling at 400 km/h over flood plains, soft alluvial ground, etc., has not been considered, nor has the cost of mitigation measures against this.
- The number of trains used in the noise modelling is 432 per day, but the potential train throughput could be up to 576 trains. The system needs to be modelled at full operational capacity, otherwise noise regulations will put a severe constraint on route utilisation.
- Noise modelling has been carried out for a maximum speed of 360 km/h, even in places where the design speed is higher.

In summary, the HS2 assessment of noise levels both uses an arguably too-high definition of acceptable noise level, and underestimates noise levels arising from pantographs, ground-borne shock waves and full system capacity. This highlights the need for a full Environmental Impact Assessment and a clearer remit on noise and vibration levels in the AONB.

The strongest arguments against HS2 can be countered by lowering the line speed from 400 km/h to, e.g., 240 km/h in sensitive areas. Although this will increase journey time, and weakens the economic case for HS2, it will significantly reduce the environmental impact of construction and of operational noise and energy requirements. A lower design speed also allows the route to follow the existing M1 motorway, further reducing environmental impact.

5. EVALUATION

KEY FINDINGS

- There are different possibilities for financial support and regulative activities to foster the introduction of noise reduction measures.
- **Noise depending track access charges** are one possibility next to direct support for low noise measures.
- Noise depending track access charges shall bear in mind that **relevant noise reduction effects** are only coming from **trains which are (nearly) completely equipped** with low noise rolling stock and that noise reduction measures may cause **extra operative costs** (next to investment cost).
- Regulation can focus on the **TSI Noise** where noise limits for new rolling stock are regulated. They **shall be compulsory for existing rolling stock** after about 10 – 12 years and **lowered from time to time** according to latest technical possibilities.
- Currently **Switzerland** and the **Netherlands** have introduced noise depending track access charges, **Germany** is planning to introduce them at the end of the year 2012.
- **Competitiveness of rail transport** in comparison with other transportation means must be borne in mind in all activities, so all financial and regulative measures shall not burden the rail sector.

This chapter describes and evaluates different methods for financial support of noise reduction measures with the focus on promoting the retrofitting of freight wagons with new braking systems. This is currently the most important discussion. Regulation possibilities are also discussed.

5.1. Economic incentives

Economic incentives through rail track charging differentiated according to noise emissions can help to:

- stimulate the use of low-noise technology for the rolling stock,
- foster the use of routes which avoid hot spots for noise and
- foster noise-reducing operational routines and speeds in sensitive areas.

In general, there are two possibilities for the design of mark-ups for noise emissions: First, the mark-ups can be added to the rail infrastructure charges of high noise polluters while low noise polluters would be free of additional charges. In this case revenues are generated which can be used for subsidising noise abatement investments for railway cars.³³ Second, the mark-ups can be designed in a way that they are neutral with respect to the total burdens from rail track charging, i.e., additional charges would be levied on high noise

³³ We discount the option to allocate the revenues to the infrastructure manager, because they do not reflect infrastructure costs.

polluters while low noise polluters would receive a bonus. Penalty and bonus payments would balance after aggregation. This scheme would be comparable to the charging scheme for heavy goods vehicles on motorways according to Directive 2006/38/EC (variant of differentiating the charges on the base of EURO emissions standards).

The recast of Railway Directive 2001/14/EC foresees the differentiation of rail track charges according to noise (see [Com(2010) 475] Article 31. There are several options to be analysed:

- Differentiation of rail track charges according to measured noise emissions (see Section 5.1.1);
- Differentiation of charges for wagons according to their noise classification (see Section 5.1.2);
- Differentiation of charges for trains according to the composition of wagons (see Section 5.1.3);
- Bonus payments for new and retrofitted cars (see Section 5.1.4);
- Combined bonus systems (see Section 5.1.5).

5.1.1. Differentiation of rail track charges according to measured noise emissions

The object of charging would be the train. The train-related noise emissions would have to be measured at critical points in densely populated areas and/or low distances to residential zones and then allocated to the train. The noise mark-up for the track charge then would vary with the noise level, eventually in a progressive way.

Such a scheme would perfectly implement the polluter-pays principle. It works independently from the car or wheel technology and cannot be manipulated by wrong classification or changing electronic identification plates. However, it would require many measurement posts or gentries alongside the tracks and a complex information, payment and administration system. As a result, the implementation cost of such a system could be very high.³⁴

As the charge will be paid initially by the train operator, the question is open how the train operator (the railway enterprise) will pass on the costs to the cars' owners/operators or to the shippers.

5.1.2. Differentiation of charges for wagons according to their noise classification

The simplest way to differentiate track charges according to noise is to classify the wagons into noise categories and charge each wagon separately with a noise mark-up. The train operator would pay the charge to the infrastructure manager and send the bill to the car owner or operator.

³⁴ Some form of infrastructure for dynamic measurement and reporting of vehicle noise may be necessary anyway to reflect changes in the vehicle's status, e.g., wheel out-of-roundness, which significantly affect noise levels; this could be coupled with existing trackside measuring stations. Higher-than-expected noise levels may indicate an urgent need for vehicle maintenance.

This scheme presupposes the introduction of noise standards for rail wagons (comparable to EURO categories for road vehicles) and a rail-car-based km charge. While the technology of charging, control and monitoring can be kept simple there is one serious caveat: The noise emission curve is shaped in a strictly concave way (“diminishing marginal noise emissions”) with increasing share of low noise cars. This means that a 50% share of low noise cars in a train will lead to a noise reduction of only 1.5 dB(A) compared with a high noise train, so that the exposed population will hardly notice the progress. The share of low noise cars should be very high to achieve a significant noise reduction of a train. If, for instance, 100% of freight cars are equipped with silent brakes the noise reduction can be as much as 10 dB(A), which implies cutting noise by half.³⁵

In conclusion, this scheme is simple to implement, but does not fully reflect the polluter-pays principle, i.e., a train composed of 50% low noise cars would pay reduced charges for 50% of the cars although the noise reduction is negligible. There is a risk, furthermore, that identification plates (e.g., RFIDs) are manipulated to get wagons classified in favourable categories.

5.1.3. Differentiation of charges for trains according to the composition of wagons

To avoid the caveats mentioned in Section 5.1.2 on page 94, an alternative is to classify the trains instead of the wagons. In this case, the trains will be classified on the basis of the rail car types from which they are composed. This presupposes the introduction of noise standards for rail wagons (as in 5.1.2 on page 94) and, in addition, the classification of trains on the basis of the expected noise emissions.

In the case of freight trains, the problem arises that the emission category of a train would vary with every change of the train composition in marshalling yards (single wagon traffic). Indeed, the problem is that only block trains which do not change wagon types from start to end can be easily classified. In single wagon transport, this classifying is much more difficult as train composition changes with every shunting activity. If charging followed the polluter-pays principle, then adding a few high-noise cars to a low-noise train would imply a very high mark-up for the train, while adding a low-noise car to a high-noise train would not lead to a change of the train charge. This will not be accepted by the market players (i.e.: investment in low noise cars will not pay if these cars are often integrated in high noise trains), so such a scheme should be modified in a more pragmatic way.

Nevertheless, the problem remains that the railway undertaking would have to charge the car owners/operators/shippers, accordingly.

5.1.4. Bonus payments for new and retrofitted cars

Against the background of the manifold problems of noise-related rail track charging and the possible second round effect of losing market share to road transport, if the noise charges are really high but lead to the desired noise reduction, the easiest way to come to low noise technologies is to pay public subsidies for new low-noise cars and for retrofitting used cars. Certainly this is the approach which will be most readily accepted by the market players.

³⁵ Because of the logarithmic scale of the noise curve, details see Section 3.4 and Figure 23

While this burden should not fall on the tax payer, nevertheless this instrument can be an element of an overall strategy to introduce an incentive-based system and to achieve a high rate of penetration within a short period of time – much shorter than the lifetime of railway cars, which can be estimated at about 40 years.

5.1.5. Combined bonus systems

Whenever charging schemes are considered, companies worry about higher costs and the possibility of losing market shares to the road transport mode. This is a relevant argument, in particular in a political environment which aims at increasing rail freight market shares for environmental reasons and to meet climate challenges.

Public financial assistance should be given in the initial phase of a charging scheme with noise mark-ups. This could be implemented by a bonus payment for the purchase of new cars which are equipped with noise reducing technology, and/or for retrofitting used cars.

5.1.6. Current status of track charges

As the European Commission has decided on 27 September 2011 to allow charging for emissions of road vehicles (see Directive 2011/76/EU of the European Parliament and of the Council of 27 September 2011, amending Directive 1999/62/EC on the charging of heavy goods vehicles for the use of certain infrastructures, as published OJEU L 269 on 14.10.11 [Dir. 2011/76/EU]) the way is also free for track charges according to noise emissions on railways without regard for total earning of the infrastructure company (see Recast of Railway Directive 2001/14/EC in [Com(2010) 475] Article 31).

The European Commission established a working group in 2011 to harmonise and implement Trace Access Charge systems including noise depending instruments. The recommendations from this study shall be considered by this group.

UIC has published (in [UIC 2010]) an overview about the current status of noise abatement legislation in different countries. The Netherlands and Switzerland already have track charges with a noise bonus and penalty. Since 2002, Switzerland has granted a bonus for all wagons which are equipped with low noise brakes of 0.01 CHF (0.0075 €, exchange rate November 2010) per axle-kilometre. The bonus is financed by the state, as well as the retrofitting programme of all Swiss wagons. The Netherlands grants a bonus of 0.04 € per wagon kilometre for all low noise wagons. The bonus is granted for two years up to a total maximum of 4,800 € per wagon.

In Germany, a system will be introduced in 2012 in which a bonus will be granted only to single freight wagons which are newly retrofitted with low noise equipment like composite brake blocks after the introduction of the bonus scheme. Furthermore, a bonus is planned for whole freight trains which consist of only low noise wagons. In this second part of the bonus scheme, new and recently retrofitted wagons are also considered. Both parts of the bonus will be realised as a discount on the track charge according to wagon kilometres. This will be granted directly from the infrastructure company to the wagon owner.

In Switzerland there is a discussion about modifying the existing system. Both the German and Swiss plans include a funding of owners of low-noise freight cars. The funding will be organised and calculated by the infrastructure companies. They rely on the owner notifying

which freight cars are low-noise. The funding depends on axle-kilometres in both countries. There are also discussions about the costs for the implementation and operation of the accounting system. For VDV (in [KCW 2011]), KCW calculated the operating costs for different kinds of funding systems for low-noise freight wagons. Funding for new wagons which are equipped with LL-blocks (if they are admitted) is currently being discussed.

In detail, Germany plans to fund retrofitted freight cars with 0.0028 € per axle-kilometre on German tracks up to a total of 1,688 € per axle. The total comes from estimated investment costs of about 2,120 € per axle minus 432 € as opportunity saving for replacement of an old cast iron block by a new one. The costs for the bonus will be covered 50% by the German state and 50% by a general increase of track prices for all freight trains.

In a study for the European Commission, KCW proposes a funding of 0.008 € per axle-kilometre for K-block equipped wagons and 0.0025 € per axle-kilometre for LL-block equipped wagons [KCW 2009]. The figures mentioned are for a funding period of 8 years. For a potential funding period of 12 years the figures are 0.0045 € per axle-kilometre for K-blocks and 0.002 € for LL-blocks.

Irmhild Saabel from WASCOSA AG held a presentation at Forum Güterwagen (forum freight wagons) in May 2011 about costs coming from K-blocks [Saabel 2011]. The total costs for blocks and wheels increase by a factor of 1.5 to 2.6. Although K-blocks have a life cycle of about 110,000 to 130,000 km, the wheels need reprofiling each 120,000 to 310,000 km (instead of 450,000 to 500,000 km) and have a life cycle of about only 360,000 to 1,140,000 km (instead of 2,700,000 to 3,500,000 km). Also Mr Gilliam from the AAE reports higher operating costs, from first experiences, caused by abrasion of wheels with modified blocks³⁶.

Costs for railway undertakings or wagon owners, related to composite brake blocks, arise not only from investment but also from operating.

To harmonise NDTAC on an EU-wide scale in 2011, the Commission established an expert group under the DERC Committee [Rapacz 2011].

- The main aim: to discuss and propose practical solutions on how to harmonise NDTAC schemes across Member States, focusing on financial aspects.
- The result of the work of the group could be a set of guidelines for the Member States on NDTAC harmonisation / implementing measure adopted by the Commission on the basis of the recast.
- The group is to be restarted in 2012, following the recast developments.

³⁶ Early trials with composite tread brakes in the UK in the 1970s–80s found similar results.

5.2. Analysis of regulation possibilities

The number of regulations on railway noise in the EU Member States is large. A brief overview of the national noise measures is listed in Annex IV.

In 2003, the Working Group on Railway Noise of the European Commission [EC 2003] was of the opinion that “a solution to the major railway noise issues is possible within 10 years if the proposals are implemented as a cost-effective combination of the instruments described”.

The most relevant standardisation issues for railway rolling stock have been formulated in the TSI documents (Technical Specifications for Interoperability). In the latest TSI Noise [TSI Noise 2011], the following regulations for noise emissions of rail vehicles are defined:

- Limits for stationary and pass-by noise for freight wagons and locomotives (for details see Annex II of this study),
- Operation and maintenance rules,
- Application to new rolling stock, and
- Retrofitting programmes.

While the rail noise problem is well understood and the technical possibilities are clearly described in the European Commission documents, a timetable for introducing new noise standards – comparable to the Euro standards for HGVs – is missing until now. However, because rail cars are clustered tightly (i.e., grouped as trains), the equipping of rail cars with low noise technology is only effective if a large proportion of the cars use this technology (see Section 1.2 on page 15).

Retrofitting the current freight fleet with composite brake blocks will be a slow process since a charging scheme is required that creates an incentive to retrofit without increasing the overall cost of rail freight transport relative to other transport modes. The planned funding in Germany (see Section 5.1.6 on page 96) is not attractive enough for a part of wagon owners, since a negative impact on railway transport costs would be inevitable.

Therefore, developing a regulation scheme for a staged process towards low-noise rolling stock must be the heart of a noise abatement strategy for railways. The economic instruments developed in Section 5.1 on page 93 then would serve as incentive engines, for instance as a motivation for top runners to start early with retrofitting or purchasing new noise-reduced cars and for the followers to reduce their costs.

5.2.1. Regulating technology for noise emissions?

Currently the discussion focuses on the braking system of rail cars. Most noise in railway operations is caused by rough running surfaces of wheels and tracks. If both can be kept smooth, noise can be reduced significantly [CER UIC 2007]. The conventional cast-iron brake blocks cause a fast deterioration of wheels and rough wheel surfaces and high noise levels are a consequence. If this braking technology can be exchanged by modern composite brake blocks the noise emissions can be reduced by up to 10 dB(A).

Retrofitting with composite brake blocks targets brake noise and elevated rolling noise, but there are other sources of noise, locations which require an even greater noise reduction

than can be gained by retrofitting alone, and there are many railway vehicles which do not have cast-iron tread brakes. Noise reduction can also be achieved by rail- and wheel-tuned absorbers and other technical measures. Furthermore, technological development may yield new technologies in the next years to come. This brings up the question whether the regulation towards a particular noise reduction technology makes sense. In any case, the regulation should allow for alternative technologies if they have proved to achieve at least the same reduction performance. The Japanese Top-runner scheme gives an example for an incentive compatible regulation scheme. The current best technology is set as a standard in the medium term (e.g.: 5–7 years).

An alternative way of regulation consists of setting upper limits for local noise emissions. Directive 2002/49/EC gives the basic definitions of indicators, methods of measurement and mapping of exposed population. The Member States are obliged to identify hot spots where noise limits are exceeded and to prepare action plans not later than July 2013. The national legislation for noise control is well developed for new investments which lead to additional traffic and noise production. The big challenge remaining is the noise protection of population alongside existing railway tracks. In principle it would be possible to prepare a noise directive comparable to the Air Quality Directives 1999/30 and 2008/50, which limit the local concentration of exhaust emissions like NO_x and PM. Analogously, a noise quality directive could limit the noise levels alongside the tracks at maximum thresholds, depending on the environment and the exposed population.

The advantage of emission dependent regulation is that the industry is free to find the best technologies to meet the limit values set. A disadvantage is that it will take some time to achieve a consensus of the Member States on noise limit values. After the painful experiences gained with the introduction of Directive 1999/30 (Council Directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air) one can expect that the Member States will check such values carefully to avoid massive investments in their transport infrastructure for noise abatement.

Therefore, the most promising way for the medium term future is to start from the platform of TSIs and the Recast of the Railway Packages (see [TSI Noise 2011] and [Com(2010) 475]). This can be formulated in a way that the expected noise reduction is clearly defined while the technology used is not specified in detail, leaving options open for technological progress.

5.2.2. Regulation authorities

The European Railway Agency (ERA), established in 2006 in Valenciennes following the second railway package, is responsible for TSIs and can take responsibility for developing the appropriate noise regulation for railway cars as well. This regulation can be controlled by the national railway regulation authorities – following the first railway package the establishment of national railway regulators is obligatory for each Member State.

From this follows that the existing national bodies can be involved in the control of rail noise emissions more intensively and with the necessary administrative power. A close coordination with the road and air transport regulators is necessary to avoid market distortions stemming from unbalanced regulation.

5.3. Analysis of stakeholder remarks on economic incentives and regulation

Since it is not possible to reflect the position of each railway stakeholder in Europe within this framework, the position of the International Railway Union (UIC) is provided. UIC makes frequent statements of the issue which generally acknowledge the need for noise reduction measures. UIC favours the following strategies [UIC 2010]:

- Reduce the noise of all new freight vehicles by introducing TSI limit values.
- Promote the retrofitting of existing freight vehicles with composite brake blocks.
- Build noise barriers and install noise insulated windows.
- Pursue further solutions in special cases such as acoustic rail grinding, rail absorbers, wheel absorbers, friction modification against curve squeal, etc. The precondition is regular maintenance.

UIC considers LL-brake blocks to be a "promising noise reduction measure; however they still require further improvement before they can be used on a large scale in Europe".

Other options, such as speed limits and land-use planning are rejected [UIC 2008]. Speed limits need to be substantial (50 km/h) to have a considerable noise impact and thus "are not compatible with the operation of a commercially competitive railway". Land-use planning measures are of little effect, since at distances further than 50 metres from the source "noise level is insensitive to even medium changes in distance".

UIC's main concern is that noise reduction measures might burden the railways in a manner that the competition with the road sector is distorted. The burden may be created either through high investment costs or excessive administrative tasks. "Due to fierce competition, wagon owners do not have sufficient resources to finance the retrofitting of their fleet. Any incentive system should neither weaken the overall market share of the freight sector nor disadvantage any freight market player" [UIC 2011].

Therefore, the cost efficiency of the measures (see Section 5.1 on page 93) is a major UIC decision criterion. For example, the retrofitting with composite brake blocks is considered as more efficient than the construction of noise barriers. UIC argues that an incentive scheme should be developed, where public funds for retrofitting are diverted from the railway network operators to the wagon owners. Additionally, UIC criticises the above-mentioned studies commissioned by the EU [PWC 2007] and [KCW et al. 2009] for its "too low cost assumptions related to the use of composite brake blocks. These assumptions combined with too high an estimate of the average annual mileage may lead to a differential track access charge which is insufficient for promoting retrofitting."

Since direct funding does not take into account the wagon mileage, [UIC 2011] proposes a bonus system combined with access charges: "national authorities should fund the retrofitting of freight wagons by means of a noise reduction bonus ... [which] would be granted based on the mileage travelled on lines of the respective national networks. The bonus would compensate the investment costs as well as the additional operating, transaction and administrative costs."

In an interview with the authors in July 2011, Mr Kerth from VDV mentioned that the total costs for retrofitting are about 0.008 € per axle-km if the additional operating costs and financing costs are included in the calculation. Currently, the interest of the wagon owners in retrofitting existing wagons due to this funding scheme is very low. A problem for the rail sector can also rise because part of the financing of the bonus system will be financed by an increase of track prices for the total freight train sector. This increase also affects existing wagons which are already equipped with composite brake blocks. The press release of VDV and VPI concerning the financing of the bonus from July 5th 2011 announces the 50% share of the rail sector as unfair [VDV VPI 2011]. It is the first time a transportation mode would be burdened by costs for noise and it would only fund recently retrofitted wagons, while existing low-noise or new-build wagons have to carry the increased track prices.

In general, the planned funding scheme in Germany is accepted by the rail sector as it is a direct funding of wagon owners and the system is not too complicated. The implementation costs seem to be acceptable (see the elaborations in [KCW 2011]). Nevertheless, many details still have to be clarified and agreed, such as the size of the bonus and its financing. Also the inclusion of additional operating costs is still in discussion. If they are included, this could lead to a lower share of the German state as this part of the funding is limited to 152 million Euros per year [VDV-2011-2]. VDV expects only 15% share of costs will be carried by the Germany state if the additional operating costs remain to the rail sector.

UIC, CER, UIRR, ERFA, EIM and UIP comment in their position paper on a Consultation document of the Commission concerning rail noise abatement measures in 2007 [UIC et al. 2007]. In this respect they point out that the funding scheme should not burden the rail freight sector with additional costs and the funding and monitoring scheme should not be cost-intensive itself.

6. CONCLUSIONS

Reducing railway noise is an important activity for the environment and citizens' health in Europe and for the acceptance of the railways as a driving force for ecological and economic development of Europe. Therefore, the acceptance of railways by citizens living near railway lines, especially the main rail freight corridors, is vital.

In freight corridors, the number of trains will increase, and so noise for the citizens will increase as well. Therefore, measures to reduce noise levels are essential to prevent health risks and to have the acceptance of the neighbours. Without this acceptance, the risk remains that the increase of capacity on main railway lines will be inhibited for a long period of time, which will cause losses for the rail sector and for the total economy.

6.1. Recommendations of measures

The recommendations cover the following three main aspects, considering the revival of the rail sector as one of the most important measures for greening transportation and meeting climate change targets:

- identifying effective technical measures;
- providing effective regulation and economic incentive schemes which do not distort competition with other transportation modes;
- funding the necessary investments.

Technical Measures

On the technical side, the noise reduction measures focus on two pillars: vehicle-related measures and infrastructure-related measures.

There are several **vehicle-related** measures:

LL-blocks: One of the main sources of railway noise is freight wagons, particularly those with cast-iron tread-brake blocks. The cast-iron blocks damage the running surface of the wheels, making the surface rough and increasing the noise level at the wheel-rail interface. High-speed trains and passenger trains use disc brakes rather than tread brakes; new vehicles can be fitted with composite tread brake blocks (K-blocks), but these are not suitable for retrofitting. There are still about 370,000 freight wagons with cast iron brakes which are worth being retrofitted in Europe, and finding a cost-effective composite brake block replacement (LL-blocks) for retrofitting is a priority for many railway operators. The current estimate for retrofitting the 370,000 freight wagons is between 2.2 and 4.2 billion Euros, but the impact of LL-blocks on wheelset maintenance costs is yet to be established.

Noise can also be a problem on railways with no freight traffic, so other vehicle-related measures are important:

- **Wheel absorbers** are used to reduce rolling noise and can be effective against curve squeal. A range of wheel noise absorption technologies and products have been developed. The interaction of wheel noise absorbers and any track noise absorbers needs to be considered for optimum system performance.

- A number of **modified wheels** have been developed in recent years but the accident with an ICE in Eschede in 1998 has left the industry wary of modified wheels for high-speed trains. However, these developments have had significant noise reduction potential and it is worth continuing research in this area.
- Vehicle-mounted top-of-rail **friction modifiers** (TOR FM) or flange lubrication systems can be used to combat curve squeal (as well as to reduce wear). A range of technologies and products are available. These are appropriate for closed systems where the vehicles are regularly monitored and maintained, such as local commuter networks; urban systems also have tighter curves and consequently more problems with curve squeal.
- Pantograph noise is a problem with high-speed electric trains, particularly since the pantograph is usually higher than noise barriers, if present. **Aerodynamic designs** like shielding or **special materials** like porous coating of pantographs can be used to reduce aerodynamic noise.

Additionally, new rolling stock, introduced since the year 2000, already have lower noise emissions by 10 dB(A) in comparison with equipment produced in the 1960s and 1970s. This shows the importance of replacing old rolling stock as soon as possible.

The effectiveness of vehicle-related measures has the best cost-benefit ratio. So the introduction of composite brakes on freight wagons should be approached with the highest priority. Other measures can be done complementarily.

A wide variety of **infrastructure-related** technologies have been developed to combat noise and vibration. Mostly these fall into three categories:

- Noise barriers and bunds are usually large earth mounds creating an artificial cutting for the railway; these require several metres of land to the side of the railway which is not normally an option for existing railways or urban environments. **Noise barriers**, on the other hand, are suitable for existing railways and urban environments, but to be effective they need to be at least two metres high. Noise barriers have a poor visual impact, especially since they are a target for graffiti; they create problems for track access and incur a high on-going maintenance cost. Special acoustic enclosures are sometimes used to surround the railway above as well as at the sides.
- Track-side lubricators are a traditional method of reducing curve squeal (as well as reducing wear) and **friction modifiers** are used also to reduce brake squeal (in shunting yards, for example). Top-of-rail friction modifiers (TOR FM) are also effective at reducing corrugation (a major noise source) on the low rail in curves.
- Resilient track forms and technologies include: floating slab track, ballast mats, resilient base plates, rail pads of various stiffnesses, rail clips that clamp the web under the railhead, tuned **rail dampers**, and booted sleepers. Tunnels under urban environments, such as the Channel Tunnel Rail Link and Crossrail in London, are targets for such technologies. (As noted earlier, the interaction of wheel noise absorbers and track noise absorbers needs to be considered for optimum system performance.)

Additional considerations:

- Wheels and rails need to be monitored so that (a) out-of-round wheels (and especially wheels with flats) can be turned, and (b) corrugated rails can be ground. Out-of-round wheels and corrugated rails are a source of increased rail noise, as well as a cause of increased wheel-rail forces and consequent damage.
- Track geometry and substructure should be designed and maintained to avoid sudden changes in direction or stiffness, both of which increase noise emission, wheel-rail forces and consequent damage.
- Rail joints should be avoided (insulated rail joints are an exception) and continuously welded rail used instead; expansion joints should be scarfed.

Large infrastructure-related investments have already been made in several countries, including Sweden, Denmark, The Netherlands, Germany, Poland, Czech Republic, France, Switzerland, Austria, Italy and Portugal. These measures are necessary, particularly in densely populated areas. Noise-reducing infrastructure-related measures are usually introduced with new construction or major redevelopment of railway links according to new standards where these measures are a requirement, whereas for the existing infrastructure there is no obligation to lower noise.

Intelligent combinations of vehicle- and infrastructure-related measures help to bring rail noise down to long-term sustainability levels for a reasonable cost. The analyses of this study show that infrastructure-related measures can be reduced if effective vehicle-related measures are also taken. Therefore, a fast retrofit of the existing freight wagon fleet is the most urgent action to be taken.

Regulation and economic incentive schemes

International examples such as the Japanese top-runner scheme³⁷ underline that a sound **regulation scheme** is the heart of any successful pollution reduction strategy. This holds in particular for noise, because an effective reduction of noise through vehicle-related measures presupposes that almost all internationally operating rail wagons are equipped with low-noise technology.

The TSI Noise is an appropriate basis for noise regulation in the medium and long term. Presently, the standards for noise emissions are valid for new or modified vehicles only. In the medium and long-term view the TSI can become compulsory for all vehicles. The time schedule for validation of the noise levels for all vehicles should be long enough to allow for an adjustment of technology without major additional investment costs. We propose a time period of 10–12 years, which covers 1–2 revision cycles and is half of the normal life time of rolling stock (a quarter for freight wagons). The noise levels in TSI Noise should also be lowered from time to time according to technical development.

Economic incentive schemes consist of charging and bonus/penalty systems. Rail track charging is an important element of an incentive-compatible penetration strategy for low-noise rail technology. The principles and request for introducing noise emissions into the track access charging system are formulated in the Recast of the First Railway Package (proposed in 2010) and can be implemented by the Member States as the revision of

³⁷ This scheme aims at reducing energy consumption and climate impact by dynamic setting of emission targets on the basis of current best practice ("top runners' performance").

Directive 2006/38/EC (Eurovignette) has been adopted on 27 September 2011 (see [Dir. 2011/76/EU]) as the existing Directive 2001//14/EC already allows NDTAC if the same is allowed for other transportation means. The Directive 2011/76/EU allows for mark-ups reflecting environmental costs (including noise) for HGVs on motorways and highways. This means that in the future a balance can be found between road and rail pricing for noise emissions which does not disturb competition between the transport modes. It is important to take into consideration that a substantial noise reduction requires that a large proportion of rail cars are equipped with modern technology. This suggests that lower tariffs should be offered only to trains which consist entirely of noise-reduced cars. Such a system can be implemented without installing further electronic devices in the rail cars, if an effective reporting system is established. The example of the proposed German rail track charging and retrofit-funding scheme shows that this requirement can be fulfilled. This underlines that the transaction cost of a noise-differentiated charging system can be held low, which is an important argument, because many objections against the introduction of such systems are based on the presumed high transaction costs.

Further alternative or complementary incentives can be introduced through bonus/penalty systems. In particular, in the transitory phase, bonus payments can motivate the rail car operators to switch to new technology as early as possible. The railway companies will call for wide use of this instrument if the state pays for the bonus. From the viewpoint of setting incentives right, at least a part of financial contributions should be covered by the rail car owners/operators.

Funding schemes

After assessing the best combinations of technical and economic measures, the financial implications have to be considered and the impacts on stakeholders have to be analysed. In our view, the adjustment of braking systems is the most urgent and promising strategy, complemented by infrastructure-related measures at noise hot-spots. There are different funding sources, which have to be developed for these measures.

Infrastructure-related measures are financed by the state and/or the rail infrastructure managers. In the latter case, the additional costs for the infrastructure managers are passed on to the railway undertakings through the rail track charges. This implies that the state will have to cover a substantial part of the infrastructure-related costs if the competitive balance between road and rail is not to be affected.³⁸

Vehicle-related measures have to be financed by the car owners/operators in the long term. In the short and medium term, subsidies by the state or the European Union, for instance bonus payments for retrofitting, can accelerate the change of technology. Member States will have to decide on the magnitudes of bonus payments and the method of refinancing. In this context it is crucially important that the territoriality principle will be fully applied with the rail track charging system, which means that retrofitted rail cars get a lower tariff regardless of which country they have been licensed in and where the owner/operator is located.

The vehicle-related funding scheme should be a limited programme for some years (e.g., 10 years) and should focus on retrofitting existing vehicles. Existing low-noise vehicles can also be included if the cost of the noise-reduction measure can be verified (former

³⁸ Note that the mark-ups for noise, as suggested by the Commission, are rather low for HGVs on motorways and freeways and the Member States are not obliged to implement them.

retrofitting without funding of the measure, price differences between normal and low noise vehicle of the same type).

Funding and regulation schemes should be harmonised in the EU to minimise distortions of competition as many freight transport companies are operating internationally, carrying a high share of freight rail cars cross-border. "Noise leakages" should be avoided, which could occur if noisy freight cars, registered in a "low noise cost" country, are operating in "high noise cost" countries. Therefore a common regulation scheme is necessary, accompanied by a widely harmonised system of pricing and funding. Variations from this general rule could only be accepted to the positive side, i.e., to motivate top runners to start early with appropriate actions. In this context, the trade-off between low noise policy and competition policy could be more balanced in favour of low noise in the medium-term. The reason is that rail freight as a whole may lose market share in the medium term if the noise problems cannot be solved appropriately, and the resistance of the affected population might impede full capacity utilisation and the removal of capacity bottlenecks.

6.2. Recommendations for parliamentarian activities

To support and accelerate the introduction of noise reduction measures, the European Parliament could – in the second reading of the Recast of First Railway Package – only accept the Recast if the following issues are fulfilled:

- Including an obligation for a harmonisation of charging of railway noise in all Member States within a reasonable short time period.
- Integrate the dependence of the introduction of Noise Depending Track Access Charges (NDTAC) from the same introduction in road transport.
- Including an obligation to create "Noise Depending Track Access Charges (NDTAC)" for the introduction and use of noise reducing measures in each Member State according to the levels in TSI Noise (COMM. DEC. 2011/229/EU).
 - The NDTAC could include funding / covering of higher operational costs if the noise reduction measure causes extra costs.
 - The NDTAC could also include a significant special bonus for trains which are completely equipped with noise reduction measures (in addition to funding of individual equipment of single rolling stock units).
- Including an obligation for the infrastructure managers to maintain the infrastructure in a way to avoid noise caused by poor infrastructure conditions (rail roughness).

Additional to this, the European Parliament could request the European Commission:

- Creates an European Funding Scheme for vehicle-related noise-reduction measures, and to motivate Member States to introduce noise-reduction funding for internationally operating rolling stock.
- Modifies the latest TSI Noise, introduced with Commission Decision (2011/229/EC) of 4 April 2011, so that the maximum noise levels are also obligatory for existing rolling stock about 10–12 years after introduction of the modification of TSI Noise.

- Lowers the maximum noise levels introduced by TSI Noise in a staged process for the long-term future, with adjusted obligations for new and existing rolling stock (top runner scheme).

To harmonise the competitiveness between rail and road sectors, the European Parliament could request the European Commission:

- Prepares a Directive for a network-wide regulation and charging of lorry noise, at least for the TEN-T roads (comprehensive network) – eventually embedded in a concept of full internalisation of external costs under explicit consideration of noise-reduction targets, extending the optional noise-related motorway charging as in Directive 2011/76/EU.

To lower noise at hot spots which cannot be solved by the introduction of vehicle-related measures, the European Parliament could:

- Observe the introduction and fulfilment of noise action plans concerning hot spots in rail and road sectors.
- Include noise-reduction measures at noise hot spots of the TEN-T (comprehensive network including existing links and nodes) into the EU funding facilities (in particular the Connecting Europe Facility).

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ANNEX I: ENVIRONMENTAL NOISE EMISSIONS IN MEMBER STATES AND AGGLOMERATIONS

		Rail noise outside agglomerations									
Country	km	Nr of people exposed to different noise bands (Lden) [dB(A)]					Nr of people exposed to different noise bands (Lnight) [dB(A)]				
		55-59	60-64	65-69	70-74	>75	50-55	55-59	60-64	65-69	>70
Austria		217,300	121,700	47,900	16,900	7,500	194,200	98,900	36,700	13,300	5,600
Belgium		33,300	19,700	16,100	13,400	3,900	25,700	17,200	15,000	7,500	1,800
Czech Republic	270	13,300	2,600	1,100	300	0	6,700	2,000	800	200	0
Denmark	1,776	20,200	5,500	1,900	1,200	100	12,100	3,300	1,600	800	0
Finland		15,100	5,900	2,300	200	0	8,800	4,000	800	0	0
France	1,435	624,200	420,000	250,300	139,500	105,200	519,600	348,400	207,100	112,900	70,000
Germany	17,282	1,588,700	693,400	218,200	87,900	58,000	1,392,500	547,600	175,700	73,100	44,800
Hungary	32	0	0	0	0	0	0	0	0	0	0
Ireland	58	0	0	0	0	0	0	0	0	0	0
Italy	591	89,900	61,900	37,300	33,000	24,800	87,000	67,300	35,600	31,300	25,400
Luxembourg	20	100	100	0	0	0	100	0	0	0	0
Norway		4,500	2,600	2,000	700	900	3,600	2,100	1,300	500	600
Poland	16	900	200	100	0	0	700	100	100	0	0
Portugal	115	21,200	11,600	8,000	7,200	4,400	14,900	9,400	7,500	5,500	1,100
Romania		3,900	1,000	0	0	0	5,500	3,400	700	0	0
Slovenia	68	5,600	2,600	1,100	400	300	4,700	2,400	1,000	400	300
Spain	742	45,700	23,500	11,000	1,600	0	34,900	19,300	6,000	500	0
Sweden		58,100	33,800	12,300	4,800	1,700	43,900	21,200	7,700	2,500	1,200
Switzerland		39,500	23,600	12,500	8,800	3,800	30,400	16,700	10,700	6,100	2,400
United Kingdom		80,800	50,300	32,500	14,100	2,100	56,400	36,400	18,500	3,800	100
Total general		2,862,300	1,480,000	654,600	330,000	212,700	2,441,700	1,199,700	526,800	258,400	153,300
Total EU 27		2,818,300	1,453,800	640,100	320,500	208,000	2,407,700	1,180,900	514,800	251,800	150,300

Rail noise in agglomerations											
Country	Inhabitants	Nr of people exposed to different noise bands (Lden)					Nr of people exposed to different noise bands (Lnight)				
		55-59	60-64	65-69	70-74	>75	50-55	55-59	60-64	65-69	>70
Austria	1,610,578	107,000	81,100	57,900	35,500	9,500	101,900	76,700	41,900	28,800	4,100
Bulgaria	2,084,000	18,400	5,800	500	100	0	16,300	6,100	200	0	0
Czech Republic	1,852,955	74,800	59,500	65,900	14,500	0	63,300	69,800	32,000	400	0
Denmark	1,071,714	19,400	7,400	2,600	1,000	100	12,500	4,900	1,500	600	0
Estonia	401,140	10,600	6,900	3,500	900	0	9,000	5,700	2,500	300	0
Finland	560,905	27,500	25,400	16,700	200	0	27,600	21,500	2,000	0	0
France	13,664,912	1,488,600	208,800	117,700	63,500	43,000	1,426,900	148,200	63,700	34,300	12,800
Germany	17,265,322	478,300	246,700	122,400	31,400	5,700	393,800	194,400	75,800	16,700	3,300
Hungary	2,065,230	132,500	50,600	19,600	7,900	1,200	110,700	40,900	16,400	6,000	700
Ireland	1,150,000	10,600	6,800	2,800	500	0	7,700	3,500	1,400	100	0
Italy	4,190,684	34,000	30,900	24,800	6,400	1,400	34,500	37,800	19,500	4,600	2,100
Latvia	806,993	28,400	20,100	6,300	800	100	25,500	9,400	4,700	400	0
Lithuania	932,847	9,100	5,000	1,100	300	0	8,600	2,800	800	200	0
Netherlands	5,026,059	118,600	60,700	25,000	8,800	1,000	94,100	40,800	12,700	4,100	1,200
Norway	822,800	19,200	15,500	16,000	4,900	0	18,300	18,100	7,900	600	0
Poland	7,446,365	323,600	197,900	98,100	38,500	6,900	191,800	108,100	37,300	700	100
Romania	4,079,364	135,700	90,700	15,700	1,300	100	184,200	111,700	44,600	4,800	200
Slovakia	528,129	95,100	67,600	38,500	16,600	3,700	92,300	54,200	32,900	8,700	2,600
Slovenia	266,251	6,700	3,500	900	0	0	5,800	2,300	500	200	0
Spain	8,116,104	16,300	7,200	1,300	500	0	9,700	2,900	1,000	200	0
Sweden	1,548,886	84,900	37,800	13,400	5,400	1,500	56,300	22,100	7,100	2,800	300
Switzerland	5,300,000	182,700	126,600	98,500	62,300	25,900	156,100	107,700	85,000	41,600	16,900
United Kingdom	25,613,309	395,500	291,400	157,900	46,800	6,000	321,000	193,700	69,600	14,000	2,200
Total general	106,404,547	3,817,500	1,653,900	907,100	348,100	106,100	3,367,900	1,283,300	561,000	170,100	46,500
Total EU 27	105,581,747	3,615,600	1,511,800	792,600	280,900	80,200	3,193,500	1,157,500	468,100	127,900	29,600

Source: ETC 2010.

ANNEX II: MAXIMUM NOISE LEVELS OF ROLLING STOCK ACCORDING TO TSI NOISE

Table 1: Limiting values $L_{pAeq,Tp}$ for the pass-by noise of freight wagons

Wagons	$L_{pAeq, Tp}$ in dB
New wagons with an average number of axles per unit length (apl) up to $0,15 \text{ m}^{-1}$ at 80 km/h	82
Renewed or upgraded wagons according Article 20 of Directive 2008/57/EC with an average number of axles per unit length (apl) up to $0,15 \text{ m}^{-1}$ at 80 km/h	84
New wagons with an average number of axles per unit length (apl) higher than $0,15 \text{ m}^{-1}$ up to $0,275 \text{ m}^{-1}$ at 80 km/h	83
Renewed or upgraded wagons according Article 20 of Directive 2008/57/EC with an average number of axles per unit length (apl) higher than $0,15 \text{ m}^{-1}$ up to $0,275 \text{ m}^{-1}$ at 80 km/h	85
New wagons with an average number of axles per unit length (apl) higher than $0,275 \text{ m}^{-1}$ at 80 km/h	85
Renewed or upgraded wagons according Article 20 of Directive 2008/57/EC with an average number of axles per unit length (apl) higher than $0,275 \text{ m}^{-1}$ at 80 km/h	87

Table 2: Limiting value $L_{pAeq,T}$ for the stationary noise of freight wagons

Wagons	$L_{pAeq, Tp}$ in dB
All freight wagons	65

Table 3: Limiting values $L_{pAeq,T}$ for the stationary noise of electric locomotives, diesel locomotives, OTMs, EMUs, DMUs and coaches

Wagons	$L_{pAeq, Tp}$ in dB
Electric locomotives and OTMs with electric traction	75
Diesel locomotives and OTMs with diesel traction	75
EMUs	68
DMUs	73
Coaches	65

Table 4: Limiting values L_{pAFmax} for the starting noise of electric locomotives, diesel locomotives, OTMs, EMUs and DMUs

Vehicle	$L_{pAF_{max}}$ in dB
Electric locomotives $P < 4\,500$ kW at the rail wheel	82
Electric locomotives $P \geq 4\,500$ kW at the rail wheel and OTMs with electric traction	85
Diesel locomotives $P < 2\,000$ kW at the engine output shaft	86
Diesel locomotives $P \geq 2\,000$ kW at the engine output shaft and OTMs with diesel traction	89
EMUs	82
DMUs $P < 500$ kW/engine	83
DMUs $P \geq 500$ kW/engine	85

Table 5: Limiting values $L_{pAeq, Tp}$ for the pass-by noise of electric and diesel locomotives, OTMs, EMUs, DMUs and coaches

Vehicle	$L_{pAeq, Tp}$ in dB
Electric locomotives and OTMs with electric traction	85
Diesel locomotives and OTMs with diesel traction	85
EMUs	81
DMUs	82
Coaches	80

ANNEX III: COMPARISON OF COVERAGE OF BOGIES FROM DIFFERENT MODERN ROLLING STOCK EQUIPMENT



Well covered bogies by engine body of Swiss Engine type RE 460 (Lok 2000)



Open bogie of modern Bombardier Engine Traxx (example German type 186)



Well covered bogies of Swiss passenger wagon IC2000



Open bogie of modern German double deck wagons

ANNEX IV: IMPORTANT AND ANALYSED REGULATIONS

EU Political Papers and Directives	Relevant Contents with Respect to Railway Regulation and Railway Noise
Political Papers	
White Paper 2001	EU transport policy for 2010. Shifting the balance between the modes of transport. Revitalising the railways. Towards multi-modal corridors giving priority to freight.
White Paper 2011	A true internal market for railway services. Standards for controlling noise pollution. Among the ten goals for achieving a competitive and sustainable transport system: Shift 30 (50)% of road freight over 300 km to rail and IWW by 2030 (2050).
Directives	
Directives 1991/440	Framework and legal requirements for a competitive railway system. Commercial organization of companies. Separation of infrastructure management and service undertakings. Open access to the railway network. Liberalized cross-border transport.
Directives 2001/12-14	Comprehensive railway regulation framework, e.g.: Clear separation of public and commercial issues. Freeing companies from old debt. Separate bookkeeping and balance sheets for infrastructure management and service provision. Capacity provision and pricing for infrastructure provision.
Railway Packages 2001, 2002, 2004	Specification of open access, essential facilities. Specification of regulatory requirements. Establishment of national and EU regulatory bodies (European Railway Agency). Rail track charging principles (marginal cost plus mark-ups). Market opening for freight (2007) and passenger long-distance (2010) transport. Regulation of passenger rights and freight transport quality. EU train driver license.
Recast of the First Railway Package 2010 Status: Under discussion.	Comprehensive specifications for establishing a single European railway area. General objectives: Establish an internal railway market with high degree of competitiveness and harmonious, balanced and sustainable development of economic activities. Revitalization of railways, modal shift. Horizontal objectives: Legal simplification, clarification and modernization to facilitate implementation. Specific objectives: Ensuring sustainable funding of the infrastructure. Avoiding distortions of competition. Providing effective and independent regulation. Applied principles of rail track charging under consideration of external effects (e.g. noise). 12 appendices with detailed specifications for application

Related COM Decision	
COM 2006/66 (TSI Noise)	Technical Specifications for Interoperability related to the subsystem 'rolling stock-noise'. Functional and technical specification of the sub-system. Limits for pass-by and stationary noise. Limits for locomotives, multiple units and coaches. Measurement, assessment, application to new and existing rolling stock.
Related Directives	
Directive 2002/49	Assessment and management of environmental noise. Noise indicators, noise measurement and assessment. Obligation to publish noise maps. Obligation to develop noise action plans. Obligation for reviews and regular reporting. 6 Annexes with detailed specifications.
Report from the Commission to the EU Parliament and to the Council on the Implementation of Directive 2002/49	First implementation report based on the implementation deadlines 2005 – 2012. Noise indicators and limit values widely transposed. Significant achievements with harmonized measurement and statistical reporting/noise mapping. Difficulties still existing with health-based noise assessment and heterogeneous situation with country-based action plans.
Directive 2006/38 revised	Charging heavy goods vehicles on motor- and freeways for infrastructure use. Basis: Allocated infrastructure costs plus mark-ups for noise and air pollution. This was the pre-condition set in Dir. 2001/14 for including noise costs in the rail track charging scheme.

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From: [Florence LaRiviere](#)
To: [Council, City](#)
Subject: Rail Separation
Date: Tuesday, October 16, 2018 9:22:51 PM

Dear Council members,

We live in South Palo Alto a block from the train. We have lived here since 1950. We favor the trench/tunnel option for Meadow and Charleston railroad crossings. By the way, what is the status of the partial tunnel with single rail at grade for freight?

Apparently a crucial step that needs to take place is to get Caltrain to approve the 2% grade (the consultants did their plans based on the 2% grade). We respectfully ask that you and city staff let us know progress on this issue. Also, please work with Caltrain to lower the top of the rail to bridge from 24.5 feet to 18.5 feet and keep us informed about those efforts.

Thank you so much for the time and effort already put into this project. Again, our preference is trench/tunnel. The idea of the train on a wall/viaduct is out of the question and would badly degrade the surrounding neighborhoods. Please listen to those most affected by the Caltrain electrification. Let's put equal energy and consideration for the south part of Palo Alto. If all parties are truly heard and valued, we can come up with the least intrusive option that is also the least divisive politically and physically to our city.

Respectfully yours,
Florence LaRiviere
Virginia LaRiviere

453 Tennessee Lane
Palo Alto, Ca 94306

From: [Jay E. Thorwaldson](#)
To: [Sharleen Fiddaman](#)
Cc: [Council, City](#)
Subject: Re: Cal-Train issue
Date: Monday, October 22, 2018 8:21:50 AM

Thanks, Sharleen.

Sorry about the mental typo of the \$150,000 cost of grade separations instead of the \$150 million estimate.

Have you heard of anyone pushing actively for a new election on high-speed rail based on the later cost projections? Seems that \$33 billion is wildly off base, and perhaps only a third of the real cost of the system.

-jay

From: "Sharleen Fiddaman" <sf@sharleenfiddaman.com>
To: "jaythor" <jaythor@well.com>
Cc: "city council" <city.council@cityofpaloalto.org>
Sent: Saturday, October 20, 2018 7:23:23 PM
Subject: Cal-Train issue

Dear Jay Thorwaldson,

I've been a Palo Alto resident for 50+ years and have read many of your articles. I think the Oct. 19th one in the Weekly is most important. I'm very concerned about the Cal-Train decision and our resulting quality of life in Palo Alto.

When the issue of electrifying Cal-Train was *first* discussed many years ago, a visual presentation was made to the District Board of Realtors who met at the Senior Center on Friday mornings. This presentation had great impact! It showed drawings of options.

One drawing showed the electrified train, elevated 15' over the roadway with the required 15' tower of wires overhead. This was horrifying to see! So ugly, and dividing our fine city. This alone in any scenario, elevated or trenched, would surprise residents who probably assume the

electrified train operates like an electric car – just turn a switch, not so. As is said, **a picture is worth a thousand words!**

One drawing showed the electrified train in an underground tunnel with a green park-like field over it. A beautiful solution. Ideal. We need more open useful space. This brings to mind the wonderful modern underground parking garage at Stanford University which has a huge park over it. I've observed students relaxing, reading, playing Frisbee, etc. on the expansive lawn. If they can do it, Palo Alto can do it!

I definitely favor the tunnel solution for Cal-Train. Major cities of the world have underground transportation. I know the argument is that it is too expensive. Palo Alto is quite affluent and could make it happen. Where there's a will there's a way!

Please see if you can find these drawings and print them in the newspaper, and share them with study groups, city council, all media and neighboring cities. I feel that people are making decision without full information of the implications! I have not seen any renderings. It's a permanent solution...our future! We should do it right!

Sharleen Fiddaman

Old Palo Alto



Virus-free. www.avast.com

From: [Ken Joye](#)
To: [Council, City](#)
Subject: study session on traffic 22 October
Date: Tuesday, October 16, 2018 4:36:37 PM

I will not be able to attend the study session on traffic scheduled for 22 October 2018, so write you here instead.

I wish to propose that you and staff *consider prioritizing cross-rail traffic* at the Charleston and Meadow crossings. I believe that this can be done by re-programming the traffic light signals at those two intersections. I concede that I am not a traffic engineer and so my naive idea may have fatal flaws. Nonetheless, I believe it worthy of your consideration.

Currently, when a train approaches those intersections, the crossing arms come down and these things happen: all directions are shown a red light except for traffic headed toward Middlefield Rd, following which traffic on Alma is given a green light (first “southbound, then “northbound” after southbound left-turning). From that, the normal cycle ensues.

I propose a fundamental change: when the crossing arms descend, give a red light to all directions except for traffic headed toward Middlefield Rd, *followed by a red light in all directions until the rail tracks are clear* and the crossing arms are lifted. At that point, begin the normal cycle with “westbound” traffic toward El Camino Real, followed by “eastbound” traffic toward Middlefield Rd, then Alma “southbound” and “northbound”. That is, don’t have every crossing arm trigger a north/south flow on Alma St.

The effect of this will be to reduce wait time for Palo Alto residents attempting to cross the rail tracks, favoring that movement over the out-of-town traffic between Mountain View and Palo Alto.

Obviously this would be a considerable change and would need to be validated by a proper traffic study. I believe that the time currently between the green light to southbound and the lifting of the crossing arms is approximately 20 seconds. This would not be an overly long time to delay traffic movement and would considerably improve cross rail travel.

thank you for your consideration,
Ken Joye
Ventura neighborhood

From: [Svetlana Yepanechnikova](#)
To: [Council, City](#)
Subject: Trench/Tunnel Option
Date: Monday, October 15, 2018 10:55:37 AM

October 15, 2018

To: Rail Committee

RE: Tunnel/Trench vs. Hybrid and Viaduct

Dear City Council and City Staff,

As a longtime resident of Palo Alto and the property owner on Park Boulevard, I would like to state that **you have my full support on Tunnel/Trench option**. As young mother with two kids I do care for safety and decreased/eliminated noise level this option provides.

I would like to ask City Council and City Staff to get Caltrain to approve 2% grade. Please publish those efforts as a standing agenda for the CAP and for all the committee/council meetings. As I see it, this is the one most critical factor that will reduce the cost irrespective of the option chosen.

Additionally, I would like to ask to get Caltrain to approve 18.5ft top of rail to bridge clearance instead of 24.5ft". Please publish those efforts as a standing agenda for the CAP and for all the committee/council meetings.

An update on the Trench/Tunnel Option would be greatly appreciated. AECOM / Rail Committee cannot make unilateral decision to suddenly stop or merge this option with Shallow Trench. These are two different options. The Tunnel for Charleston/Meadow should be analyzed with Caltrain electric for tunnel and freight single rail at grade. CAP/Residents should be provided with detailed analysis on the Trench/Tunnel option. While the Shallow Trench should continue to be explored assuming 2% grade is approved by Caltrain. Since underground is a preferred choice, all options from this category should have detailed analysis.

Furthermore, I would like to ask for Raised rail options to be merged to one - Hybrid and Viaduct option.

In conclusion, I would like to restate that Tunnel/Trench is my preferred choice and our petition for the LOWERED RAIL has 555 signatures as of today.

Respectfully,

Svetlana Yepanechnikova

From: [Yuriy](#)
To: [Council, City](#)
Subject: Tunnel/Trench vs. Hybrid and Viaduct
Date: Monday, October 15, 2018 12:07:22 PM

Dear City Council and City Staff,

As a longtime resident of Palo Alto and the property owner on Park Boulevard, I would like to state that **you have my full support on Tunnel/Trench option**. As young father with two kids I do care for safety and decreased/eliminated noise level this option provides.

I would like to ask City Council and City Staff to get Caltrain to approve 2% grade. Please publish those efforts as a standing agenda for the CAP and for all the committee/council meetings. As I see it, this is the one most critical factor that will reduce the cost irrespective of the option chosen.

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In conclusion, I would like to restate that Tunnel/Trench is my preferred choice and our petition for the LOWERED RAIL has 555 signatures as of today.

Respectfully,

Yuriy Yepanechnikov

SEPTEMBER 2018 EMAILS TO CITY.COUNCIL ABOUT CONNECTING PALO ALTO GRADE SEPARATION

From: [Cedric de La Beaujardiere](#)
To: [Council, City](#); [De Geus, Robert](#); [Transportation](#); [Gennady Sheyner](#); [de La Beaujardiere, Cedric](#)
Subject: Room for a raised rail between Alma and retained Western Track, keep option on the table
Date: Wednesday, September 26, 2018 2:14:03 AM
Attachments: [ViaductBetweenWestTrackAndAlma.Overview.MeadowCharleston.png](#)
[ViaductBetweenWestTrackAndAlma.NearVenturaAtGrade.png](#)
[ViaductBetweenWestTrackAndAlma.AtMeadow.png](#)
[ViaductBetweenWestTrackAndAlma.AtCharleston.png](#)

Members of the City Council Rail Committee,

I believe **there is room to build a raised rail structure between the western track and alma**, and I have done a graphical analysis to show this is possible. The benefit of this is that **the Western track could be left in place and potentially continue to carry rail traffic while the raised tracks are constructed, thus avoiding the expense and impact of temporary tracks down Alma**. In addition, the infrequent freight trains could stay at grade on that Western track, reducing noise propagation and potentially allowing a 2% grade for the raised portions. A further benefit of this alignment is that it **pushes the passenger rail line as far away as possible from the houses along Park Blvd**. There would be room to put trees between the western track and the houses to shield the structure from view.

I would like to point out that it would likely be a financially disastrous mistake to prematurely remove the viaduct options from consideration before they have been fairly evaluated from a cost perspective. The cost of a viaduct structure has never been estimated by the city staff. The closest was a set of preliminary estimates (on page 23 of [Types of Grade Separations and Constraints, Sep 16, 2017](#)) including a hybrid of partially raised rail and partially lowered road, at \$180M. Of note in that same estimates chart that: leaving the rail at grade and lowering the road under the rail was 4 times the cost of raising the road over the rail, and similarly, lowering the rail under the road was over 6 times the cost of raising the rail slightly (and the lowering the road a bit). **One sees then that trenching anything appears to be 4x to 6x the cost of raising it instead.** Further, One can then reasonably assume that the cost of entirely raising the rail is in the same order of magnitude as partially raising the rail, and many times less expensive than trenching the rail.

I recognize that the current political pressure is from those who live closest to the rail, and the politically expedient thing to do is to bend to their pressure. However, if you remove raised rail on wall or viaducts from consideration, we'll be left with the options of trenching at an astronomical cost, or closing intersections, with no middle ground. At that point, when it comes time to somehow scrape together \$2B, you will be faced with much different political pressure as the rest of the city and taxpayers begin to realize the financial burden you then plan to place upon them and the city. A raised rail option appears to be a middle-ground solution which achieves grade separation and much lower construction and lifetime maintenance cost.

Below are some images from my graphical analysis. Here I used the [Right of Way \(ROW\) maps available from the CA HSR website](#), and standards for horizontal clearance laid out in [Peninsula Corridor JPB Standards for Design Structures.pdf](#) which call for **10' clearance from track center lines to the face of a barrier, and 15' clearances between two adjacent tracks**. In my calculation of the distance of the structure from the western track, I assumed a 1' thick outer edge on each side of the structure, where a soundwall could be installed. Thus, east of the Western track's Center Line (CL), I leave a 10' space, then a 1' thick structure western edge,

then 10' clearance to the first track CL, 15' to the second track, 10' to the inner edge of the structure, and a 1' thick eastern edge. For illustration purposes I created segments of such a structure, each 0.1 mile long (528 feet), and laid these out on a map of the rail ROW. **One can see from this illustration that there is room for such a structure without encroaching onto Alma.**

For my distance calculations of the rail ramping up and down I have a 10 km radius curve to go from horizontal to reach a 1% slope, followed by another 10km radius curve to reach horizontal, then back down again. If the ground is level the whole time, the ramp length is just under 1900' feet long to go from 0' to a clearance height of 15.5' above the road.

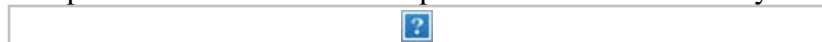
Here is an overview of the segment over West Meadow and Charleston:



Below is the northern edge of the structure, reaching grade near El Verano Ave and Ventura Ave.

The light green lines with tick marks indicate the 10' + 1' + 10' + 15' + 10' + 1' spacings. The light green lines are extending from a thicker black line which indicates the Western track's Center Line on the ROW maps.

The pink double-dashed lines represent the ROW boundary.



Below is the segment crossing West Meadow.

Here i have made the structure semi transparent to show the ROW boundary line below, which it would slightly overhang, but still be well outside of the Alma ROW



Below is the segment over Charleston, totally within the JPB ROW and totally outside of the Alma ROW, even with Alma's right-turn pocket on the north side of Charleston:



Respectfully,
Cedric de La Beaujardiere

From: [herb](#)
To: [Council City Clerk City](#)
Subject: September 26, 2018, Rail Committee Meeting, Item #1: Agreement with Caltrain
Date: Tuesday, September 25, 2018 7:19:50 PM

Herb Borock
P. O. Box 632
Palo Alto, CA 94302

September 25, 2018

Palo Alto City Council
250 Hamilton Avenue
Palo Alto, CA 94301

ATTN: RAIL COMMITTEE

SEPTEMBER 26, 2018, RAIL COMMITTEE MEETING, AGENDA ITEM #1: AGREEMENT WITH CALTRAIN

Dear City Council:

Why is this agreement appearing on your agenda a month after the Joint Powers Board started work in Palo Alto on the Caltrain Electrification Project.

According to the August 27, 2018, press release from Caltrain (http://www.caltrain.com/about/MediaRelations/news/Caltrain_to_Hold_Public_Meeting_on_Electrification_in_Palo_Alto.html), construction activities were set to begin that week.

Of the 19 cities and counties requiring Construction & Maintenance agreements with Caltrain, only Atherton and Palo Alto had not signed an agreement for a long time, while San Francisco had signed its agreement by November 30, 2017, but still needs to sign a Condemnation Authority agreement.

Sincerely,

Herb Borock

From: [Letha DiLauro](#)
To: [Council, City](#)
Subject: train crossing Charleston and Meadow
Date: Sunday, September 2, 2018 10:11:34 PM

Dear City Council,

I want the train or tunnel. I do not it on a wall. The wall will make the train louder, it is an ugly choose for Palo Alto and we do not deserve a better than an eyesore. We will live wit the decision for the next 100 years. Do what is right.

We have enough noise with airplane traffic and the train. We do not need any additional noise pollution. I have lived here for 47 years and am losing my hearing. Do you think the train could have anything to do with it? Before my husband's passing in 2016 he was also losing his hearing.

Why are we still studying the train on the wall? Put the money into a decision. Has anyone brought up the concern over suicide prevention?

Thank you for reading y email.

Letha DiLauro
4131 Park Blvd.
Palo Alto, CA 94306

650-493-4278