Hybrid Rail Service Planning for San Bernardino – Los Angeles Corridor

San Bernardino County Transportation Authority

November 19, 2018

Mott MacDonald
500 South Main Street
Suite 420
Orange CA 92868
United States of America

T +1 (714) 782 9212
F +1 (714) 836 4179
mottmac.com/Americas

HDR
3230 El Camino Real
Suite 200
Irvine CA 92602
United States of America

San Bernardino County Transportation Authority
1170 West Third Street, 2nd Floor
San Bernardino, CA 92410

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Definitions/Acronyms

ADA............. Americans with Disabilities Act
BNSF........... Burlington Northern Santa Fe Railway Company
CP .... Control Point
CPUC .... California Public Utilities Commission
DMU .... Diesel Multiple Unit
FRA............. Federal Railroad Administration
FTA .... Federal Transit Administration
HR .... Hybrid Rail
I-10 .... Interstate 10
LAUS........... Los Angeles Union Station
LHC .... Locomotive Hauled Coach
Metro .... Los Angeles County Metropolitan Transportation Authority
MP............... Milepost
MSF............. Maintenance and Service Facility
NPRM.......... Notice of Proposed Rule Making
O&M .... Operations & Maintenance
ROW .... Right-Of-Way
RPRP .... Redlands Passenger Rail Project
SANBAG .... San Bernardino Associated Governments
SBCTA .... San Bernardino County Transportation Authority
SBL .... San Bernardino Line
SCC............. Standard Cost Categories
UPRR.......... Union Pacific Railroad

1 Introduction & Background

1.1 Introduction

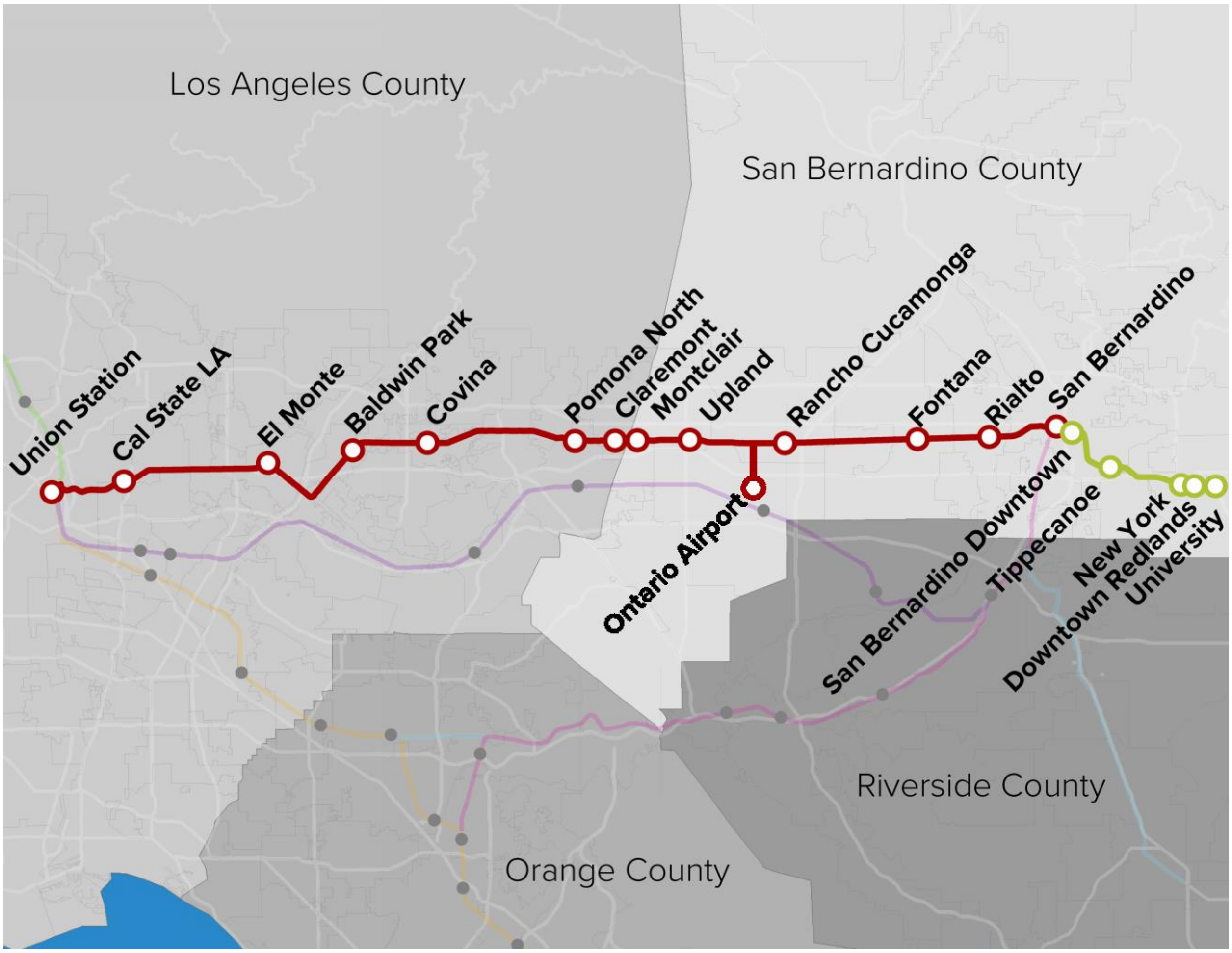
Metrolink's San Bernardino Line (SBL) between San Bernardino and Los Angeles Union Station (LAUS) is an underutilized transportation asset due to limited bi-directional service. During peak periods, trains typically run every 30 minutes in the peak direction and every hour in the off-peak direction, while during the middle of the day trains run in both directions about every hour.

The development of the Redlands Passenger Rail Project (RPRP) presents an opportunity to provide additional service on the corridor at a lower cost by using hybrid rail (HR) diesel multiple unit vehicles. The RPRP Project is a nine-mile extension of passenger rail service from the San Bernardino Transit Center to the University of Redlands. The service will utilize vehicles called diesel multiple units (DMU), which are a hybrid between the locomotive-hauled coaches (LHC) operated by Metrolink and light-rail transit vehicles like the Metro Blue and Green Lines in Los Angeles County. Light-rail transit vehicles operate with electric power using overhead catenary lines and are lighter weight vehicles that cannot operate in freight rail or LHC railroad corridors. Hybrid Rail vehicles, which include DMUs as well as Electrical Multiple Units, currently provide transit service in five corridors around the United States and are more commonly used in other parts of the world. The latest generation of HR vehicles have been approved as crash compliant by the Federal Railroad Administration (FRA) via a waiver process, meaning they can safely operate on freight railroad corridors as LHC trains do. In addition, a Notice of Proposed Rule Making (NPRM) is underway that would negate the need for the waiver. Being smaller and lighter than LHC trains, HR trains have been found to be cheaper to operate and maintain, so the use of HR technology may present an opportunity to cost-effectively increase service in the San Bernardino-LAUS corridor.

1.2 Background

The SBL is a 55-mile rail corridor used by the Southern California Regional Rail Authority for running Metrolink commuter rail service between LAUS and the Downtown San Bernardino Station, as shown in Figure 1-1. The SBL is the busiest line on the Metrolink commuter rail system in Southern California and serves as a vital transportation link amongst Los Angeles, San Bernardino and all communities in between. The SBL is also a critical line for the BNSF Railway and Union Pacific Railroad (UPRR) to serve a multitude of customers via industrial tracks throughout the line. East of where the SBL adjoins with the River Subdivision (East Bank), UPRR and Amtrak also provide additional service into Downtown Los Angeles on the adjacent UPRR Alhambra Subdivision.

Figure 1-1: Study Area



The average passenger train speed on the SBL is approximately 40 miles an hour (when factoring in station stops), resulting in an average travel time of approximately 90 minutes between the Metrolink San Bernardino Station and LAUS. In May of 2011, Metrolink added a roundtrip express train on the SBL with intermediate stops at the Metrolink Covina and Rancho Cucamonga Stations that reduced the average total travel time by 25 minutes. Metrolink temporarily suspended the SBL express train while implementing positive train control due to schedule impact but plans to restore it in the near future. During peak periods, trains typically run every 30 minutes in the peak direction and every hour in the off-peak direction, while during the middle of the day trains run in both directions about every hour.

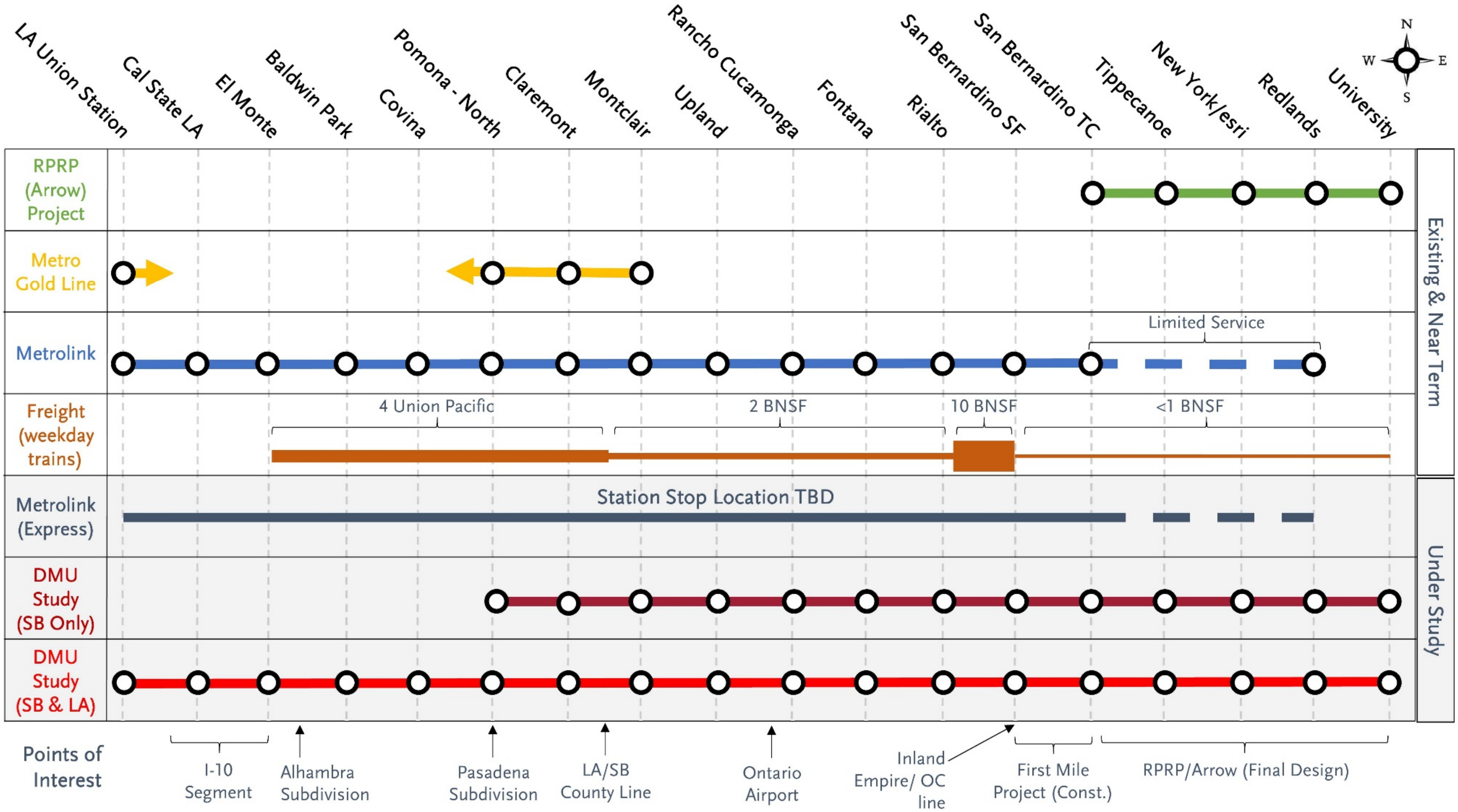
The operation of additional service in the San Bernardino-LAUS corridor would enhance the corridor's ability to support transit-oriented development and regional travel by alternative modes. Desirable service improvements could include:

a. Additional bi-directional midday service;
b. Additional peak period, peak direction express service for longer-distance trips; and
c. Additional peak period, reverse-peak direction service.

Unfortunately, the opportunity to implement such service improvements is constrained by the existing infrastructure and the cost of operating additional Metrolink rail service. The infrastructure constraints are due to the fact that extensive segments of the corridor have a single track, so bi-directional train frequencies can only be increased if double-track sections or sidings are available where trains need to pass. The cost constraint is due to the fact that Metrolink is currently operating as much service as its available funding sources can afford, and no additional sources of funding for operations and maintenance (O&M) of Metrolink service are expected in the near future even with the passage of State Bill 1, the State of California's recent transportation funding bill.

An overview of the existing and planned rail operations on the San Bernardino corridor is shown in Figure 1-2.

Figure 1-2: Existing Conditions in the San Bernardino Corridor



1.3 Study Purpose

The primary goal Study is to analyze the feasibility and operating parameters for supplementing or converting existing Metrolink service on the San Bernardino Line with DMU or Hybrid Rail service. The goals of the expanded service are two-fold:

1. reduce overall operating costs for rail service in the corridor; and
2. provide more frequent off-peak service and a more convenient overall schedule for rail riders in the corridor.

1.4 Study Questions

The questions of this study are based on responding to the following:

1. What would be the potential western terminus stations for HR service in the corridor?
2. Can HR supplement existing peak service and facilitate more Metrolink express trains?
3. Can off-peak service be converted from Metrolink trains to HR trains to reduce operating costs?
4. What infrastructure improvements would be needed to achieve reliable 30-minute and 15-minute peak direction service using blended Metrolink and HR service?
5. In the long term, could 30-minute or 15-minute blended service be provided, including direct service to Ontario Airport?
6. What infrastructure improvements would be needed to achieve unconstrained bi-directional service with 30-minute, 20-minute, and 15-minute headways?
7. What are the O&M and capital costs associated with improvements?
8. What are the Rail Systems technical challenges of the current United States HR operators?

The following chapters will address each of the questions listed above.

2 Western Terminus for Hybrid Rail Service

Question 1: What would be the potential western terminus stations for HR service in the corridor?

The introduction of HR vehicles on the SBL allows for the flexibility in determining where HR service should terminate. Even if HR service is unable to travel the entire length of the SBL for capacity reasons, an intermediate station on the SBL could serve as a feasible location for turning HR trains around.

The potential western terminus for HR service is determined in part by available right-of-way (ROW) for the infrastructure required to turn trains around, the existing railroad capacity on that segment of the corridor, and opportunities for multimodal connectivity. Ideally, HR service would span the entire corridor from LAUS to the RPRP University Station. However, Metrolink already operates the maximum number of peak trains possible between LAUS and El Monte Station due to the single-tracked corridor in the median of the Interstate 10 freeway (I-10). The westernmost terminus of HR service could potentially be El Monte prior to the I-10 constraint, but opportunities to turn trains around exist at the Pomona North and Montclair Stations as well. Turnback tracks would be required to allow any passenger train to turn around or layover at the terminus station.

The El Monte, Pomona North, and Montclair Stations all provide multimodal connections to over a dozen bus routes one-half mile away from El Monte Station, and future Metro Gold Line service at the Pomona North and Montclair Stations. These stations may also potentially accommodate the required infrastructure and ROW needed for storing and turning around trains.

3 Supplementing Existing Peak Service

Question 2: Can HR supplement existing peak service and facilitate more Metrolink express trains?

The study identified opportunities to supplement existing Metrolink peak service with HR trains, and thereby accommodate more Metrolink express trains. Within the existing Metrolink schedules, there are gaps sufficient to insert four HR trains in each peak:

- AM Peak: two westbound and two eastbound trains
- PM Peak: two westbound and two eastbound trains

These HR trains could provide local service, stopping at all stations between western terminus station and SBTC. The Metrolink train following each HR train in the morning and preceding each HR train in the afternoon could operate in express mode. Thus, for the AM period, two trains would provide express service in the westbound direction with one or two stops between SBTC and Pomona North, while two express trains would operate in the eastbound direction during the PM period.

In this scenario the Pomona North Station is assumed to serve as the western terminus station for passengers transferring between the local HR service, the Metrolink express trains, and the Metro Gold Line. Details of schedule and modeling assumptions for this scenario are documented in *Appendix A: Rail Modeling Summary Report.*

This scenario would need no rail infrastructure improvements other than the layover track for HR trains at the Pomona North station. This track would be used by HR train sets while changing operating ends and awaiting scheduled departure times, thereby minimizing the use of mainline capacity and improving operational flexibility.

4 Converting Off-Peak Metrolink Service to Hybrid Rail

Question 3: Can off-peak service be converted from Metrolink trains to HR trains to reduce operating costs?

Review of current Metrolink ridership patterns found that most midday, evening, and reverse-direction trains between SBTC and LAUS carry relatively low volumes of passengers. Low-volume Metrolink trains could be converted to HR for trains where HR capacity is sufficient to carry the passenger volume. Since Metrolink passengers generally travel longer distances, the HR vehicles should have enough seating capacity for the existing passenger volumes. Based on this assumption, trains with daily ridership of fewer than 200 passengers were considered as potential candidates for replacement using 4-car HR train sets. The RPRP is currently constructing a maintenance and service facility (MSF) to accommodate up to six (6) Arrow HR 2-car train sets, however a new MSF would be required to accommodate any 4-car train sets.

The evaluation determined that 16 low-ridership Metrolink trains could be converted to HR without creating unnecessary HR equipment positioning moves. Four HR equipment sets, however, would need to layover at the Central Maintenance Facility and start their service days at LAUS. The analysis did not attempt to determine how (or if) the replaced Metrolink trains might be used; this type of conversion from LHC trains to HR should only be done in the context of a comprehensive scheduling analysis to make sure that efficient use is made of vehicles and crews.

Details of the modeling for this scenario are documented in *Appendix A: Rail Modeling Summary Report.*

5 Metrolink and HR Blended Service

Question 4: What infrastructure improvements would be needed to achieve reliable 30-minute and 15-minute peak direction service using blended Metrolink and HR service?

The San Bernardino Line's primary capacity constraint is the single-track section that extends for over eleven miles from Pasadena Junction to the El Monte Station. Much of this segment is located in the median of I-10, and there is insufficient room to widen for a second track without rebuilding the freeway, which would incur exponentially high costs. Metrolink currently operates the maximum number of trains that this single-track section can carry, with three trains operating in the peak direction and one train in the reverse direction during both the morning and afternoon peak periods. This analysis is focused on providing additional train service in the San Bernardino Line corridor east of El Monte Station, and specifically evaluates scenarios in which HR service is added between Pomona North Station and the University of Redlands, and between El Monte Station and the University of Redlands.

The second premise of this blended (i.e. HR and LHC service) analysis is that the existing Metrolink schedules for the San Bernardino Line are maintained while HR service is added to achieve the desired service frequencies with a combination of Metrolink and HR service. For this blended service analysis, peak period peak-direction frequencies of 30 minutes and 15 minutes were evaluated to determine where double tracking would be needed to provide reliable service at these frequencies. Since Metrolink trains do not operate at regular intervals and the existing Metrolink schedule had to be maintained, HR trains were modeled to operate between Metrolink trains so the desired service frequencies were approximately achieved. Limited reverse-direction service with 60-minute frequencies was modeled for these scenarios because operation of more frequent service would require a significant amount of train equipment be moved to the western end of the corridor (Pomona or El Monte) in the morning and to the eastern end (San Bernardino or Redlands) in the afternoon, and significant infrastructure improvements would be needed to accommodate those reverse-peak train movements.

Details of schedule and modeling assumptions for this scenario are documented in *Appendix A: Rail Modeling Summary Report.* The four blended scenarios are:

- 30-minute limited bi-directional blended service between Pomona North and University
- 15-minute limited bi-directional blended service between Pomona North and University
- 30-minute limited bi-directional blended service between El Monte and University
- 15-minute limited bi-directional blended service between El Monte and University

These blended scenarios are intended to simulate a situation in which HR services are scheduled without being able to adjust Metrolink schedules. If LHC and HR services are to operate within the same San Bernardino Line corridor, a more efficient way to serve the corridor would be to adjust both services to provide a single, integrated schedule, similar to how the Amtrak Pacific Surfliner service operates with Coaster and Metrolink commuter services on the Los Angeles – San Diego – San Luis Obispo rail corridor. This operation would allow for more efficient utilization of both existing and planned infrastructure, maximize utilization of both services' equipment fleet and operating crews, and provide a more consistent, effective service offering for passengers. This schedule integration could be achieved regardless of whether one or two operating entities provide the services.

5.1 Infrastructure Needs for 30-Minute and 15-Minute Blended Service

5.1.1 Double Tracking

The four limited blended operation scenarios described above were modeled to determine where added infrastructure would be required to accommodate bi-directional 30-minute and 15-minute service provided by existing Metrolink service overlaid with HR trains along the SBL. Detailed design drawings for double tracking improvements are included in *Appendix B: Infrastructure Improvement Designs*.

Figure 5-1 shows where double tracking would be needed for the scenarios in which HR service is operated between Pomona North or El Monte and the University of Redlands. To achieve reliable 15-minute peak service, the following areas of the corridor would need to be double-tracked:

- Along the entire San Gabriel Subdivision between Pomona and SBTC with the exception of the San Bernardino Flyover and through the historic Redlands core
- Along the entire RPRP

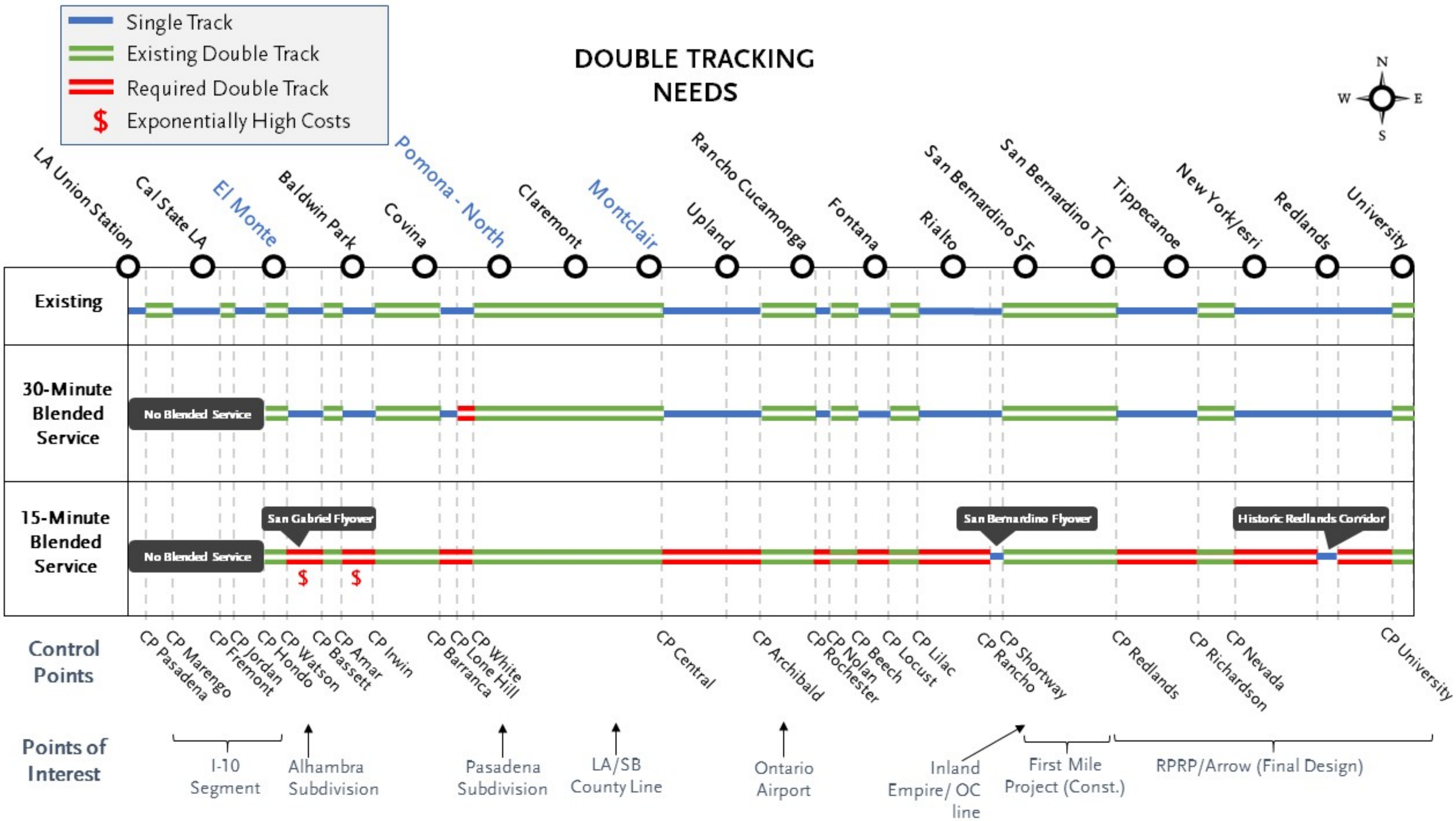
Within the RPRP section of the corridor, there is a short segment within the historic Redlands core that would be sensitive to the addition of double track. While this segment was maintained as single track for the Study, future analysis may require this segment to be double tracked to meet future service needs.

Limited blended bi-directional 30-minute peak service can be provided by double-tracking the segment between Control Point (CP) Lone Hill and CP White. To achieve limited blended bi-directional 15-minute peak service, double-tracking most of the SBL corridor from El Monte to Redlands would be required. In the area between Pomona North and El Monte, there are four key locations that would require double-tracking and pose exponentially high costs and/or ROW challenges. These four locations are:

- The San Gabriel Flyover east of the El Monte Station (Mile Post (MP) 13.9 to 15.0)
- The I-10 underpass west of the Baldwin Park Station (MP 17.2)
- Baldwin Park Station (MP 18.9)
- The narrow right-of-way through the curve east of the Covina Station (MP 25.6 to 26.0)

Detailed design drawings for double tracking improvements are included in *Appendix B: Infrastructure Improvement Designs*.

Figure 5-1: Double Tracking Needs for Constrained Scenario with 60-Minute Reverse Headways



5.1.2 Station Infrastructure

The study has used a DMU reference vehicle to identify the technical solutions necessary to enable DMU vehicles to operate at existing, or legacy, Metrolink stations.

Stadler has recently been awarded the contract to design and manufacture three, two-car FLIRT DMU trains for SBCTA for the RPRP and future Arrow service. As these vehicles will operate on SBCTA's network, these vehicles have been used as the reference vehicle to determine the feasibility and technical requirements associated with the introduction of a DMU or hybrid rail service. A key consideration and one of the main drivers of cost and feasibility of implementation, is the passenger-platform interface and maintaining freight traffic at existing Metrolink stations and along the corridor. At station platforms there are two competing requirements:

- California Public Utilities Commission (CPUC) requirements for side clearance; and
- Federal Transit Administration (FTA) and American with Disabilities Act (ADA) requirements for level boarding.

Detailed drawings of legacy station modifications are included in *Appendix B: Infrastructure Improvement Design*.

5.1.2.1 Vehicle Platform Interface

The CPUC specifies the minimum offset from the centerline of the adjacent track to the track side structures, as shown in Figure 5-2. To allow for safe passing clearance for wider freight vehicles, the platform is pushed away from the passenger vehicle envelope. Each of the legacy platform faces on the SBL meet this requirement.

The competing requirement is defined by ADA and the subsequent FTA Regulations and Guidance that provide access for individuals with disabilities, including individuals who use wheelchairs. The FTA requires level boarding at new passenger rail stations to provide level-entry boarding to all accessible cars in each train using the station (with all new cars required to be accessible). Level boarding is defined as a door threshold-to-platform interface that has a horizontal gap of less than three inches and a vertical height difference of no more than +5/8 inch as shown in Figure 5-3.

Figure 5-2: CPUC Side Clearance

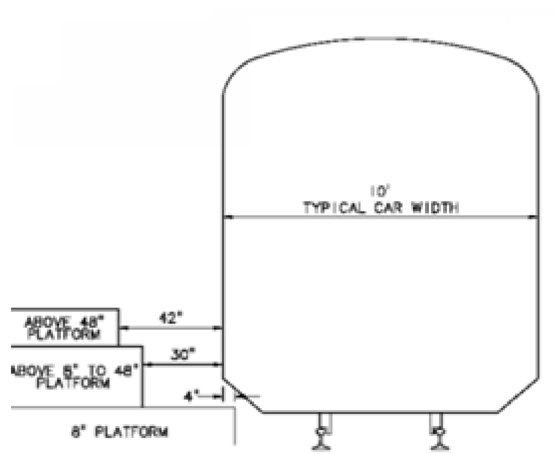
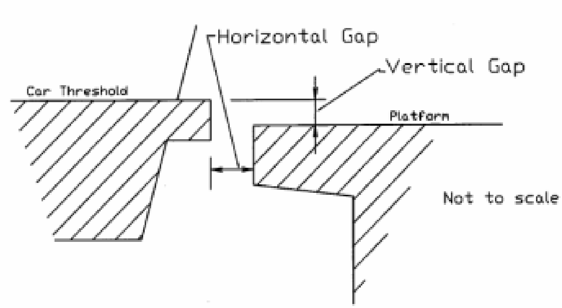


Figure 5-3: ADA Level Boarding



The Study has developed options to determine how to address these competing requirements in the most cost-effective way while maintaining compliance with the local, state, and federal standards and regulations. The following technical solutions have been considered:

- Gauntlet or Dedicated Loop Tracks
- Shared Raised Platform
- Modified Vehicle with Retractable Step

These solutions were considered with the goal of identifying a cost-effective solution to achieve level-entry boarding, RPRP platform compatibility, Metrolink station compatibility, freight operator compatibility, and regulatory compliance.

5.1.2.2 Option 1: Gauntlet or Dedicated Loop Tracks

Figure 5-4: Gauntlet Track

Gauntlet and dedicated loop tracks can be used where freight traffic passes through existing stations and on tracks adjacent to existing platform faces. An example of a gauntlet track is shown in Figure 5-4. The offset between the two sets of tracks provides the additional side clearance needed for freight vehicles while enabling passenger vehicles to stop adjacent to existing platform faces.

Another option is to provide dedicated loop tracks that would require the addition of a new shared or dedicated platform adjacent to the existing station. This would eliminate the side clearance conflict by putting DMU services on a completely separated track and platform. Given the variety of station configurations on the SBL, pedestrian plans showing the different platform and track options were developed for each station for feasibility purposes, and are included in *Appendix B: Infrastructure Improvement Designs*.

Level-entry boarding of the train at existing Metrolink stations is currently done using mini-high platforms and a manually deployed bridge-plate at one Metrolink car door by the train conductor. Under this option, this same manually deployed bridge-plate, or ramp, would be utilized to achieve level-entry boarding. The Arrow service is currently planning to utilize two operators (driver and conductor) per train set, so the conductor would be assumed to deploy the ramp for ADA passengers.

The use of gauntlet and loop tracks were considered and then ruled out on the basis of the likely high costs associated with the additional infrastructure and the possible right-of-way needed for its implementation. It was also concluded that the freight operators may object to the increased maintenance and reliability risk associated with the additional switches at each station.

5.1.2.3 Option 2: Shared Raised Platform

By raising the existing Metrolink platform or parts of the platforms to 15" from top of the existing rail elevation, both Metrolink and DMU trains could utilize the same platform face without conflicts. This would require a 9” step down from the DMU in combination with a level boarding approach similar to Metrolink’s existing approach. It would not require the use of gauntlet tracks nor would it require any modification to the DMU vehicle.

The platform height modification could either be implemented at discrete sections along the platform (i.e. at DMU door locations) or along the entire platform length. The use of 15” mini-high platforms at discrete locations as opposed to the entire existing could result in lower construction costs and fewer impacts. Discrete step-ups would require only a segment of the existing platform to be raised and installation can be carried out during normal operating hours, with minimal additional downtime experienced. Raising the entire existing platforms would require taking the platform out of service during construction.

Similar to Option 1 and existing conditions, a manually deployed ramp would be required to achieve level-entry boarding at certain DMU door locations.

Although this option would require a waiver from the CPUC, it is considered to be acceptable to Metrolink on the basis that there is a precedent with the FRA as this approach has been implemented at the Anaheim Regional Transportation Intermodal Center and the Oceanside Station on the Metrolink system. The regulatory conflict between the CPUC and FRA is resolved on a case-by-case basis and is not guaranteed in every instance.

5.1.2.4 Option 3: Modified Vehicle with a Retractable Step

The third option considered would not require modifications to the legacy platforms by fitting DMU vehicles with a retractable step. A fixed-step would create conflicts with the RPRP platforms that do not exist with retractable steps. The Project Team is currently working with the vehicle manufacturer to confirm whether the DMU vehicles could be modified at a later date to support the addition of a retractable step.

There is a precedent for retractable steps on the Stadler vehicles used in Suwex, Germany (see Figure 5-5). These vehicles use ultra-sonic sensors to detect platform gaps which trigger the use of retractable steps that take

Figure 5-5: Retractable Step

approximately 6 to 7 seconds to deploy or retract. These steps span up to 12 inches, however for the application on SBL they would need to span upwards of 15 inches. Preliminary discussions with Stadler suggest that it is feasible to adopt this approach on SBL. In summary, Stadler is currently considering and will confirm whether;

- They can adapt the vehicles with structural components under the door to add retractable steps;
- These modifications will not impact the vehicles crash worthiness;
- Once the retractable steps are added, whether they have to go through additional crash worthiness testing.

Similar to Option 1 and existing conditions, a manually deployed ramp would be required to achieve level-entry boarding at certain DMU door locations.

No examples of retrofitting existing DMU vehicles with retractable steps are currently available. The footstep units are built into new trains and vary in application. Furthermore, costs for retrofitting retractable steps to existing Stadler vehicles are not available at this time. At the conclusion of the Study, the next steps would be to pursue vehicle modifications with Stadler to further identify costs and operational feasibility.

5.1.3 Maintenance and Service Facility

The RPRP is currently constructing an MSF for Arrow vehicles, and can be expanded to accommodate a total of six two-car hybrid train sets. Under certain operational scenarios, a new maintenance and service facility (MSF) may be required to maintain hybrid rail vehicles. A new MSF would be required if hybrid rail service on the SBL meets any of the following criteria:

- Four-car hybrid train sets;
- Hybrid rail service terminates as far west as El Monte Station; or
- Headways are 20-minutes or less

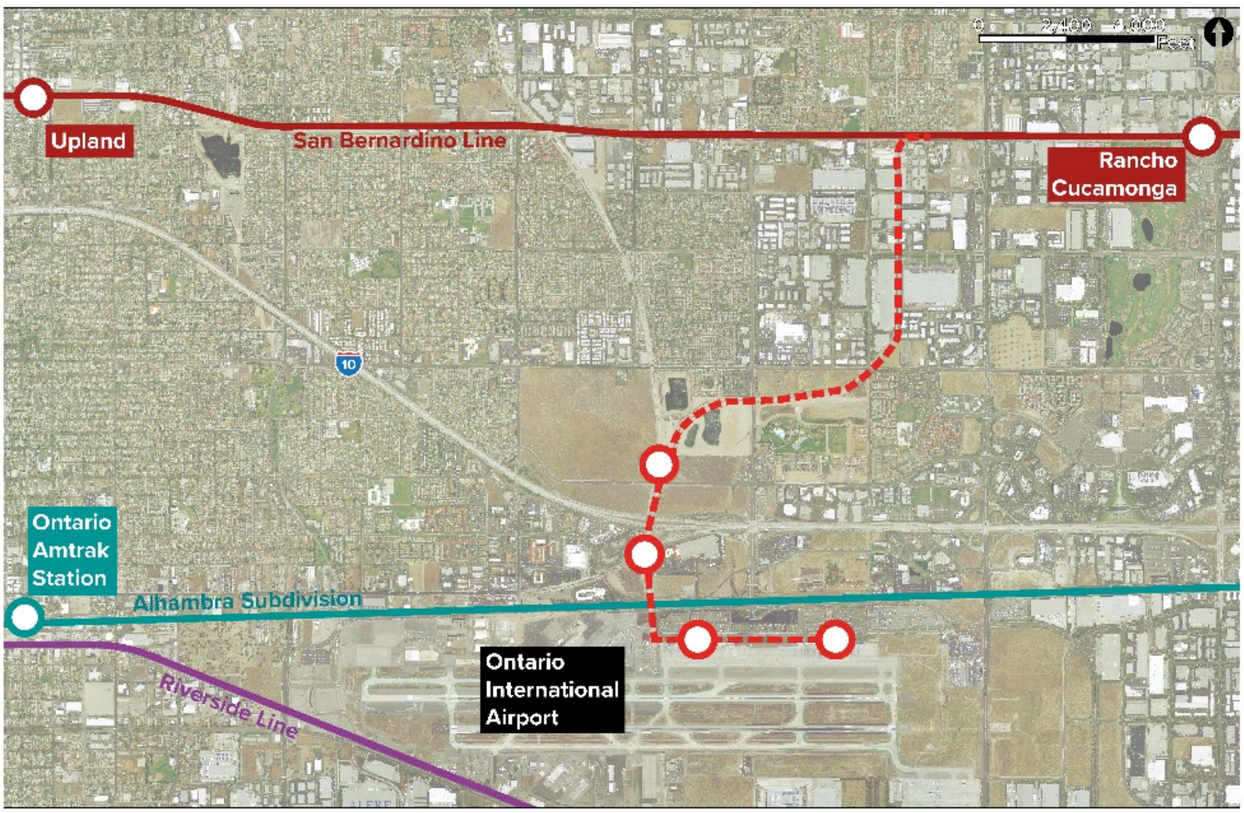
For the Study, a generic maintenance facility for up to 15 Stadler FLIRT DMU four-car sets has been designed in order to develop capital cost estimates in case the need for a new MSF is triggered by the aforementioned criteria. A detailed memorandum on the MSF is included in *Appendix C: Maintenance and Service Facility Design Memo*.

6 Rail Service to Ontario Airport

Question 5: In the long term, could 30- or 15-minute blended service be provided, including direct service to Ontario Airport?

In 2014 SBCTA (then SANBAG) prepared the Ontario Airport Rail Access Study to evaluate alternatives for connecting Metrolink service with the airport. The Study identifies these rail alternatives for long-term implementation once airport passenger activity has grown to at least 15 million annual passengers. The identified preferred alternative is a rail connection between the Rancho Cucamonga Metrolink Station and the airport terminals via Deer Creek and Cucamonga Creek. The alignment is illustrated in Figure 6-1.

Figure 6-1: Rail Access to Ontario Airport



Modeling was performed to determine whether the HR service scenarios could provide direct service to Ontario Airport as part of regular San Bernardino Line service. In an ideal operating scenario, every other train would make the direct trip between Pomona and San Bernardino, and the in-between trains would divert to the airport.

In an unconstrained or clock-face scenario where Metrolink operates on a consistent 30- or 60-minute schedule, one-seat rides to Ontario Airport could be provided using HR vehicles that operate in between the Metrolink trains. The trip diversion to and from the airport, including stops and turnaround time, is about 30 minutes.

Since existing Metrolink service along the San Bernardino Line is not operating on a consistent clock-face schedule, it would not be possible to operate a blended service with some HR trips diverting to the airport. In a blended scenario, service to the airport would need to be provided using a shuttle-style operation with a required transfer at the Rancho Cucamonga Station.

7 Bi-Directional Unconstrained Service

Question 6: What infrastructure improvements would be needed to achieve unconstrained bi-directional service with 30-, 20-, and 15-minute headways?

This scenario examined infrastructure improvement needs for bi-directional HR service between either El Monte, Pomona North, or Montclair Station, and University of Redlands operated at regular intervals of 30-, 20-, and 15 minutes throughout the day. The modeling assumed that all trains between El Monte Station and the University of Redlands were HR trains, but it would also be possible to operate these scenarios using both LHC and HR trains in a mixed service as long as the regular or clock-face train frequencies were maintained. Details of schedule and modeling assumptions for this scenario are documented in *Appendix A: Rail Modeling Summary Report*.

7.1 Infrastructure Needs for 30-Minute, 20-Minute, and 15-Minute Unconstrained Service

The three unconstrained operation scenarios were modeled to determine where added infrastructure would be required to accommodate reliable 30-minute, 20-minute, and 15-minute bi-directional service. The double tracking segments that will be required for each of the scenarios is shown in Figure 7-1.

7.1.1 30-minute Unconstrained Bi-Directional Service

To support all-day bi-directional 30-minute service, a total of 5.0 miles of double-tracking would be needed, specifically between CP Rochester and CP Nolan (2.9 miles), and between CP Lilac and CP Rancho (2.1 miles).

7.1.2 20-minute Unconstrained Bi-Directional Service

To support 20-minute all-day bi-directional service, more extensive double-tracking would be needed, including:

- San Gabriel Flyover between CP Watson and CP Bassett
- Baldwin Park Station between CP Amar and CP Irwin
- Between CP Barranca and CP White
- Between CP Central and Upland Station
- Between CP Rochester and CP Nolan

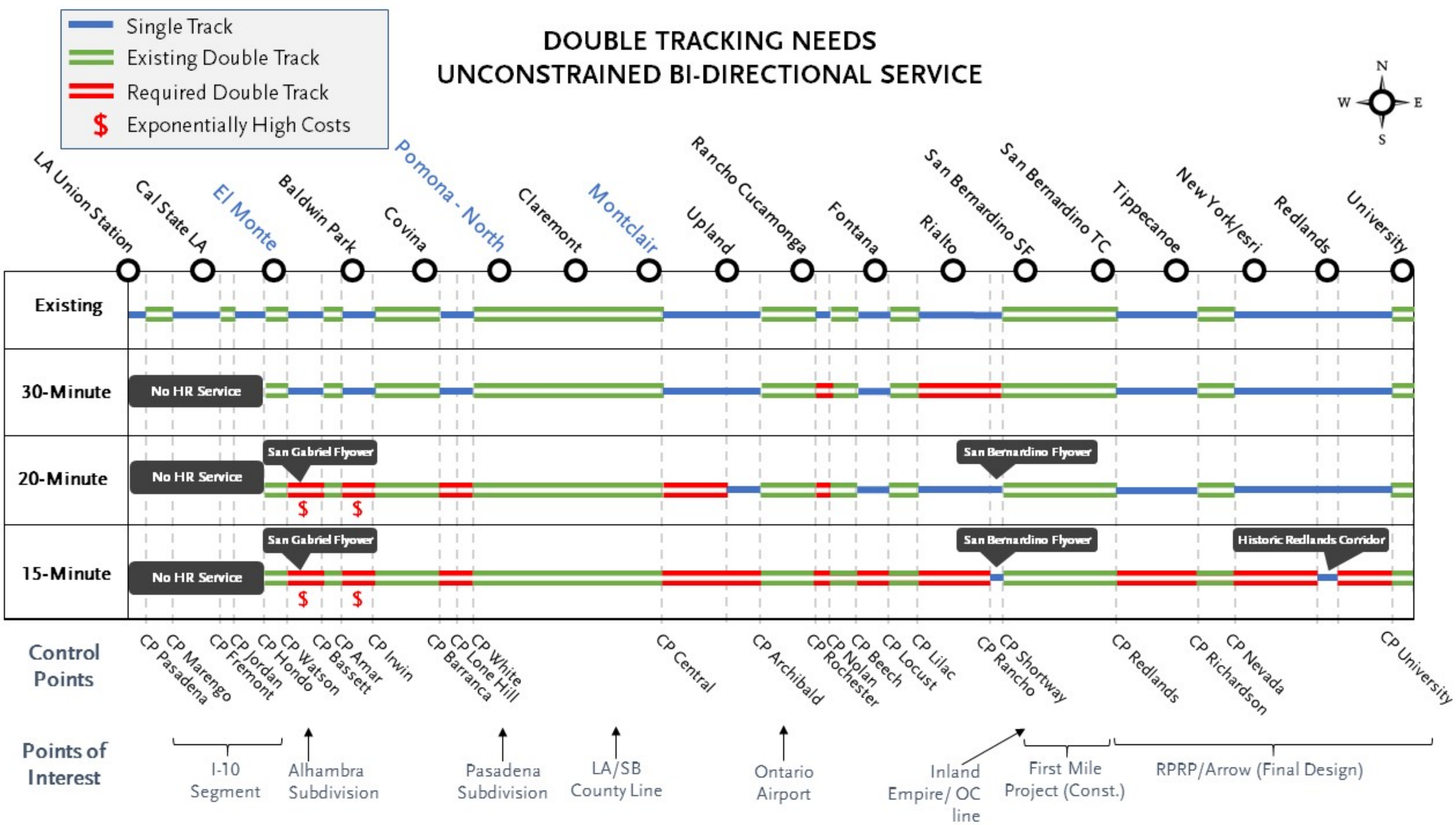
A new MSF would also be required to support this level of service.

7.1.3 15-minute Unconstrained Bi-Directional Service

To support 15-minute all-day bi-directional service, extensive double-tracking would be needed, as well as extending the University of Redlands station track approximately 0.5

mile to the east side of the 6th Street grade crossing. A new MSF would be required to support this level of service. The needed double-tracking includes the entire corridor from El Monte Station to Redlands, excluding the San Bernardino Flyover and the historic Redlands corridor segment.

Figure 7-1: Double Tracking Needs for Unconstrained Scenario Bi-Directional Service



8 Cost Estimates

Question 7: What are the operations and maintenance (O&M) and capital costs associated with improvements?

8.1 Cost Estimating Methodology

8.1.1 O&M Cost for Added Hybrid Rail Service

The costs to operate and maintain the various hybrid rail service scenarios were estimated based on the unit O&M costs of operating HR services in the United States. The sections below describe the basis for the assumed unit cost per train mile of additional HR service and for cost savings per train mile of replacing Metrolink service with HR. The O&M costs were annualized by assuming weekday service levels 255 days per year with weekend and holiday service levels proportional to existing service levels on those days. Detailed methodology information can be found in *Appendix E: Operational Cost Estimate Memo.*

For scenarios in which HR service would be added to the corridor, the annual O&M cost of HR service was estimated using a range of $25-38 per train mile. This cost range is based on the total O&M cost per train mile of the three HR systems which operate more than 300,000 annual train miles (Sprinter in North San Diego County, New Jersey Transit River Line, and Denton County Texas A-Train). For comparison purposes, the cost range for the two existing HR services with less than 300,000 annual train miles is between $40-80 per train mile, and the estimated O&M cost for the Arrow service between Redlands and San Bernardino is $57.13 per train mile based on the estimated 137,476 annual train miles. Since the added HR service in this analysis would likely be operated in conjunction with the Arrow service, it is reasonable to assume the lower range of per-mile O&M cost for HR service being added. Additionally, two of the three comparable systems utilize DMU technologies that are over 10 years old. The brand-new Arrow service and vehicles will benefit from recent vehicle advancements and therefore will likely favor the lower range of the per-mile O&M cost.

8.1.2 O&M Cost Savings for Replacing Metrolink Service with Hybrid Rail

The primary O&M cost elements include operations labor, vehicle maintenance, and fuel.

8.1.2.1 Labor Costs

The potential for labor cost savings depends on whether hybrid rail would be able to operate with one-person crews (Metrolink trains have two-person crews). In the replacement scenario, two-car HR train sets were assumed to provide enough seating capacity for the current Metrolink ridership, so two-person crews would likely be needed to operate this service. For this cost saving analysis, it was assumed that the labor cost would be essentially comparable to operating Metrolink trains. In addition, it was assumed that the modified schedules for equipment and crews could be implemented without causing scheduling issues that would require labor costs be paid for the Metrolink trains when not in service.

8.1.2.2 Vehicle Maintenance

Vehicle maintenance costs are in the range of $1.06-5.44 per train mile for HR systems, and $11.78-15.81 per train mile for LHC systems, so there is potential for cost savings in terms of vehicle maintenance if off-peak Metrolink trains were replaced with HR trains. However, daily maintenance is required for a train regardless of how main miles it logs or hours it operates in service. To be conservative and not over-estimate potential savings, it was assumed that there would be no net reduction in the cost to maintain vehicles if HR equipment were used to replace Metrolink trains.

8.1.2.3 Fuel Costs

Fuel cost savings would be realized because HR trains are smaller and lighter than LHC trains. LHC trains average approximately 0.33-0.36 miles per gallon of diesel fuel, whereas DMU trains average approximately 0.78-0.875 miles per gallon. With a current cost of $3.65 per gallon for diesel fuel in California, the cost of fuel for LHC ranges from $10.04 to $10.96 per train mile, while the cost of fuel for HR ranges from $2.83 to 4.56 per mile. The cost savings estimate for replacing Metrolink service with HR was determined based on fuel cost savings of $5.48 to $8.13 per train mile.

8.1.3 Capital Cost Estimating Methodology

To accompany each operational scenario, rough order-of-magnitude capital cost estimates were developed to include double tracking along the SBL as described in Chapter 7, modifications to the legacy platforms, rolling stock, turnback tracks at the terminus station, and other system costs. Design allowances and allocated and unallocated contingencies are also included. Capital cost estimates for the Study are based on a preliminary five percent level of design. The format used for the estimate is the FTA Standard Cost Categories (SCC) for Major Capital Projects. The FTA SCC format presents the capital cost estimates in an industry-recognized format that considers all project components known to drive cost. The assumptions and limitations of the estimating process are further detailed in *Appendix F: Capital Cost Estimate Memo.*

8.2 Supplementing Existing Service

The scenario to supplement existing Metrolink service with HR involves two added HR trains in each direction during each weekday peak period (morning and afternoon), for a total of eight daily HR train trips between Pomona North and San Bernardino. The estimated annual O&M cost of this additional service is $1.4 million to $2.1 million.

Capital costs are comprised of the cost of additional HR vehicles. This scenario assumes a total of five HR train sets, with two in each direction and one train set as a spare. Each HR train set was estimated to cost approximately $7.5 million and the Arrow service would provide the three existing train sets for this scenario. Additional capital costs to supplement existing service with the two additional train sets is $20 million, including contingencies and spare parts.

Table 8-1: Costs for Supplementing Existing Service

Operating and Maintenance Costs	Capital Costs (2 new HR train sets)
$1.4M - $2.1M	$20M

Sources: HDR; Mott MacDonald

8.3 Converting Off-Peak Metrolink Service to Hybrid Rail

The scenario to replace off-peak Metrolink trains with HR involves replacing 16 Metrolink trains during low-ridership hours of the day. For weekend service it is assumed that HR trains would have sufficient capacity to replace all Metrolink trains in the current schedule. By operating HR trains instead of LHC, fuel cost savings could be in the range of $1.5 to 2.4 million annually.

8.4 Metrolink and HR Blended Service

O&M costs were estimated for four scenarios with HR service blended with existing Metrolink service.

- 30-minute limited bi-directional blended service between Pomona North and University
- 15-minute limited bi-directional blended service between Pomona North and University
- 30-minute limited bi-directional blended service between El Monte and University
- 15-minute limited bi-directional blended service between El Monte and University

The O&M cost of the HR service in these scenarios is summarized in Table 8-2.

Table 8-2: Annual O&M Cost for HR Service in Blended Service Scenarios

HYBRID RAIL SERVICE ROUTE	30-MINUTE BLENDED	15-MINUTE BLENDED
POMONA NORTH TO UNIVERSITY OF REDLANDS	$4.4M - $7.0M	$22.7M - $33.5M
EL MONTE TO UNIVERSITY OF REDLANDS	$6.2M - $9.8M	$35.8M - $54.9M

The capital cost estimates for these scenarios include rolling stock, legacy station modification, and turnback tracks at the noted terminus station, and are summarized in Table 8-3.

Table 8-3: Capital Costs for Blended Service Scenarios

HYBRID RAIL SERVICE ROUTE	30-MINUTE BLENDED	15-MINUTE BLENDED
POMONA NORTH TO UNIVERSITY OF REDLANDS	$20M	$259M
ADDITIONAL HR TRAIN SETS NEEDED	2	6
EL MONTE TO UNIVERSITY OF REDLANDS	$138M	$524M
ADDITIONAL HR TRAIN SETS NEEDED	6	13

Source: Mott MacDonald

8.5 Blended Service with Extension to Ontario Airport

In the blended service scenarios, the HR service to Ontario Airport would be operated as a rail shuttle from the Rancho Cucamonga Station to the two Airport terminals. O&M costs for these scenarios were estimated by adding the O&M cost of the rail shuttle service to the cost for operating the Pomona North to Redlands blended service. The total annual O&M cost for these scenarios is summarized in Table 8-4.

- Pomona to Redlands: 30-minute peak-direction, 60-minute reverse direction, with 30-minute service to Ontario Airport
- Pomona to Redlands: 15-minute peak-direction, 60-minute reverse direction, with 15-minute service to Ontario Airport

Table 8-4: Annual O&M Cost Estimates for Blended Service with Ontario Airport Connection

HYBRID RAIL SERVICE ROUTE	30-MINUTE BLENDED	15-MINUTE BLENDED
UNIVERSITY OF REDLANDS TO POMONA NORTH WITH RAIL SHUTTLE TO ONTARIO AIRPORT	$7.2M - $11.3M	$28.3M - $42.1M

Capital costs for the rail service to Ontario Airport were developed for the 2014 Ontario Airport Rail Access Study and were estimated to be $776 million in 2014 USD. This was escalated to $881.4 million in 2018 USD for the purposes of this Study, and includes additional infrastructure to meet the needs of a rail shuttle service described above.

8.6 Unconstrained Service

The cost estimate comparisons for the unconstrained service assume that existing Metrolink service is maintained between LAUS and Pomona and that two-direction all-day (18 hours) HR service is operated between Pomona and Redlands with no other rail service east of Pomona. Table 8-5 summarizes the cost difference between this level of HR service and the cost to operate the existing Metrolink service between Pomona and San Bernardino. The low end of the 30-minute service scenario is a negative number because the low-end estimate of O&M cost for 30-minute two-way service is less expensive than the cost to operate the existing Metrolink service.

Table 8-5: Potential O&M Cost Difference for HR Compared to LHC Service

HYBRID RAIL SERVICE ROUTE	30-MINUTE UNCONSTRAINED	20-MINUTE UNCONSTRAINED	15-MINUTE UNCONSTRAINED
POMONA NORTH TO UNIVERSITY	($6.7M) - $3.6M	$3.2M - $18.7M	$13.1M - $33.8M

Capital cost estimates for unconstrained service are shown in Table 8-6. The estimates include double track improvements, legacy platform modifications for HR vehicle compatibility, turnback tracks at the Pomona North Station, and rolling stock.

Table 8-6: Capital Cost Estimates for Infrastructure Improvements

HYBRID RAIL SERVICE ROUTE	30-MINUTE UNCONSTRAINED	20-MINUTE UNCONSTRAINED	15-MINUTE UNCONSTRAINED
POMONA NORTH TO UNIVERSITY	$42M	$75M	$259M

9 HR Rail Systems Technical Challenges

Question 8: What are the Rail Systems technical challenges of the current United State HR operators?

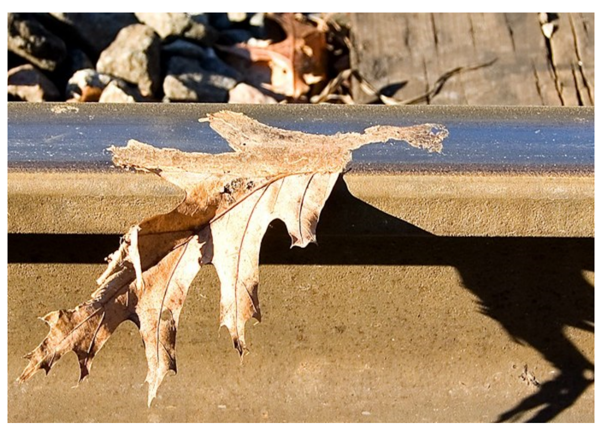
DMU rail vehicles currently in service in United States are lightweight rail vehicles that occasionally fail to shunt track circuits, resulting in loss of train detection. Loss-of-shunt (LOS) is associated with light axle loading, infrequent traffic, wheel tread building-up, and other conditions which raise wheel-rail contact resistance. The effects of LOS are exacerbated by certain types of track circuits such as grade crossing predictors (GCP) which are overly susceptible to LOS events.

9.1 Light Axel Loading

Light axle loading is the most common characteristic of vehicles that exhibit poor track circuit shunting performance. Lightly loaded axles (less than 8-10 tons) with low contact pressure between the wheel and rail are less capable of mechanically displacing or otherwise breaking-thru an insulating barrier of non-conducting build-up on wheel treads and railheads. The Stadler vehicle being considered for the Arrow service shows a non-loaded passenger weight of 120.6 tons (average of 15 tons per axel) and maximum axel weight of 18.6 tons.

9.2 Wheel-rail film

Track circuit shunting is impaired by the presence of any sort of barrier between the rail and wheel. Rust, sand, crushed leaves, top-of-rail lubricants, etc., prevents low resistance electrical contact between the wheel and rail. This well-established phenomenon is somewhat remarkable in view of the very high contact pressure between the wheel and rail, where the contact patch between the wheel and rail is less than the size of a dime.



An insulating film at the wheel-rail interface in combination with light axle loads results in poor shunting performance. Additionally, wheel profile, railhead profile, track curvature, gauge, etc., each play a role in shunting performance. These factors are usually unknown or uncontrolled, but there are mitigation measures such as high-rail vehicles with brushes that can remove the debris.

9.3 Track Circuit Types

Track circuits having a low inter-rail voltage at the receiver are more apt to experience LOS. Audio frequency overlays (AFO) such as AFTAC or PSO have very low inter-rail voltages in comparison to the 1-2 volts across the rails of Electrocode or 5-10 volts for a Style C circuit. The relatively large declining voltage gradient along the length of an AFO circuit is the unavoidable consequence of high(er) rail impedance at audio frequencies.

GCPs are a form of AFO track circuit which are unduly susceptible to malfunction caused by LOS. Noisy, intermittent shunting by lightly loaded leading axles causes premature activation of the crossing warning system. As the train recedes from the crossing, a noisy shunt will cause tail ringing (delayed clearing) or unintended restart of the crossing.

9.4 LOS Prevention Management

LOS occurrence can be mitigated through implementation of the following measures:

1. Lightly loaded unpowered axles at the ends of vehicles exacerbate LOS problems. Preference should be given to rail vehicles having the opposite configuration towards the leading axle.
2. Utilize high-rail vehicles equipped with rotating wire brushes that can clean the rail head on a regular schedule.
3. Implementing modifications to the existing train control system, such as:
    a. Replacing GCPs with Style C track circuits;
    b. Setting GCPs to operate in motion monitor mode;
    c. Replacing short HX island AFO circuits with FMCW radar units;
    d. Shortening long track circuits to allow increased inter-rail voltage;
    e. Identifying and correcting over-energized track circuits which may be unduly susceptible to LOS;
    f. Adding additional LOS time and sequential occupancy checks in signal control and route locking logic; and
    g. Supplement track circuit-based train detection with a check-in/check-out system utilizing AEI readers or video image recognition of vehicles at block boundaries. AREMA committees 37 and 39 are currently studying proposed requisites for alternative methods of train detection.

10 Conclusions and Next Steps

The Study evaluates the different levels of service and potential cost savings that can be achieved using hybrid rail vehicles to supplement and/or supplant existing LHC service on the SBL corridor. With today's infrastructure and schedules, four HR trains can be added on the SBL to complement Metrolink service. While there are also opportunities in the existing infrastructure and schedule to convert LHC to HR trains at reduced operational costs, but changes to equipment cycles on one line of the Metrolink system will have system-wide implications. Equipment cycles, crew schedules, and interfacing with other railroad operators such as freight and Amtrak services could be affected by any changes to Metrolink equipment schedules.

This study looked at both fitting HR trains into the existing Metrolink schedule by filling service gaps as well as unconstrained bi-directional service at regular clock-face intervals. A clock-face is a timetable system under which services run at consistent intervals, as opposed to a timetable schedule that has irregular headways. Currently, Metrolink does not run on a clock-face schedule but a timetable schedule that allows them to get as much service as possible, based on demand, and the available double track sections on the SBL. In order to complete this initial study, the team had to isolate the review of the SBL and does not take into account Metrolink's current practice of moving equipment throughout the larger system.

The Study discussed DMU loss-of-shunt issue confronting the current United States HR operators and presented potential mitigation solutions.

A system-wide approach would be the next step in order to understand how a blended fleet could be implemented on the SBL, provide increased service beyond these additional four trains and how those changes might impact the existing signal system on the San Bernardino Line. The next phase should also include a review of how the Eastern Maintenance Facility could be utilized to support HR train service beyond the six HR two-car sets that can be serviced at the maintenance facility being delivered as part of the RPRP. Other next steps included a ridership analysis and cost benefit analysis that examines the O&M savings as it relates to the capital investment.

A. Rail Modeling Summary Report

B. Infrastructure Improvement Designs

C. Maintenance and Service Facility Design Memo

D. Hybrid Rail and Legacy Platform Interface Memo

E. Operational Cost Estimate Memo

F. Capital Cost Estimate Memo