HATCH LTK
Positive Change for the Next Century

UTA Future of Light Rail

Phase 1 - Final Report

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Revision History

Revision No.	Date	Description of Revision
1	February 5, 2021	Initial release
2	March 16, 2021	Revised to reflect UTA review comments
3 (Final)	April 9, 2021	Revised to address freight operating rights negotiations, released as final

Introduction

The Future of Light Rail Study includes a comprehensive look at the UTA light rail network with a focus on future fleet needs and opportunities for growth in both service delivery and ridership. The network under study includes the existing Blue, Red and Green light rail lines as well as the S-Line streetcar. Phase 1 of the study looked at major investments, such as a new line serving the Granary District and development-rich opportunities around the former Denver & Rio Grande Railroad Station, as well as smaller scale service and operational improvements that would improve travel times and make the service more competitive with other modes.

The study was initiated just before the start of the COVID-19 pandemic and its pronounced impact on travel of all modes. Phase 1 of the study concluded in the new year 2021 with UTA reporting about a 60% drop in light rail ridership (and about a 45% drop in S-Line ridership) for 2020 versus the previous year. While this decline in ridership is significant, the percentage drop is actually lower than many of UTA's peer properties and offers hope for a strong rebound once the pandemic is over.

The TRAX system comprises three lines – Red Line, Blue Line and Green Line – which serve Salt Lake City and the surrounding suburbs in Salt Lake County. The Blue Line provides service from Salt Lake Central to Draper Town Center. The Red Line provides service from University Medical Center to Daybreak Parkway. The Green Line provides service from the Salt Lake City Airport to West Valley Central. The Sugar House Streetcar (S Line) connects with the light rail network but uses dedicated vehicles in a stand-alone service.

Study Purpose

The study evaluated a range of short and long term improvements related to fleet modifications, headways and span of service, alignments of track extensions, planned and potential station locations, considering projects identified in regional transportation plans and other potential enhancements. The impact of each alternative to the system at large, including associated costs, was examined. The study considered existing conditions, operational changes in terms of travel time, capacity and reliability and costs of various improvements.

Concurrent with the Future of Light Rail Phase 1 work, separate studies are being performed that consider transit improvements on certain corridors that may evaluate potential light rail alignments. At the conclusion of Phase 1, those other studies were either still in progress or had removed light rail alternatives from further consideration. Therefore, Phase 1 evaluated likely results from three studies to aid in decision making regarding the impacts of all related work on the light rail system. Those results include: not extending the Blue Line as light rail from the Point of the Mountain study, one alignment alternative through the Granary district from the Downtown TRAX study, and an alternative end of line in Research Park from the University of Utah real estate plan for that part of campus.

Figure 1 shows the relationship with Phase 1 and Phase 2 of the study. In Phase 2, the consultant team and UTA will develop a range of scenarios to accomplish project goals and objectives. Scenarios will be identified and evaluated that include logical compilations of projects. Scenarios will include both short and long term improvements including enhancements to the existing system, including span and frequency improvements, route re-alignments, fleet modifications, safety improvements, as well as potential expansion concepts including extensions and infill stations and their associated fleet and facility needs and include their associated planning level costs. Existing and planned

FrontRunner and feeder/connecting bus services will also be incorporated to evaluate the alternatives from the perspective of the entire transit system.

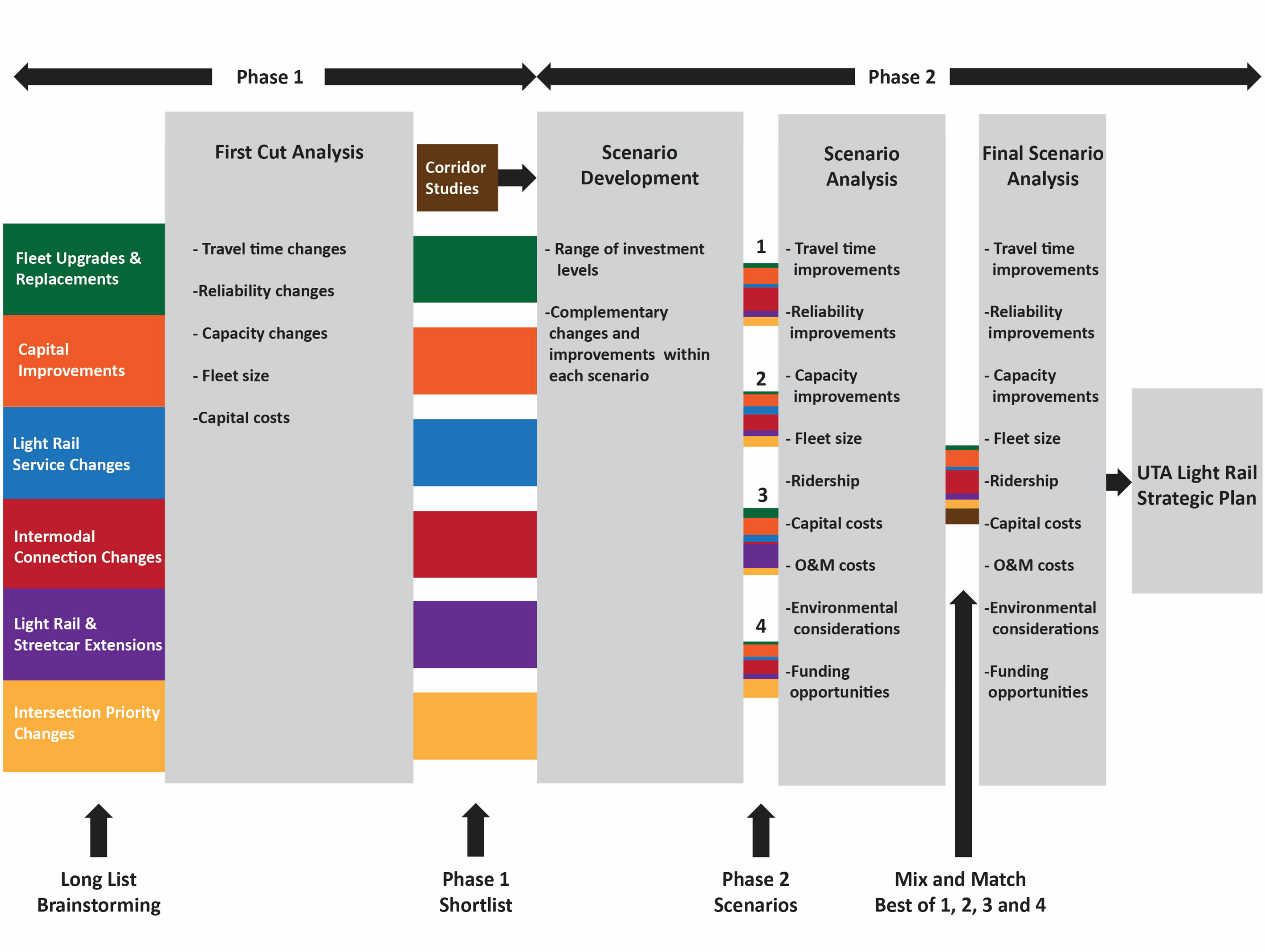

Figure 1 – Relationship of Phase 1 and Phase 2 of the Study

Working with the study Technical Advisory Committee (TAC) and other stakeholders, the consultant team and UTA will develop a range of investment package scenarios in Phase 2 to accomplish project goals and objectives. The five investment package scenarios will be designed to:

+ Represent a range of investment levels,
+ Include complementary – not competing – improvements,
+ To the greatest extent possible, allow the benefits of individual improvements to be estimated.

Figure 2 includes the WFRC and MAG 2019-2050 Regional Transportation Plan light rail expansions as well as other more focused improvements identified by the consultant team and served as a starting point for Phase 1 discussions. The figure shows the two TRAX segments with temporally-separated freight service; the benefit and cost of eliminating freight traffic from the main line was evaluated.

Phase 2 of the study will recommend:

+ A phased approach to implementing realistic incremental enhancements that will meet immediate needs and improve operational efficiencies,
+ Capital improvements that increase capacity to accommodate future growth,
+ A final version of the light rail fleet plan, and
+ A proposed light rail system plan to be considered for the 2023-2050 RTP.

Phase 2 deliverables will include a Scenarios (Alternatives) Report which details the improvements package of each of the five investment package scenarios, the focus of the scenario in terms of growing light rail ridership, and associated planning-level capital and O&M costs.

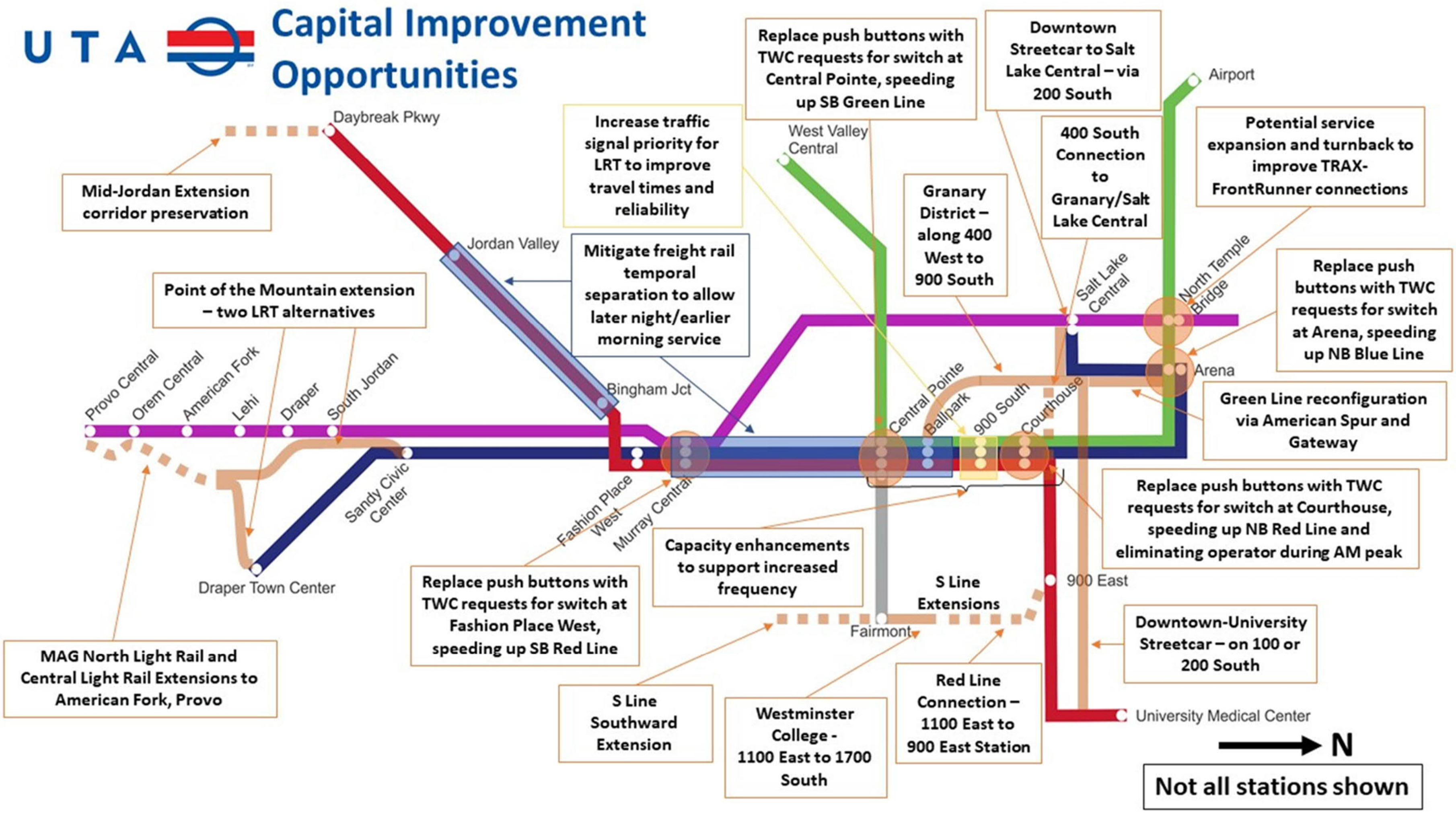

Figure 2 – Capital Improvement Opportunities

Existing Light Rail Operations and Infrastructure

The Baseline simulation model was developed using UTA-provided track charts and signal control line drawings. The TrainOps simulation model includes the following four lines:

+ TRAX Blue Line: between Salt Lake Central and Draper Town Center
+ TRAX Red Line: between University Medical Center and Daybreak Parkway
+ TRAX Green Line: between Airport and West Valley Central
+ Sugar House Streetcar (S Line): between Central Pointe and Fairmont

Although the infrastructure of Sugar House Streetcar was developed in the model as part of the effort, the focus of the Phase 1 simulation scenarios is on the TRAX system (Blue, Red and Green Lines).

Existing Light Rail Fleet

Two types of vehicles were used in the modeling and simulation - Siemens SD100 and Siemens S70. UTA's fleet includes a third vehicle type, the SD160, but this was not explicitly modeled as its performance is comparable to the SD100 (the SD160 is capable of operating at 65 MPH versus the 55 MPH top speed of the SD100 but does not normally attain this speed in revenue service because of the mixed SD100/SD160 train consists). The SD100 fleet normally operates only on the Blue Line while the S70 fleet serves all other lines. The specifications for the simulated vehicles are shown in Table 1. The underlying tractive effort curve for Siemens SD100 is shown in Figure 3 and Table 2, and the tractive effort curve for Siemens S70 is shown in Figure 4 and Table 3.

Table 1 – Vehicle Specifications for Simulation

	Siemens SD100	Siemens S70
Length (ft)	81.43	81.40
Empty Weight (lbs)	88,000	96,499
Number of Axles	6	6
Passenger Capacity (100% Seated)	60	60
Simulated Passenger Weight (Seated) (lbs)	10500	10500
Deceleration Adhesion (%)	28	28
Derate Tractive Power for Auxiliary Load	No	No
Design Maximum Speed (mph)	65	65
Operation Maximum Speed (mph)	55	65
Initial Acceleration Limit (mph/s)	3	3
Service Brake Rate (mph/s)	3	3
Rotational Weight (lbs)	9,000	11,023
Rotational Weight as a % of Empty Weight (%)	10.23	11.42
Frontal Area (ft^2)	102	107

Table 2 – Tractive Effort SD100					
Velocity (mph)	Tractive Effort (lbf)	Velocity (mph)	Tractive Effort (lbf)	Velocity (mph)	Tractive Effort (lbf)
0	15511.33	20	14731.38	40	7575.70
1	15487.50	21	14315.65	41	7393.07
2	15453.82	22	13872.26	42	7189.57
3	15408.99	23	13443.93	43	6937.90
4	15430.24	24	12981.17	44	6648.22
5	15386.18	25	12463.62	45	6327.01
6	15383.03	26	11941.29	46	5962.91
7	15370.14	27	11457.69	47	5555.52
8	15344.52	28	11022.30	48	5171.07
9	15345.13	29	10649.60	49	4830.43
10	15375.03	30	10267.31	50	4523.28
11	15431.73	31	9867.61	51	4245.19
12	15475.14	32	9509.74	52	4017.88
13	15522.68	33	9207.77	53	3876.11
14	15545.34	34	8939.22	54	3812.28
15	15527.62	35	8674.22	55	3769.76
16	15496.88	36	8427.09	65	2600.00
17	15422.76	37	8147.20		
18	15276.29	38	7880.88		
19	15048.46	39	7722.52		

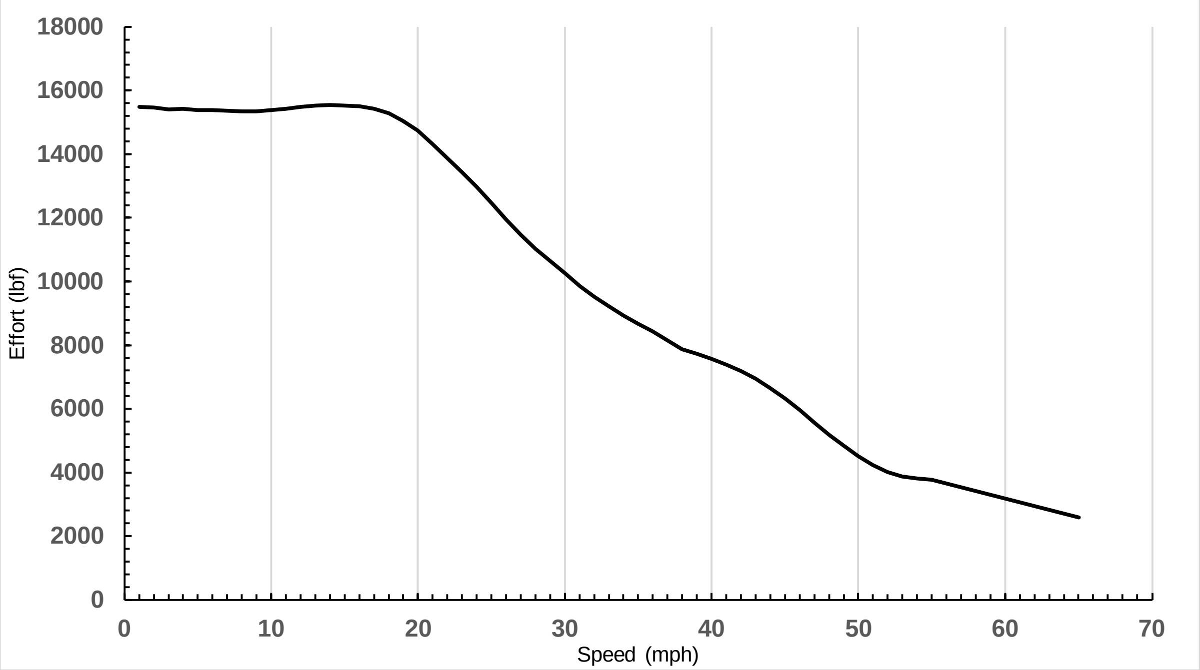

Figure 3 – Siemens SD100 Tractive Effort

Table 3 – Tractive Effort S70	
Velocity (mph)	**Tractive Effort (lbf)**
0	19108.76
21.748	19108.76
24.855	16721.29
27.962	14862.12
30.758	13511.02
34.175	10943.70
37.282	9196.93
40.389	7836.84
43.496	6755.51
46.603	5885.50
49.71	5172.85
52.817	4581.61
55.923	4087.03
59.03	3668.88
62.137	3311.44
65.244	3003.45

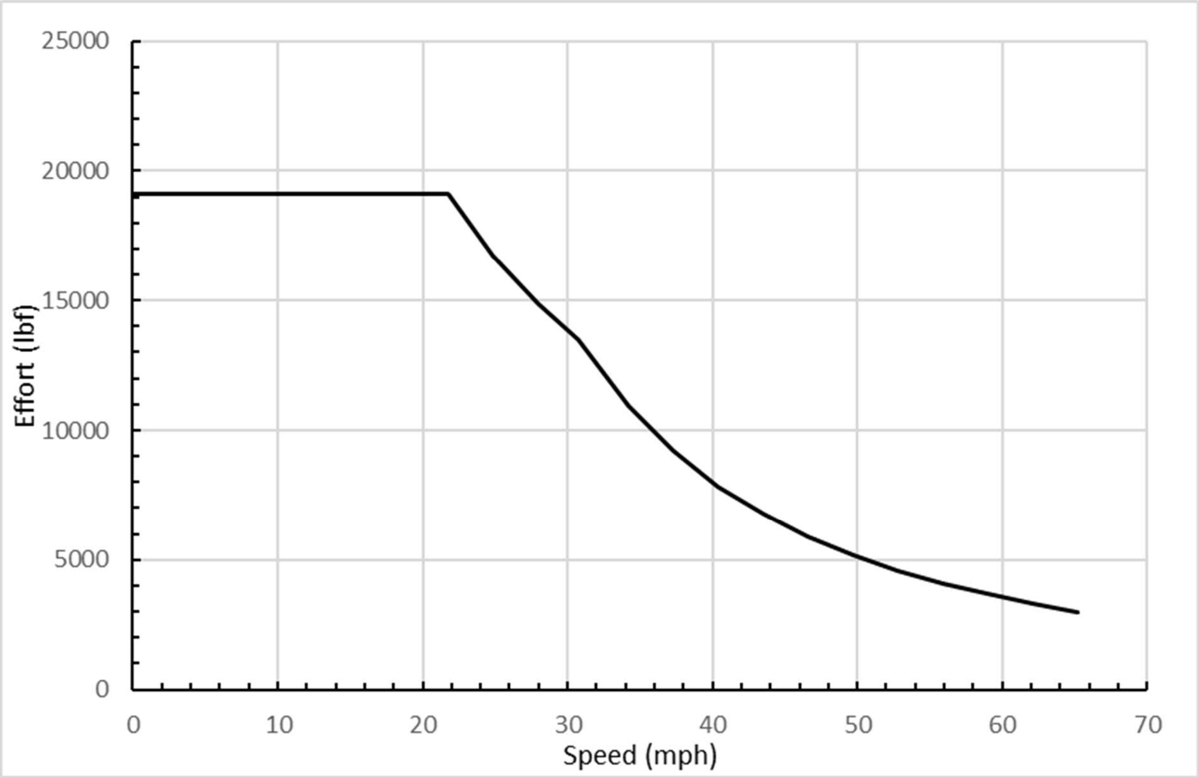

Figure 4 – Siemens S70 Tractive Effort

Existing Civil Speed Restrictions

The Hatch LTK team was directed to model the civil speed restrictions in the northbound and southbound travel directions based on the TRAX Speed Map. In street running segments, (primarily Courthouse to University Medical Center, Ballpark to Salt Lake Central) speeds are generally consistent with adjacent traffic speeds and do not exceed 35 MPH. At intersections, 90-degree turns are generally limited to 10 MPH. Where TRAX operates in its own right-of-way, maximum speeds are generally 55 to 65 MPH with some civil speed restrictions (primarily curves) limiting speed to lower values. Most of the segments with speeds higher than 55 MPH are on the Blue and Red Lines south of Fashion Place West.

Existing Wayside Signaling

TRAX is equipped with a railroad style wayside signal system. The system does not include a cab signal overlay or red signal enforcement using trip stops or Positive Train Control type profiling. The wayside signals and control lines modeled in the simulation are based on the UTA-provided signal control line drawings. With few exceptions, the signal aspect sequences are green (proceed), yellow (caution), red (stop) approaching occupied signal blocks ahead or interlockings where the route has not yet been established. Due to signal control line drawings not matching as-in-service conditions, assumptions were made for the control line connections between Ballpark Station and Sandy Civic Center Station according to instructions received from UTA.

Existing Intersection Priorities/Delay Probabilities

At 88 intersections between the route of the street-running portion of the TRAX network and cross-streets, the movement of TRAX vehicles are governed by the street traffic signals. At these locations, the trains may be delayed if arrival at the intersection is not synchronized with a permissive phase of the traffic signal cycle.

There are 15 traffic signals along the TRAX lines that use pre-emption in place of priority. With pre-emption, the operations of the signal will be interrupted to allow the train to pass through the signal without stopping. Pre-emption is often used at more isolated traffic signals or locations where the trains are traveling at higher speeds. This also has a more significant impact on vehicle traffic at the intersections.

At the other 73 locations, stopping probabilities and hold times at traffic lights were used to model the chances of TRAX trains having to stop at intersections for red traffic lights. The stopping probabilities and hold times can vary throughout a 24-hour period day. Figure 5 illustrates a TrainOps simulation example of the street signal pattern defining delay probabilities at the intersection of 500S and 1300E in the westbound travel direction. This shows, for example, that trains in the morning peak period at this intersection have a 49 percent probability of needing to stop at this intersection in this direction. If the train does need to stop, based on randomization in TrainOps, it will wait 32 seconds before proceeding. These delay probabilities were developed by the Hatch LTK Team based on review of traffic controller settings and discussions with UDOT and municipal traffic engineers. Details of the street signal pattern at other intersections are found in Appendix A – Operations and Maintenance Cost Estimating Methodology.

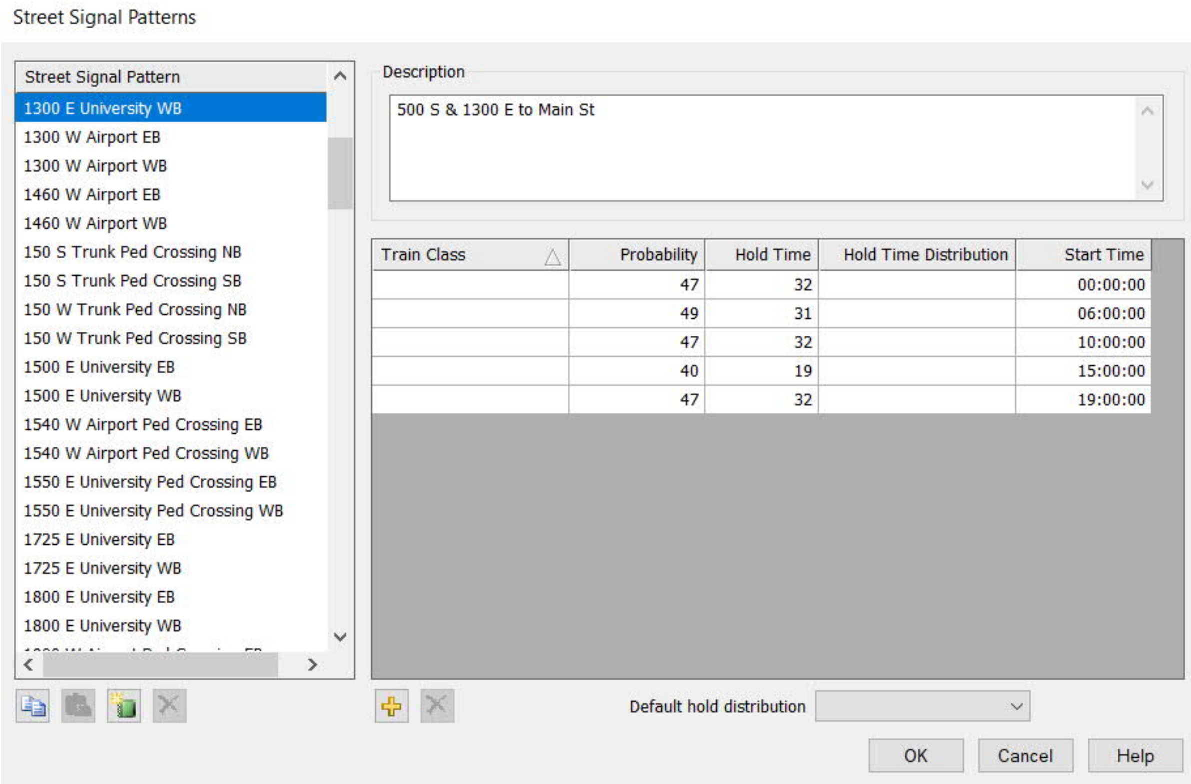

Figure 5 – Example of TrainOps Light Simulation Intersection Stopping Probabilities and Hold Times

Existing TRAX Baseline Operating Plan

Existing TRAX Baseline Operating Plan: Schedule

The pre-COVID weekday operating plan that was scheduled to take effective on April 5, 2020 (but was not actually operated due to COVID-related ridership impacts) was provided by the UTA to be used in the simulation. The 24-hour simulation of a full day service plan models the interaction of trains along the Blue, Red and Green Lines as well as on the S-Line . This includes the non-revenue moves needed to bring trains in and out of the Midvale and Jordan River Service Centers, each consisting of a yard and a light rail vehicle maintenance facility. The full operating plan can be viewed in Appendix D – Existing (pre-COVID) Baseline Operating Plan.

Existing TRAX Baseline Operating Plan: Train Consists

In the Existing Baseline scenario, the Blue Line runs SD100 vehicles and the Red Line and Green Line run S70 vehicles. The Blue Line and Green Line each run eight trains throughout the day, and the Red Line runs 13 trains. The car counts of these trains varies throughout the day, with trains adding or removing cars.

Existing TRAX Baseline Operating Plan: Train Routing

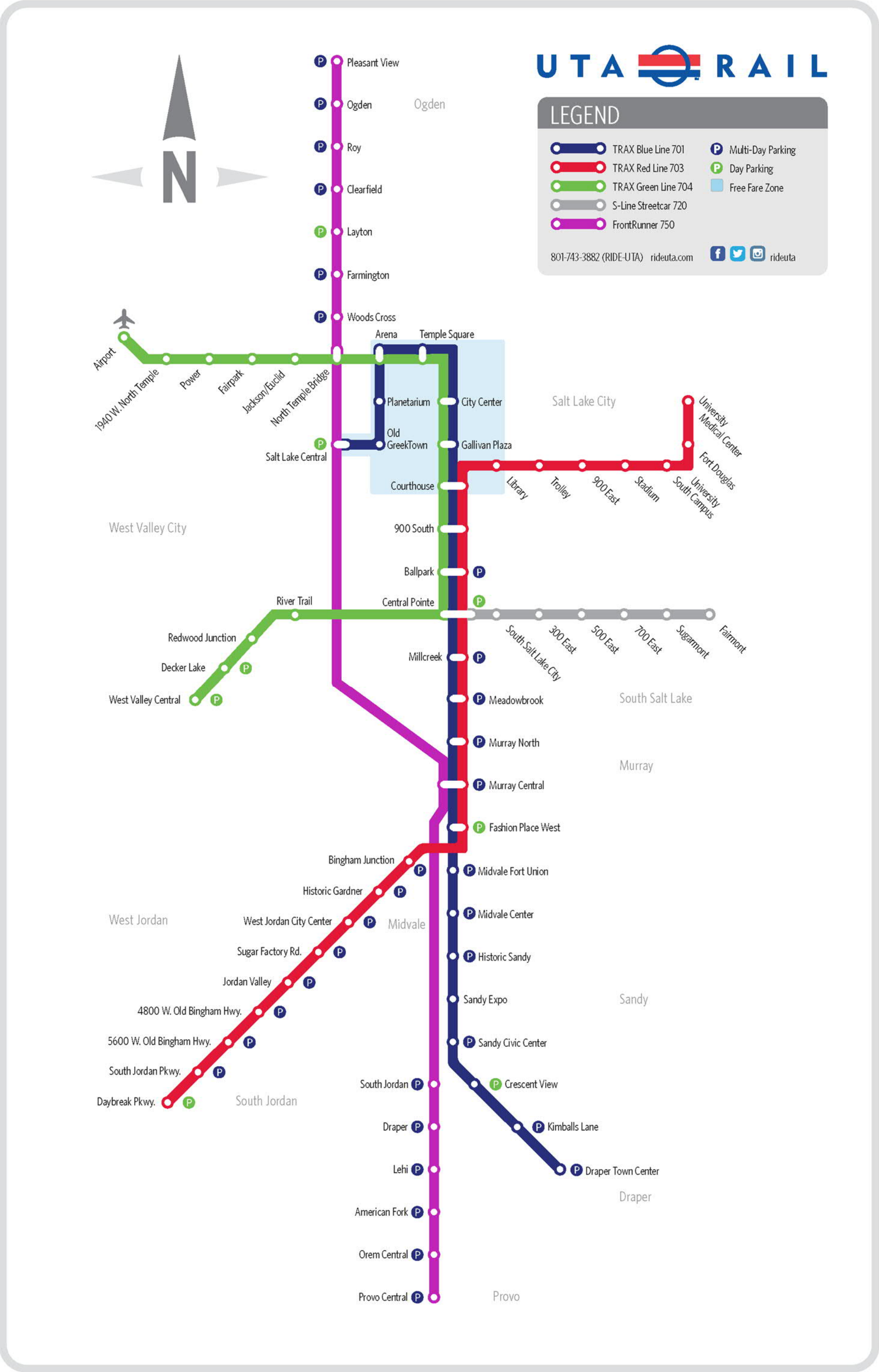

Figure 6 – Existing UTA Blue, Red and Green Line Routes

The UTA light rail network and routing of the three light rail lines is shown in Figure 6. Aside from the S-Line, the TRAX network is fully double tracked. Trains normally operate with right-hand running, except at terminals. All six TRAX light rail terminals have two tracks, allowing two trains to "turn" (change direction) simultaneously. Under normal scheduled operations, only one train at a time is scheduled to be at each terminal. Therefore, conflicts at the terminal throat crossovers are rare, occurring only when the TRAX system is recovering from a major delay and some trips are off-schedule.

Existing TRAX Baseline Operating Plan: Dwells and Terminal Turn Time

Dwell time data was compiled for the TRAX network from provided Automatic Passenger Counter (APC) data for the 2019 calendar year. To capture the variability in the real-world operation, normal distributions were used to model the dwell times at stations. Figure 7 shows an example of a typical dwell time distribution for one TRAX station in one direction. These distributions were created using a minimum and maximum value, the mean and the standard deviation based on the APC data.

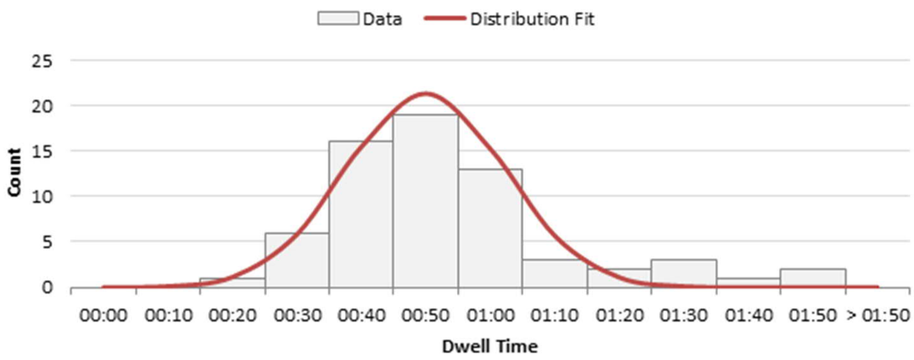

Figure 7 – Example of Normal Distribution

There are specific distributions for each station depending on the time of the day (AM Peak, PM Peak, or Off-Peak), direction and service line (Red, Blue, Green, or Sugarhouse). Table 4 is an example of the dwell time distribution for 1940 W North Temple on Green Line. A full list of station dwell times can be found in Appendix G – Light Simulation Dwell Time Distributions.

Table 4 – Example of Dwell Data for Normal Distribution (seconds)

	Min	Max	Mean	Standard Deviation
G-1940 W North Temple-PM Peak-NB	18	76	39	25
G-1940 W North Temple-PM Peak-SB	19	63	35	21
G-1940 W North Temple-AM Peak-NB	18	57	32	18
G-1940 W North Temple-AM Peak-SB	19	63	34	22
G-1940 W North Temple-Off-Peak-NB	18	56	31	21
G-1940 W North Temple-Off-Peak-SB	17	56	30	20

Existing TRAX Baseline Operating Plan: Minimum Required Train Turn Times

The simulation model uses both scheduled and minimum required train turn times at terminals. During disrupted operations, there may be insufficient time for the Train Operator to walk the train and prepare to depart in the opposite direction, while maintaining schedule. The minimum required turn times were provided by UTA Light Rail Operations with the understanding that they are not for scheduling purposes but rather reflect conscientious Train Operators striving to return to scheduled operation. The reverse turn time was set as 4 minutes at all terminals while the reverse turn time at non-terminal stations was set as 3 minutes. These non-terminal reversing moves usually occur at Central Pointe and Fashion Place West stations, , as well as a reversing move within Jordan River Service Center to reach West Valley Central station.

Existing Operations Calibration

Existing Operations Calibration: Velocity Profiles

For the speed limits calibration, one trip from each line in each direction was simulated to produce the velocity profile of each track; only one trip was running in the network at any time of the simulation to prevent interference that may cause deceleration or stopping of train. The variability was turned off to ensure the trains were able to run at its maximum allowable speed. The speed restrictions were calibrated to match the data collected from the real-world operations on the GPS Data vs TrainOps Simulation Trip Graph Overlay, and can be found in Appendix H – Light Simulation Calibration - GPS Data Recording of Actual Operations vs Existing Baseline Simulation Trip Graphs

Existing Operations Calibration: On-Time Performance

To capture real-world operations more accurately, the simulations were run five times, each receiving a new set of values for dwell times (using the distributions). The average On-Time Performance (OTP) of five sets of simulations was 91.5%, which is above the 90% OTP target. Table 5 shows the comparison of the simulation results and the monthly highest, lowest, and average OTP from the APC data. The lateness threshold in the simulation was set at 4 mins and 59 sec.

Table 5 – Comparison of On-Time Performance Between APC Data and Baseline Simulation

TRAX Line	Monthly Lowest (%)	Monthly Highest (%)	Monthly Average (%)	Simulation Average (%)
Blue Line	87.2	95.8	92.9	94.7
Red Line	89.6	96.8	91.6	92.0
Green Line	85.0	97.7	93.0	86.4

Existing Baseline Simulation Results

Existing Baseline Simulation Results: Delay Graphic

Figure 8 shows the Delay Graphic which presents the average delay per trip based on the baseline simulation results. Intersection delay (represented by circles) refers to the delays at intersections caused by the traffic light, while train delay (represented by triangles) refers to trains stopped due to other trains ahead and conflicting routes reserved or occupied at junctions/crossings.

From the Delay Graphic, it can be seen that most delays were distributed in the north of the network. Comparing to the train delays, intersection delays were making a greater impact on the On-Time Performance. Additionally, trains are more likely to undergo larger intersection delays on the area near Airport Station and West Valley Central. The intersection delays on the segment between 900 South Station and Fort Douglas Station were more significant than other areas.

Train delays were mainly distributed around junctions with the merges near Arena Station, Courthouse Station and Central Pointe Station constituting the most significant train congestion locations.

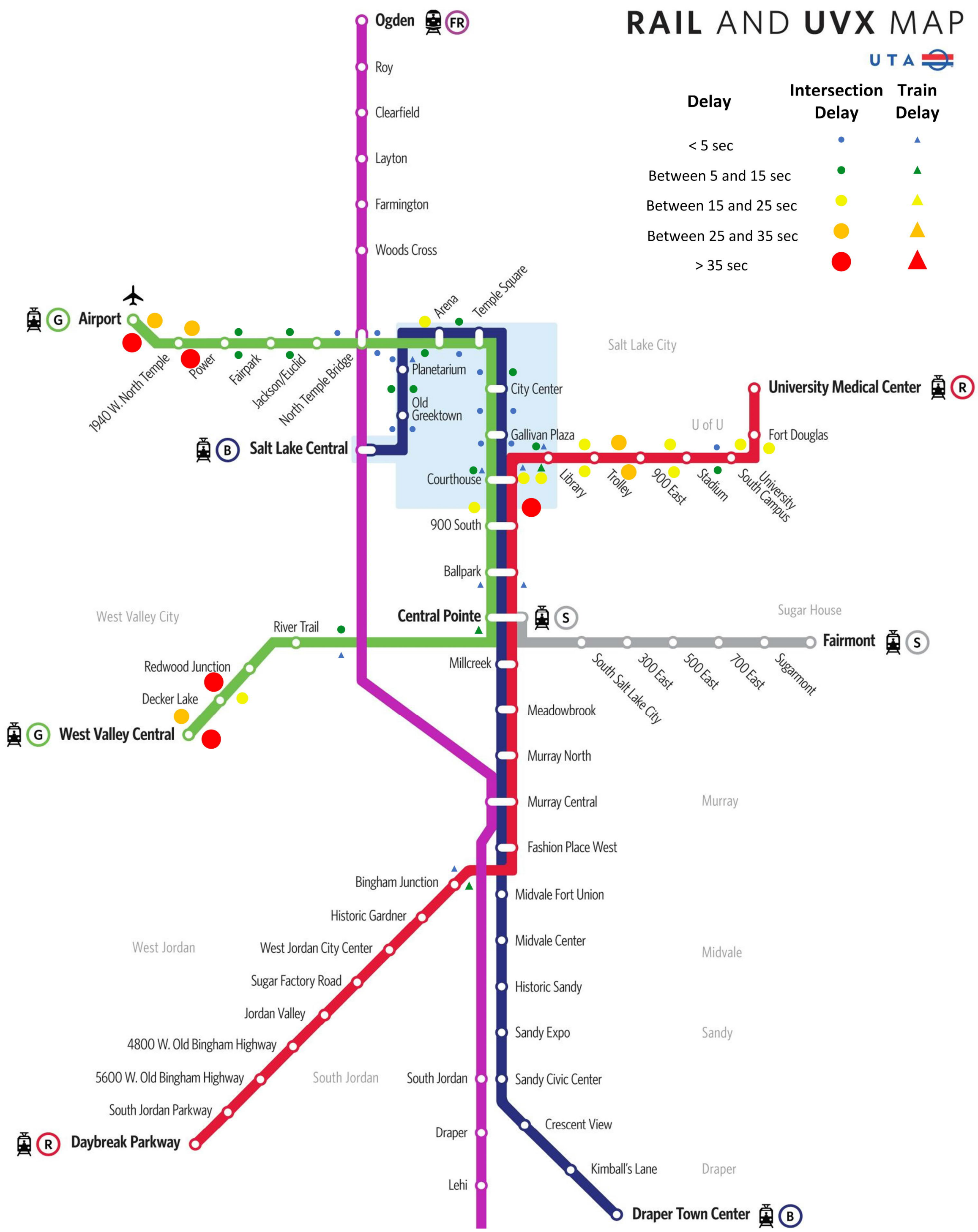

Figure 8 – Simulated Delay Results in Baseline Simulation Scenario

Existing Baseline Simulation Results: String Charts

The TrainOps time-distance ("string") charts show the simulated TRAX system during morning peak time between 7:30 AM and 8:30 AM. The left y-axis shows the stations in orange while the location along the route as measured in feet from starting station is shown on the right y-axis. The x-axis illustrates the time as the trains move along the y-axis. The time-distance (“string”) charts use dashed lines to show the scheduled activity for the train trips and solid lines colored by route for the simulated traces of train trips.

Station dwells and stopped delays in the string chart appear as horizontal portions of the string lines. Changes in train speed due to delays or temporary speed restrictions are seen by lines that demonstrate less steepness in gradient than those for typical trips.

Delays can be observed when comparing the dashed lines of a scheduled train trip to the solid lines of the same simulated train trip. For example, by inspecting the gap between the solid line and the dashed line on Figure 9 it can be seen that Blue Line trip 10-04 NB (starting from Draper Town Center but shown in the graphic south of Central Pointe) was running on time until just before Courthouse Station. Then it was gradually running behind the schedule since it was suffering delays between Courthouse Station and City Center Station.

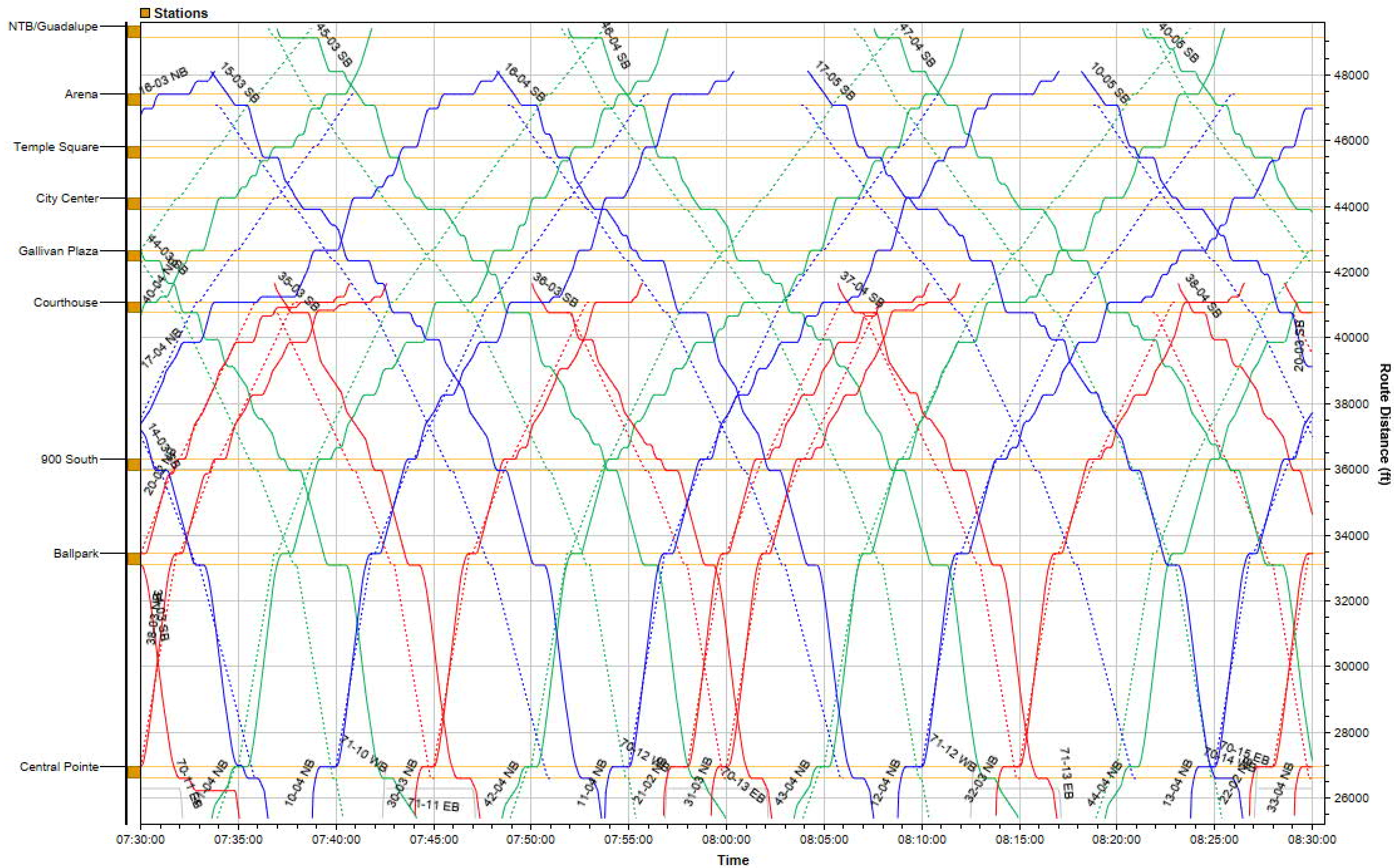

Figure 9 – Existing Baseline – Time-Distance ("String") Chart –
TRAX Trunk between Central Pointe and North Temple Bridge – 7:30 AM and 8:30 AM

Existing Baseline Simulation Results: Peak Fleet Requirement

The equipment cycles were evaluated to determine the peak fleet requirement for the Existing Baseline simulation. Table 6 shows the breakdown by line and by vehicle type. The Blue Line utilizes SD100 and SD160 vehicles while the Red Line and Green Line utilize S70 vehicles. The combined Peak Fleet Requirement is 26 SD100/SD160 cars and 61 S70 cars, for a total of 29 trains and 87 cars.

Table 6 – Existing Baseline – Peak Fleet Requirement

	Siemens SD100/SD160		Siemens S70		Combined	
Future Baseline	**# Cars**	**# Trains**	**# Cars**	**# Trains**	**# Cars**	**# Trains**
Blue Line	26	8	0	0	26	8
Red Line	0	0	45	13	45	13
Green Line	0	0	16	8	16	8
Combined	**26**	**8**	**61**	**21**	**87**	**29**

Existing Baseline Simulation Results: Discussion

The on-time performance (OTP) is calculated based on scheduled lateness departing individual stations or arriving at the final station. A train may be up to 4 minutes and 59 seconds late and considered on time. The goal of the baseline modeling effort was to produce an average OTP of 90% (to match real world data) at the 4 minute and 59 second lateness threshold. This was done using five different random numbers as shown in Table 7 to capture the real-world variability presented in the UTA data. The resulting combined average OTP of 90.8% is close to the 90% calibration target and deemed to be acceptable. The combined OTP of different random numbers was stable, varying in a range between 88.4% and 91.7%.

As observed in the Delay Graphic, the areas more prone to delays in the simulation were the Green Line terminals, and the segment between 900 South Station and Fort Douglas Station. Future simulation scenarios considered infrastructure and operational improvements focused on this segment with appropriate capital investments, to further improve individual OTP for each TRAX train line, and hence the combined average OTP for the entire TRAX system.

Table 7 – Existing Baseline – On-Time Performance				
	TRAX Train Line			
Existing Baseline	Blue Line	Red Line	Green Line	Combined Average
Run 1	93.3%	93.3%	86.2%	**91.4%**
Run 2	94.8%	92.1%	86.6%	**91.6%**
Run 3	94.7%	90.8%	86.6%	**91.1%**
Run 4	94.4%	93.5%	85.5%	**91.7%**
Run 5	95.1%	83.9%	85.9%	**88.4%**
Combined Average	**94.4%**	**90.7%**	**86.2%**	**90.8%**

Future Baseline Scenario

The Future Baseline Scenario was developed from the Existing Baseline model, with the intention of being used as a baseline to compare the future individual improvement scenario results against. This scenario includes a new 650 South Station and a relocated Airport Station.

Future Baseline Infrastructure

The Future Baseline Scenario utilized the infrastructure of the Existing Baseline but incorporated two infrastructure upgrades:

- Relocation of the Airport Terminal Station along TRAX Green Line
- A new platform, 650 South Station, along TRAX Trunk Line

Future Baseline Infrastructure: Relocation of Airport Terminal Station

An extension of the existing terminal tracks of approximately 750 ft westbound is planned. The new proposed Airport Terminal Station is relocated to a new extension of the terminal tracks (and new Airport Terminal Building). The new Airport Station is situated between stationing 991+84 ft and 995+39 ft on the Eastbound track and between stationing 991+46 ft and 995+01 ft on the Westbound track. The grade and curve profile for this track extension are assumed to be negligible. Figure 10 illustrates the track plan drawing for the new location of the Airport Terminal Station.

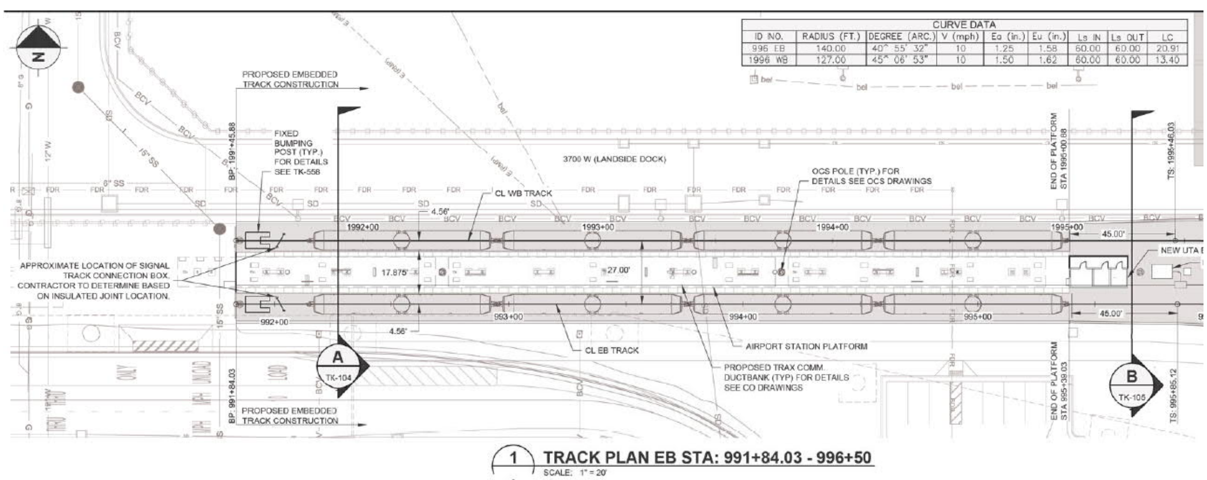

Figure 10 – Future Baseline Relocation of Airport Terminal Station (supplied by UTA)

This relocated station is utilized in all future improvement scenarios.

Future Baseline Infrastructure: New 650 South Station

UTA is also planning to build a new TRAX station in downtown Salt Lake City at the T-intersection of 650 South St and Main St, which is approximately 4 blocks north of 900 South Station and 2 blocks south of Courthouse Station. This new station, designated as 650 South Station, will be located between the existing station at 900 South Station and Courthouse Station as shown in Figure 11. Hatch LTK modeled this new future station on the tangent section of the track, from stationing 755+73 ft to 758+88 ft on both Northbound and Southbound tracks.

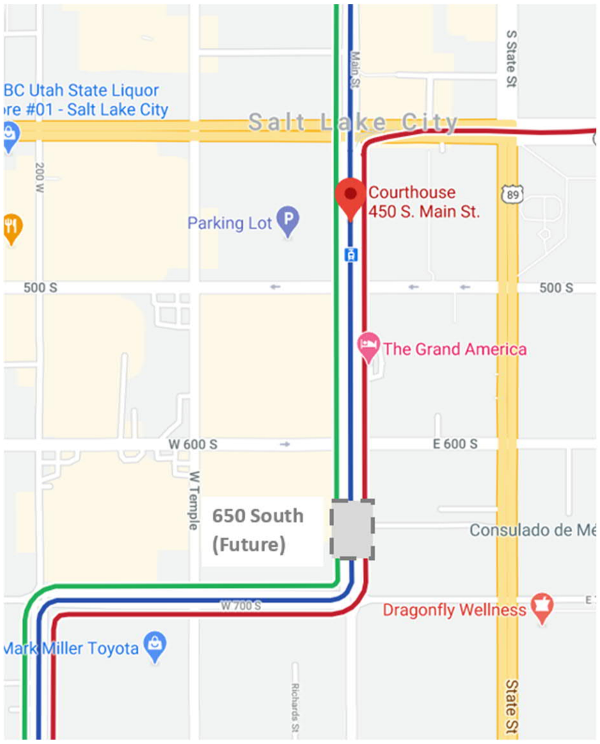

Figure 11 – 650 South Station for Future Baseline (and Future Build 1, 2, 3, and 6)

There are no changes in civil speed restrictions, wayside signaling or fleet assumptions from the Existing Baseline model. Similarly, minimum terminal turn times and intersection priorities were unchanged in the simulation.

Future Baseline Operations

The Future Baseline Scenario incorporated some changes requested by UTA from the Existing Baseline model. The dispatch time for all southbound trains on the TRAX Red, Blue and Green Lines was scheduled to depart 1 minute earlier due to an additional 1-minute travel time added to the schedule. In addition, the southbound trains departing from Airport Terminal Station (Green Line) were set to be 1 minute earlier due to the Airport terminal track extension. The trunk section between Central Pointe Station and Courthouse Station was maintained with a uniform 5-minute headway in both directions with 15 minute headways on each of the three branch lines.

The change of dispatch time and travel times are summarized in Table 8 and Table 9.

Table 8 – Future Baseline – Change in Terminal Dispatch Times							
Schedule Changes* (min)						Headway (min)	
Blue NB	Blue SB	Red NB	Red SB	Green NB	Green SB	Trunk Line (between Courthouse and Central Pointe)	Branch Line
No change	-1	No change	-1	No change	-2	5	15

*Compared to Existing Baseline schedule.
"-" indicates an earlier departure time, "+" indicates a later departure time

Table 9 – Future Baseline – Change in Terminal-Terminal Scheduled Travel Times					
Travel Time Changes* (min)					
Blue NB	Blue SB	Red NB	Red SB	Green NB	Green SB
+1	+1	+1	+1	+2	+2

*Compared to Existing Baseline schedule.
"-" indicated amount of time removed, "+" indicates amount of additional time added

Future Baseline Operations: Dwells

The station dwell distributions from the Existing Baseline were retained for the Future Baseline. The new 650 South Station utilizes the dwell distribution used at 900 South Station. A full list of station dwell times can be found in Appendix G – Light Simulation Dwell Time Distributions.

Future Baseline Simulation Results

Future Baseline Simulation Results: On-Time Performance (OTP)

Each scenario was run five times, with the TrainOps variability feature turned on to produce a set of randomized simulation results. The train lateness threshold was set at 4 minutes and 59 seconds. Table 10 shows the Future Baseline model was able to achieve an OTP of 92.5% for the combined average of the three TRAX Lines (Red, Blue and Green). As shown in Table 11, this is almost 2% higher than the Existing Baseline Scenario.

Table 10 – Future Baseline – On-Time Performance				
	TRAX Train Line			
Future Baseline	Blue Line	Red Line	Green Line	Combined Average
Run 1	96.8%	90.3%	92.1%	**93.1%**
Run 2	95.9%	89.1%	93.0%	**92.5%**
Run 3	95.7%	93.2%	95.2%	**94.6%**
Run 4	94.2%	94.6%	90.0%	**93.2%**
Run 5	97.2%	78.5%	92.9%	**89.0%**
Combined Average	**96.0%**	**89.1%**	**92.6%**	**92.5%**

Table 11 – On-Time Performance Comparison – Existing Baseline vs Future Baseline		
	TRAX Train Lines Combined Average	
Existing Baseline	Existing Baseline	Future Baseline
Run 1	**91.4%**	**93.1%**
Run 2	**91.6%**	**92.5%**
Run 3	**91.1%**	**94.6%**
Run 4	**91.7%**	**93.2%**
Run 5	**88.4%**	**89.0%**
Combined Average	**90.8%**	**92.5%**

Future Baseline Simulation Results: String Charts

Delays can be observed when comparing the dashed lines of a scheduled train trip to the solid lines of the same simulated train trip. For example, Figure 12 shows Blue Line trip 10-04 NB (starting from Draper Town Center) running on time until it leaves Courthouse Station. North of Courthouse, the trip experiences significant intersection delays and station dwell variability that cause it to leave Arena Station about three minutes late. The figure also shows that southbound Green Line trips are consistently running late when they arrive at Ballpark.

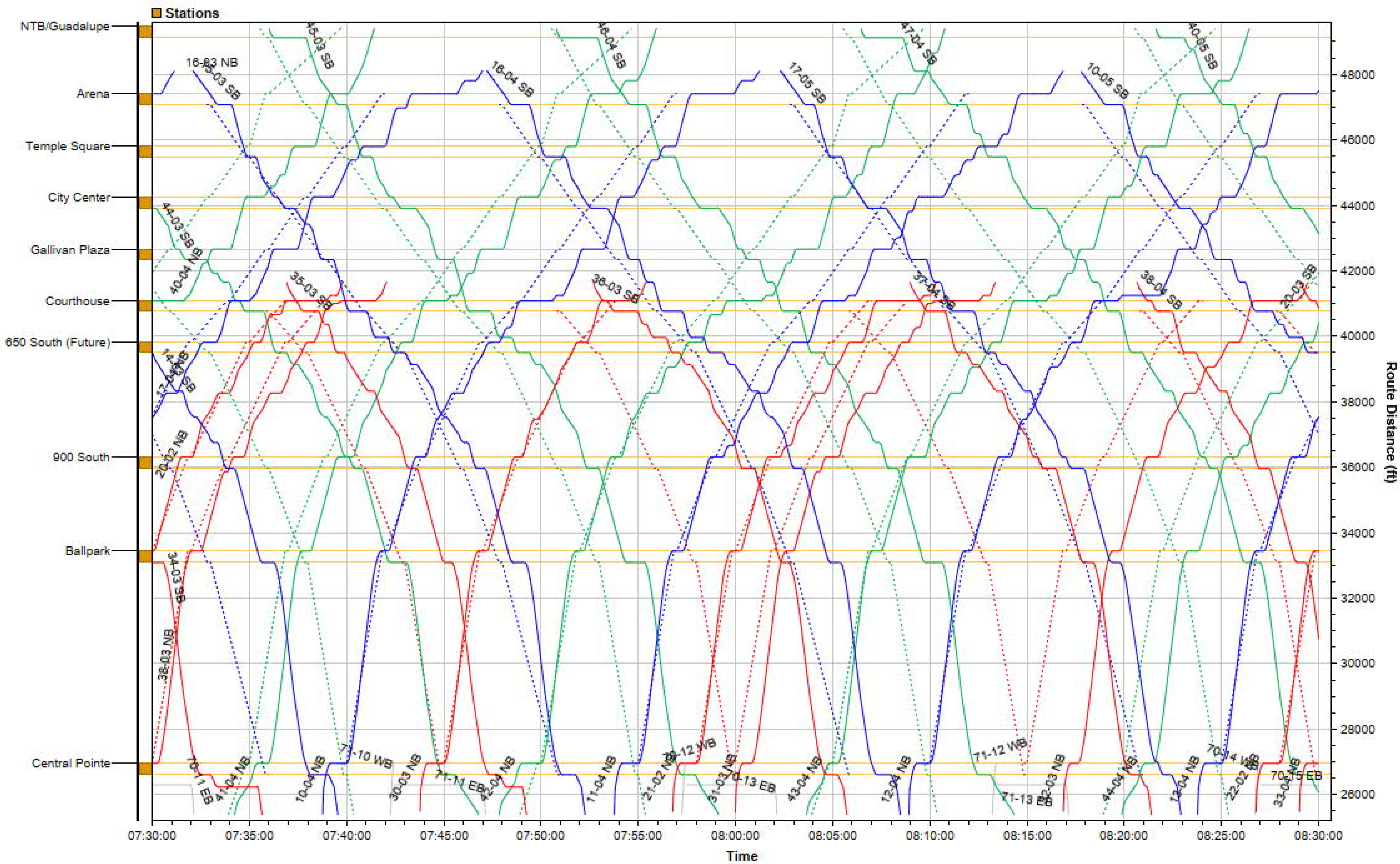

Figure 12 – Future Baseline – Time-Distance ("String") Chart –
TRAX Trunk section between Central Pointe and North Temple Bridge – 7:30 AM and 8:30 AM

Future Baseline Simulation Results: Stopped Signal Delay

The simulation logs stopped delays whenever a revenue train unexpectedly stops due to a street signal, an interlocking conflict, or a train ahead. The stopped delay duration is measured from the moment that the train stops until it begins moving again. The stopped signal delay was calculated to show the average number of seconds a train is stopped per mile travelled. This is a normalized statistic to compare various simulation results with potentially different train counts or trip distances. Table 12 presents the future baseline stopped signal delay per mile, split by lines.

Table 12 – Future Baseline – Seconds of Stopped Delay per Mile Travelled

TRAX Train Line	Northbound (seconds)	Southbound (seconds)
Blue Line	6	5
Red Line	8	7
Green Line	19	18
Orange Line		
All Lines	**10**	**9**

Future Baseline Simulation Results: Peak Fleet Requirement

The Future Baseline ran with the same consists as the existing baseline. Blue and Red Lines were modeled with a mixture of two, three and four-car trains depending on time of day. The Green Line was modeled with two-car trains all day.

The equipment cycles were evaluated to determine the peak fleet requirement for the Future Baseline simulation. Table 13 shows the breakdown by line and by vehicle type. There was no change from the Existing Baseline results.

Table 13 – Future Baseline – Peak Fleet Requirement

Future Baseline	Siemens SD100/SD160		Siemens S70		Combined	
	# Cars	# Trains	# Cars	# Trains	# Cars	# Trains
Blue Line	26	8	0	0	26	8
Red Line	0	0	45	13	45	13
Green Line	0	0	16	8	16	8
Combined	**26**	**8**	**61**	**21**	**87**	**29**

Future Scenarios

All future scenarios includes the new 650 South Station and a relocated Airport Station. In addition, all future scenarios assume retirement of the SD100/SD160 light rail vehicle fleet and replacement with vehicles functionally equivalent to the existing UTA S70 fleet. All future scenarios retain the same simulated dwell times and minimum required turn times at terminals as the Future Baseline.

Future Build Scenario 1 (Intersection Priority Improvements)

Future Build Scenario 1 is the same as the Future Baseline except that it tests higher levels of TRAX intersection priority at select intersections where such changes are deemed likely feasible to municipal and State traffic engineers. A follow-on scenario – Scenario 3 – tests higher intersection priority at additional intersections identified by Light Rail Operations as being delay-prone. Compared with the Future Baseline, there are no changes in simulated fleet, dwell times, minimum required terminal turn times, civil speed restrictions or wayside signaling.

Future Build Scenario 1 Operational Data

The operating plan for Future Build Scenario 1 was derived from the future baseline operating plan with some operational changes to optimize the on-time performance (OTP) and where possible, to achieve travel time savings between revenue stations without degrading OTP. Based on calculation of the simulated travel time between each revenue station to determine if the trips are earlier than the scheduled travel time, it was concluded that 1 minute can be removed between Murray Central station and Fashion Place West station for Blue and Red Line in the southbound direction. Similarly, another minute was also taken off from the scheduled travel time between River Trail station and Central Pointe station for Green Line in the northbound direction.

The one minute change applied between River Trail station and Central Pointe station in the northbound direction will affect the headway between trains within the trunk section shared by the 3 main TRAX lines (Red, Blue and Green). Therefore, to maintain the consistent 5-minute headway between Courthouse station and Central Pointe station, all trips departing from West Valley terminal were set to be 1 minute later than previously.

The change of dispatch time and travel times are summarized in Table 14 and Table 15.

Table 14 – Future Build Scenario 1 (Intersection Priority Improvements) Change in Terminal Dispatch Times

Schedule Changes* (min)						Headway (min)	
Blue NB	Blue SB	Red NB	Red SB	Green NB	Green SB	Trunk Line (between Courthouse and Central Pointe)	Branch Line
No change	-1	No change	-1	+1	-2	5	15

*Compared to Existing Baseline schedule.

"-" indicates an earlier departure time, "+" indicates a later departure time

Table 15 – Future Build Scenario 1 (Intersection Priority Improvements) Change in Terminal-Terminal Scheduled Travel Times					
Travel Time Changes* (min)					
Blue NB	Blue SB	Red NB	Red SB	Green NB	Green SB
+1	No change	+1	No change	+1	+2

*Compared to Existing Baseline schedule.

"-" indicated amount of time removed, "+" indicates amount of additional time added

Future Build Scenario 1 Operational Data: Intersection Priorities

For Scenario 1, the majority of the stopping probabilities and hold times at traffic lights were based on the same specifications as the Future Baseline Scenario. Hatch LTK Team member Avenue Consultants provided a list of intersections where TRAX priorities could likely be increased without objection from governing traffic engineering organizations – municipal or State depending on the intersection. UTA Light Rail Operations then provided an initial prioritization of those intersections where light rail priority was deemed feasible. For intersections where Avenue Consultants deemed improved priority feasibility to be "High", the TRAX stopping probability was reduced by 25% and the delay time if stopped was reduced by 25%. For intersections where priority feasibility was deemed "Medium", simulated stopping probability was reduced by 12.5% and the delay time if stopped was reduced by 12.5%. Intersections considered to have a "Low" feasibility of improved light rail priority were not changed versus the Future Baseline.

Table 16 lists the set of changes in stop probabilities and dwell times to the intersection priorities in the Northbound and Southbound direction for Scenario 1.

Table 16 – Future Build Scenario 1 (Intersection Priority Improvements) Changes to Intersection Stopping Probabilities and Hold Times								
			AM Peak		Off Peak		PM Peak	
Intersection	UTA Initial Priority Assessment	Dir	Probability of Stop (Red Light)	Hold Time (s)	Probability of Stop (Red Light)	Hold Time (s)	Probability of Stop (Red Light)	Hold Time (s)
Blue Line (Salt Lake Central – North Temple & 400W)								
300S & 600W	Medium	NB	26%	4	with same settings all day			
		SB	17%	4				
Red Line (University Medical Center – 400S & Main St)								
500S & 1300E	Medium	NB	51%	30	41%	28	56%	32
		SB	43%	27	41%	28	35%	16
500S & 1100E	Medium	NB	17%	5	with same settings all day			
		SB	17%	4				

Table 16 – Future Build Scenario 1 (Intersection Priority Improvements) Changes to Intersection Stopping Probabilities and Hold Times

Intersection	UTA Initial Priority Assessment	Dir	AM Peak		Off Peak		PM Peak	
			Probability of Stop (Red Light)	Hold Time (s)	Probability of Stop (Red Light)	Hold Time (s)	Probability of Stop (Red Light)	Hold Time (s)
Green Line (Central Pointe Station – West Valley Central Station)								
2320S & 1070W	High	NB	36%	8	with same settings all day			
		SB	36%	8				
2455S & 1070W	High	NB	15%	4	with same settings all day			
		SB	15%	4				
2770S & 1935W	High	NB	49%	21	with same settings all day			
		SB	49%	21				
2900S & 1935W	High	NB	42%	14	with same settings all day			
		SB	42%	14				
3025S & 2210W	High	NB	40%	19	with same settings all day			
		SB	40%	15				
3100S & 2100W	High	NB	60%	30	with same settings all day			
		SB	60%	30				
3100S & 2700W	High	NB	47%	21	with same settings all day			
		SB	47%	21				
3360S & 2700W	High	NB	23%	6	with same settings all day			
		SB	23%	6				
3500S & 2700W	High	NB	49%	28	52%	27	49%	28
		SB	51%	29	48%	25	51%	29
Green Line (Airport – North Temple & 400W)								
2400W & North Temple	Medium	NB	66%	30	with same settings all day			
		SB	66%	30				
Redwood Rd & North Temple	High	NB	55%	30	55%	30	57%	34
		SB	56%	30	57%	31	59%	35
All Lines (400 S – Central Pointe Station)								
500S & Main St	Medium	NB	38%	23	31%	17	35%	21
		SB	60%	36	53%	29	44%	26
600S & Main St	Medium	NB	69%	42	43%	23	70%	42
		SB	47%	28	27%	14	26%	16

Future Build Scenario 1 Simulation Results

Future Build Scenario 1 Simulation Results: On-Time Performance (OTP)

Each scenario was run five times, with the TrainOps variability feature turned on to produce a set of randomized simulation results. The train lateness threshold was set at 4 minutes and 59 seconds. Table 17 shows the Future Build Scenario 1 model was able to achieve an OTP of 93.8% for the combined average of the three TRAX Line (Red, Blue and Green). The combined OTP of the different runs was stable, varying in a range between 91.1% and 95%. The OTP for individual lines varied from 85.3% to 97.9%.

This reflects a 1.3% increase in OTP versus the Future Baseline. The OTP improvement in Scenario 1 is solely attributable to the TRAX intersection priority improvements.

Table 17 – Future Build Scenario 1 (Intersection Priority Improvements) On-Time Performance

Future Build S1	TRAX Train Line			Combined Average
	Blue Line	Red Line	Green Line	
Run 1	93.9%	85.3%	95.4%	**91.1%**
Run 2	96.1%	91.4%	94.7%	**93.9%**
Run 3	97.0%	90.7%	95.8%	**94.3%**
Run 4	97.9%	92.3%	94.4%	**94.8%**
Run 5	96.8%	93.1%	95.4%	**95.0%**
Combined Average	**96.3%**	**90.6%**	**95.2%**	**93.8%**

Future Build Scenario 1 Simulation Results: String Charts

Delays can be observed when comparing the dashed lines of a scheduled train trip to the solid lines of the same simulated train trip. For example, in Figure 13 it can be seen that Green Line trip 44-03 SB was running approximately 5 minutes late, ending up running from Courthouse to Central Pointe at the scheduled time of Red Line trip 35-03 SB.

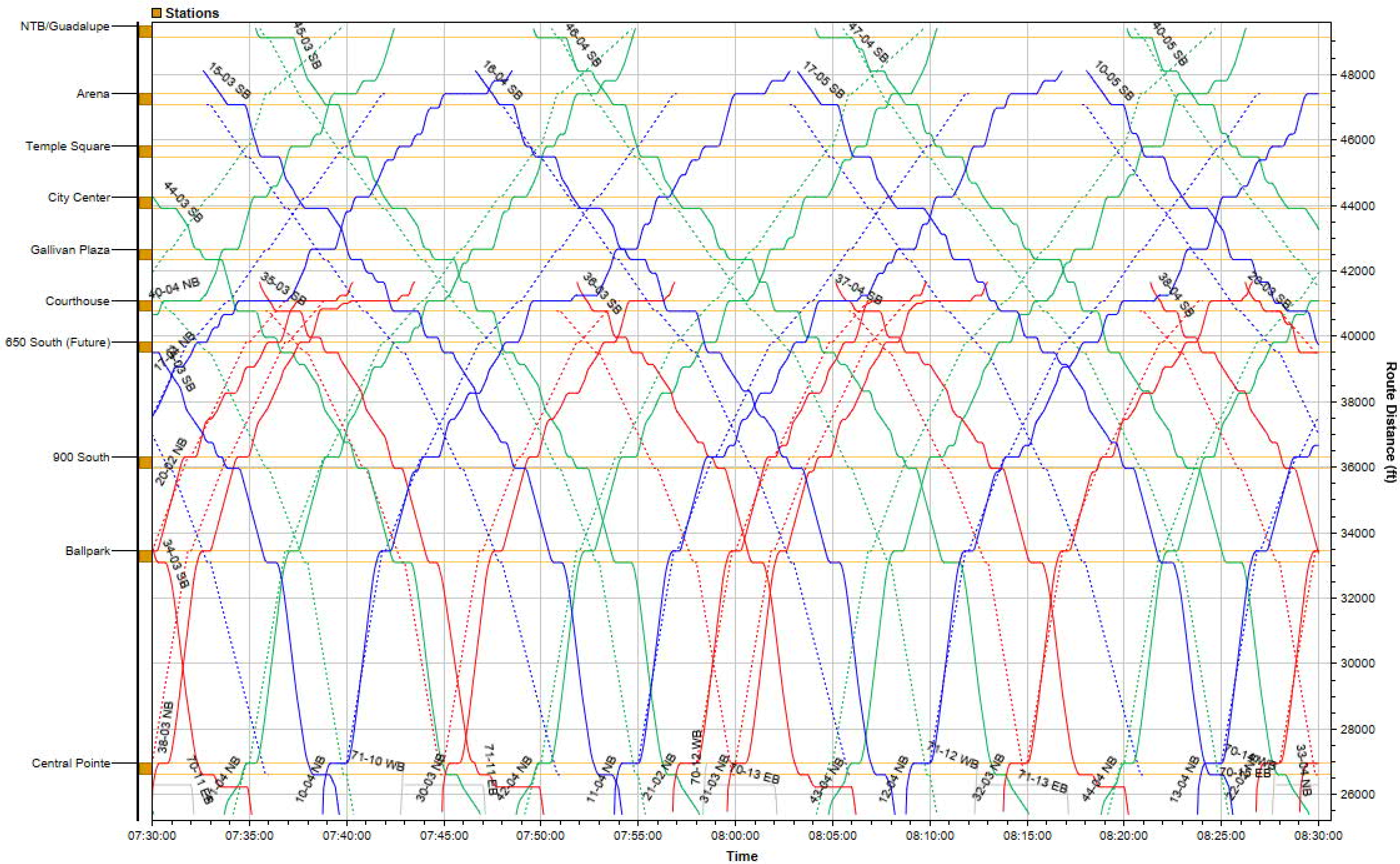

Figure 13 – Future Build Scenario 1 (Intersection Priority Improvements) –
Time-Distance ("String") Chart – TRAX Trunk between Central Pointe and North Temple Bridge – 7:30 AM and 8:30 AM

Future Build Scenario 1 Simulation Results: Stopped Signal Delay

Stopped signal delay occurs when a revenue train is brought to a stop by conflict with another trip or a traffic light. The stopped signal delay was calculated to show the average number of seconds a train is stopped per mile travelled. This is a normalized statistic to compare various simulation results with potentially different train counts or trip distances.

Table 18 presents the Future Build Scenario 1 stopped signal delay per mile, split by lines. When compared against the Future Baseline Scenario, the combined results are better, with both the northbound and southbound trains receiving slightly less delay. The most noticeable difference can be seen by comparing the Green Line results.

Table 18 – Future Build Scenario 1 (Intersection Priority Improvements)
Seconds of Stopped Delay per Mile Travelled

TRAX Train Line	Future Baseline		Future Build Scenario 1	
	Northbound (seconds)	Southbound (seconds)	Northbound (seconds)	Southbound (seconds)
Blue Line	6	5	6	4
Red Line	8	7	7	7
Green Line	19	18	15	13
Orange Line				
All Lines	**10**	**9**	**9**	**8**

Future Build Scenario 1 Simulation Results: Peak Fleet Requirement

The equipment cycles were evaluated to determine the peak fleet requirement for the Future Build Scenario 1 simulation. Table 19 shows the breakdown by line and by vehicle type. The only change from the Future Baseline results is that all cars and trains use S70 vehicles, given that this is a future scenario and the SD100/SD160 has a limited service life remaining.

When the 20% spare margin is added to the 87-car peak fleet requirement, the resultant overall fleet requirement of 105 cars is slightly less than the current light rail fleet total (excluding the three S70 streetcars) of 114 cars. Therefore, no additional fleet is required for this scenario.

Table 19 – Future Build Scenario 1 (Intersection Priority Improvements)
Peak Fleet Requirement

Future Baseline	Siemens SD100		Siemens S70		Combined	
	# Cars	# Trains	# Cars	# Trains	# Cars	# Trains
Blue Line	0	0	26	8	26	8
Red Line	0	0	45	13	45	13
Green Line	0	0	16	8	16	8
Combined	**0**	**0**	**87**	**29**	**87**	**29**

Future Build Scenario 2 (Trunk Line Curve Speed Improvements)

Future Build Scenario 2 focuses on the benefits of curve speed improvements to the TRAX Trunk Line. The Trunk Line was constructed when only the original SD100 fleet was contemplated for the system. This fleet has a top speed of 55 MPH and the Trunk Line was therefore designed for this speed. Since that time, additional fleet capable of 65 MPH operation has been placed in service. Future Build Scenario 2 includes upgrading all 55 MPH curves to 65 MPH where geometrically feasible, as well as upgrading some lower speed curves where possible given UTA Engineering Criteria.

Scenario 2 utilized the same dwell times, intersection priorities and minimum terminal turn times as the Future Baseline.

Future Build Scenario 2 Fleet

For this scenario, due to speed changes to 65 MPH, only Siemens S70 vehicles were used in the simulation. The SD100 fleet, with a maximum speed of 55 MPH, was assumed to be retired.

Future Build Scenario 2 Infrastructure

The Future Build Scenario 2 utilized the same infrastructure layout as the Future Baseline Scenario.

Future Build Scenario 2 Infrastructure: Civil Speed Restrictions

Future Build Scenario 2 involves upgrading curve speeds where possible, see Table 20 for the list of curves that were upgraded. It also involves upgrading the track speed for straight sections of track from 55 MPH to 65 MPH. The one exception to this is the speed between Ball Park and 900 South Stations which remains at 25 MPH, as the signal system ends northbound at Ball Park Station and north of Ball Park, the LRTs are operating in a corridor with automobiles under “line of sight” operation.

Table 20 – Future Build Scenario 2 (Trunk Line Curve Speed Improvements) Changes to Curve Speeds

Curve Number	Original Design Speed	Updated Design Speed
S120	30	50
S122	30	60
N120	30	50
N122	30	60
105	35	65
104	55	65
109	55	65
114	55	65
111	55	65
120	55	65
115	55	65
124	55	65
119	40	60
121	30	60

Table 20 – Future Build Scenario 2 (Trunk Line Curve Speed Improvements) Changes to Curve Speeds		
Curve Number	Original Design Speed	Updated Design Speed
126	55	65
128	40	60
130	40	65
123	55	65
125	55	65
132	55	65
134	55	65
136	55	65
140	15	35
127	50	55
144	50	55
129	50	60
133	50	65
146	40	60
148	50	65
150	50	65
135	55	65
152	55	65
137	55	65
141	50	65
154	55	65
156	55	65
158	50	65
143	55	65
164	55	65
166	55	65
149	45	45
157	55	65
182	55	65
183	55	65
186	55	65
190	25	55
184	55	65
187	25	65
189	25	65
192	25	55

These improvements can be seen in the following Trip Graphs (Figure 14 through Figure 17). The green line shows with the speed profile looked like in the Future Baseline Scenario. The orange line is showing the locations where the speed has increased.

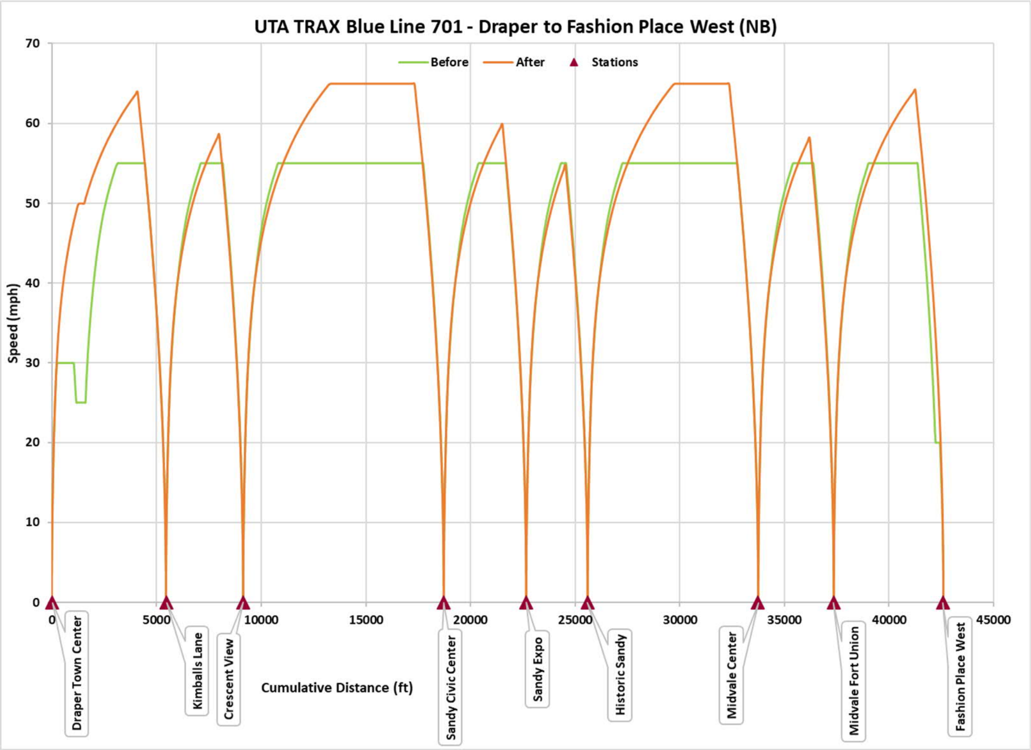

Figure 14 – Future Build Scenario 2 (Trunk Line Curve Speed Improvements) – Trip Graph of Blue Line between Draper to Fashion West Place – Northbound

Figure 15 – Future Build Scenario 2 (Trunk Line Curve Speed Improvements) – Trip Graph of Blue Line between Draper to Fashion West Place – Southbound

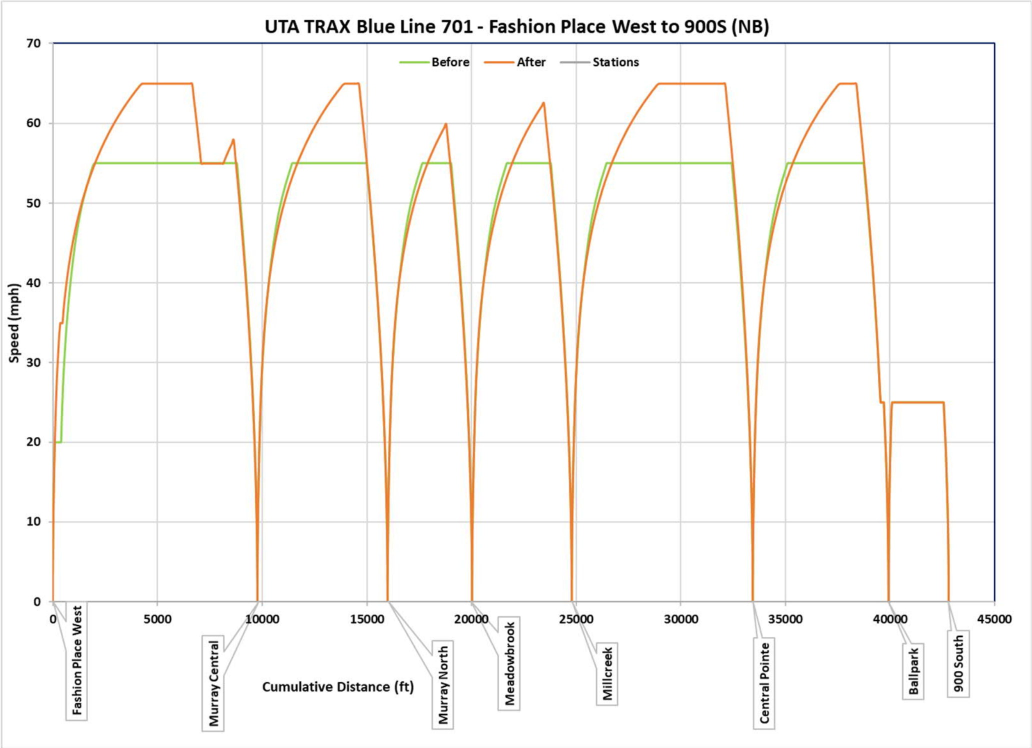

Figure 16 – Future Build Scenario 2 (Trunk Line Curve Speed Improvements) – Trip Graph of Blue Line between 900 S to Fashion West Place – Northbound

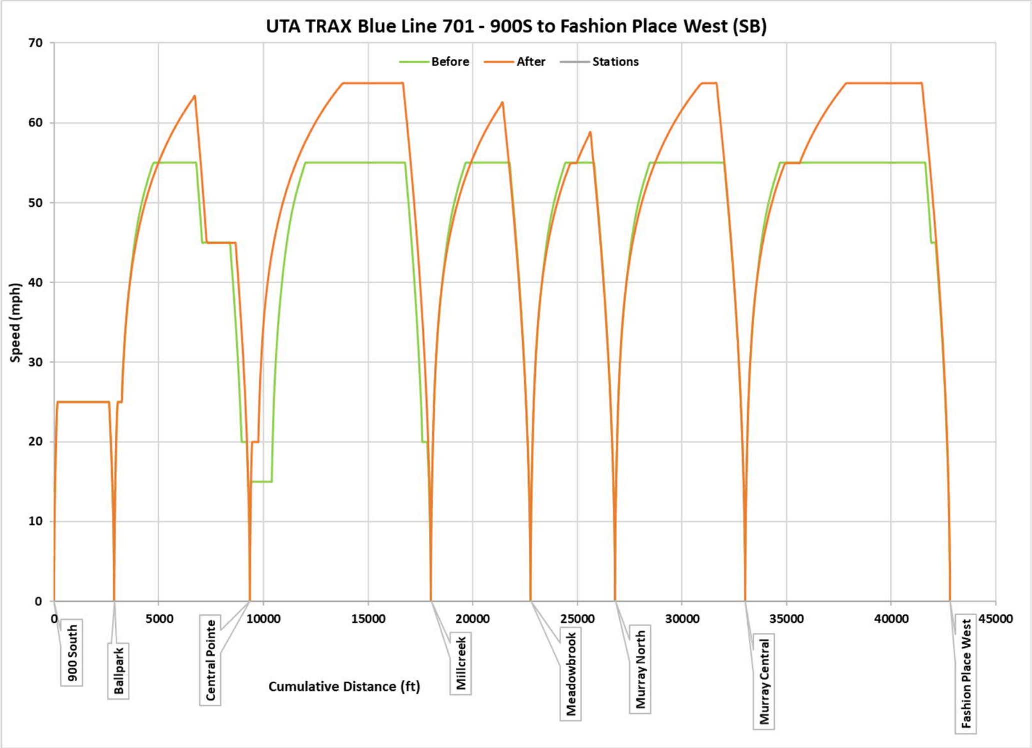

Figure 17 – Future Build Scenario 2 (Trunk Line Curve Speed Improvements) – Trip Graph of Blue Line between 900 S to Fashion West Place – Southbound

Future Build Scenario 2 Infrastructure: Wayside Signaling

Wayside signals and control lines were modeled based on the Future Baseline Scenario. An Engineering Study may be required to determine if any signal control line modifications and/or signal relocations are required in order to support the higher operating speeds.

Future Build Scenario 2 Operational Data

The change of dispatch time and travel times are summarized in Table 21 and Table 22.

Table 21 – Future Build Scenario 2 (Trunk Line Curve Speed Improvements) Change in Terminal Dispatch Times

Schedule Changes* (min)						Headway (min)	
Blue NB	Blue SB	Red NB	Red SB	Green NB	Green SB	Trunk Line (between Courthouse and Central Pointe)	Branch Line
+2	-1	+1	-1	No change	-2	5	15

*Compared to Existing Baseline schedule.

"-" indicates an earlier departure time, "+" indicates a later departure time

Table 22 – Future Build Scenario 2 (Trunk Line Curve Speed Improvements) Change in Terminal-Terminal Scheduled Travel Times					
Travel Time Changes* (min)					
Blue NB	Blue SB	Red NB	Red SB	Green NB	Green SB
-1	-1	No change	No change	+2	+2

*Compared to Existing Baseline schedule.

"-" indicated amount of time removed, "+" indicates amount of additional time added

Future Build Scenario 2 Simulation Results

Future Build Scenario 2 Simulation Results: On-Time Performance (OTP)

Each scenario was run five times, with the TrainOps variability feature turned on to produce a set of randomized simulation results. The train lateness threshold was set at 4 minutes and 59 seconds. Table 23 shows a combined average of 96.1% for all lines. In Future Build Scenario 2, changes to curve speed between Draper Town Center Station and Ballpark Station reduced the run time on this segment in both directions. Although time was taken from the schedules the OTP was well-maintained.

Table 23 – Future Build Scenario 2 (Trunk Line Curve Speed Improvements) On-Time Performance				
	TRAX Train Line			Combined Average
Future Build S2	**Blue Line**	**Red Line**	**Green Line**	
Run 1	96.6%	96.0%	94.2%	**95.7%**
Run 2	97.5%	97.0%	95.0%	**96.6%**
Run 3	96.8%	96.4%	94.4%	**96.0%**
Run 4	97.8%	95.1%	93.7%	**95.7%**
Run 5	97.6%	98.7%	92.0%	**96.5%**
Combined Average	**97.3%**	**96.6%**	**93.9%**	**96.1%**

Future Build Scenario 2 Simulation Results: String Charts

Delays can be observed when comparing the dashed lines of a scheduled train trip to the solid lines of the same simulated train trip. For example, in Figure 18 it can be seen that Red Line trip 37-04 SB is running approximately 5 minutes late, causing Blue Line trip 17-05 SB to also run late.

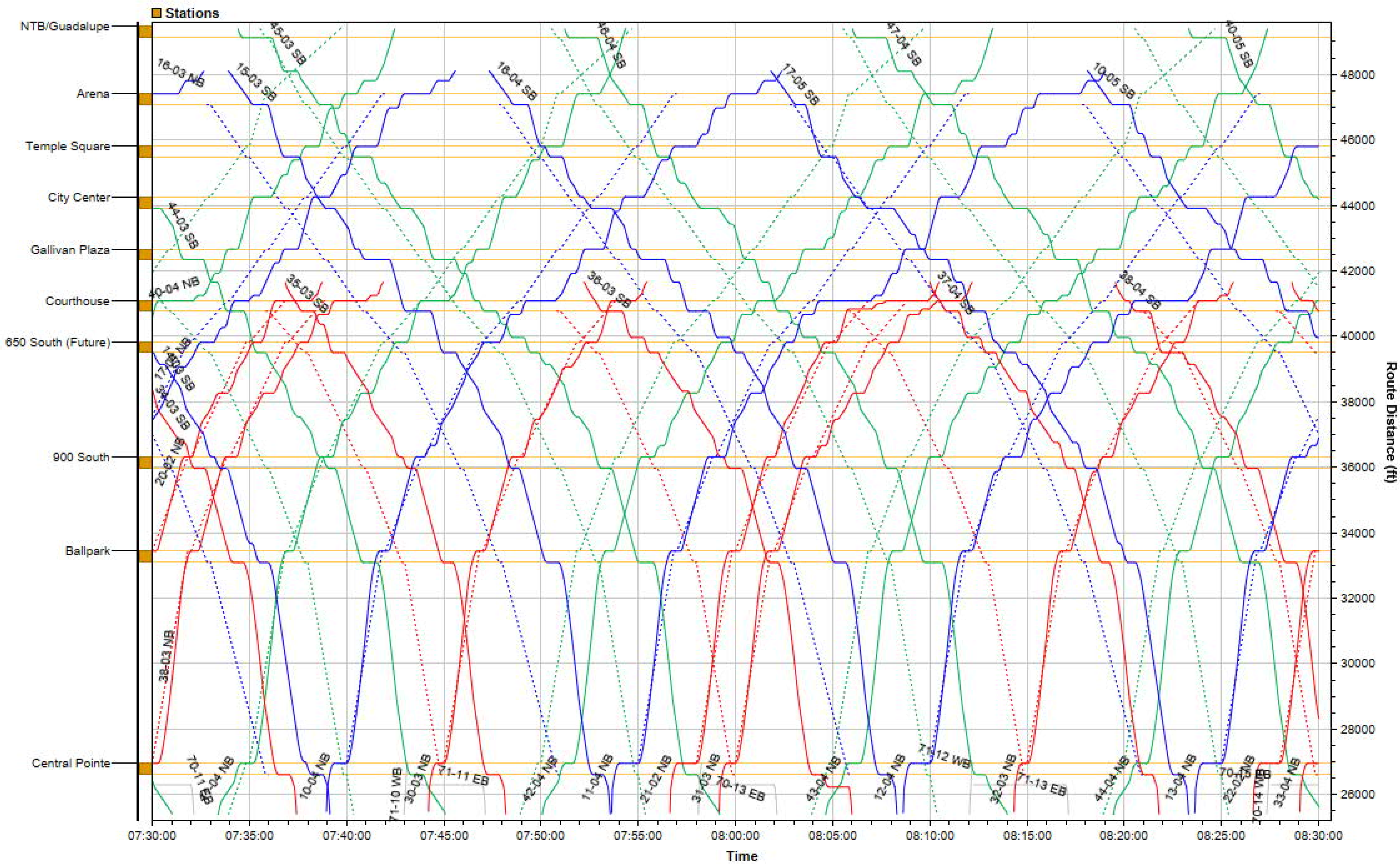

Figure 18 – Future Build 2 (Trunk Line Curve Speed Improvements) –
Time-Distance ("String") Chart – Along the trunk section between Central Pointe and North Temple Bridge – 7:30 AM and 8:30 AM

Future Build Scenario 2 Simulation Results: Stopped Signal Delay

Stopped signal delay occurs when a revenue train is brought to a stop by conflict with another trip or a traffic light. The stopped signal delay was calculated to show the average number of seconds a train is stopped per mile travelled. This is a normalized statistic to compare various simulation results with potentially different train counts or trip distances.

Table 24 presents the Future Build Scenario 2 stopped signal delay per mile, split by lines. When compared against the Future Baseline Scenario, the combined results are very similar, with the southbound trains receiving slightly less delay.

Table 24 – Future Build Scenario 2 (Trunk Line Curve Speed Improvements)
Seconds of Stopped Delay per Mile Travelled

TRAX Train Line	Future Baseline		Future Build Scenario 2	
	Northbound (seconds)	Southbound (seconds)	Northbound (seconds)	Southbound (seconds)
Blue Line	6	5	6	5
Red Line	8	7	8	6
Green Line	19	18	19	17
Orange Line				
All Lines	**10**	**9**	**10**	**8**

Future Build Scenario 2 Simulation Results: Peak Fleet Requirement

The equipment cycles were evaluated to determine the peak fleet requirement for the Future Build Scenario 2 simulation. Table 25 shows the breakdown by line and by vehicle type. The only change from the Future Baseline results is that all trains will use S70 vehicles, as the SD100s are approaching the end of their useful lives and have a maximum operating speed of 55 MPH.

When the 20% spare margin is added to the 87-car peak fleet requirement, the resultant overall fleet requirement of 105 cars is slightly less than the current light rail fleet total (excluding the three S70 streetcars) of 114 cars. Therefore, no additional fleet is required for this scenario.

Table 25 – Future Build Scenario 2 (Trunk Line Curve Speed Improvements)
Peak Fleet Requirement

Future Baseline	Siemens SD100		Siemens S70		Combined	
	# Cars	# Trains	# Cars	# Trains	# Cars	# Trains
Blue Line	0	0	26	8	26	8
Red Line	0	0	45	13	45	13
Green Line	0	0	16	8	16	8
Combined	**0**	**0**	**87**	**29**	**87**	**29**

Future Build Scenario 3 (Additional Intersection Priority Improvements)

Future Build Scenario 3 includes the intersection priority improvements from Future Build Scenario 1 and additional intersection priority improvements identified by UTA Light Rail Operations. Other than intersection priority improvements, there are no changes to TRAX infrastructure in this scenario versus the Future Baseline.

Future Build Scenario 3 Operational Data

The change of dispatch time and travel times are summarized in Table 26 and Table 27.

Table 26 – Future Build Scenario 3 (Additional Intersection Priority Improvements) Change in Terminal Dispatch Times

Schedule Changes* (min)						Headway (min)	
Blue NB	Blue SB	Red NB	Red SB	Green NB	Green SB	Trunk Line (between Courthouse and Central Pointe)	Branch Line
+1	-1	+1	-1	+1	-2	5	15

*Compared to Existing Baseline schedule.
"-" indicates an earlier departure time, "+" indicates a later departure time

Table 27 – Future Build Scenario 3 (Additional Intersection Priority Improvements) Change in Terminal-Terminal Scheduled Travel Times

Travel Time Changes* (min)					
Blue NB	Blue SB	Red NB	Red SB	Green NB	Green SB
No change	No change	No change	-1	+1	+2

*Compared to Existing Baseline schedule.
"-" indicated amount of time removed, "+" indicates amount of additional time added

Future Build Scenario 3 Operational Data: Intersection Priorities

For this scenario, the majority of the stopping probabilities and hold times at traffic lights were based on the same specifications as the Future Baseline Scenario. UTA provided a list of additional intersections that were ranked according to priorities shown in Table 28.

Table 28 - TRAX System Traffic Signal Priority Settings Summary Future of Light Rail Study						
Signal ID	**Intersection**	**Agency**	**Priority**	**Weekday Signal Operation**	**Potential for Additional Priority Based on Initial Review**	**UTA Assessment of Priority**
Green Line (Airport to North Temple & 400 W)						
1213	2400 W & North Temple	SLC	Enabled	Free	Medium	
1214	2200 W & North Temple	SLC	Enabled	Free	Low	
1215	1950 W & North Temple	SLC	Enabled	Coordinated	Low	
1234	1900 W & North Temple (Ped Crossing)	SLC	Enabled	Coordinated	Low	
7086	Redwood Rd & North Temple	UDOT	Disabled	Coordinated	High	High
1235	1540 W & North Temple (Ped Crossing)	SLC	Enabled	Coordinated	Low	
1216	1460 W & North Temple	SLC	Enabled	Coordinated	Low	
1236	1300 W & North Temple	SLC	Enabled	Free	Low	
1206	1200 W & North Temple	SLC	Enabled	Free	Low	
1237	1100 W & North Temple (Ped Crossing)	SLC	Enabled	Free	Low	
1217	1000 W & North Temple	SLC	Enabled	Free	Low	
1218	900 W & North Temple	SLC	Enabled	Free	Low	
1238	850 W & North Temple (Ped Crossing)	SLC	Enabled	Free	Low	
1219	800 W & North Temple	SLC	Enabled	Free	Low	
1220	600 W & North Temple	SLC	Preempt Enabled	Free		
1205	400 W & North Temple	SLC	Enabled	Free	Low	
1203	400 W & 50 N	SLC	Preempt Enabled	Free		
1014	South Temple & 400 W	SLC	Enabled	Free	Low	
Blue Line (Salt Lake Central to North Temple & 400 W)						
1178	300 S & 600 W	SLC	Enabled	Free	Medium	
1177	200 S & 600 W	SLC	Enabled	Free	Medium	High
1157	200 S & 500 W	SLC	Enabled	Free	Low	
1016	200 S & 400 W	SLC	Enabled	Free	Low	
1015	100 S & 400 W	SLC	Enabled	Free	Low	

Table 28 - TRAX System Traffic Signal Priority Settings Summary Future of Light Rail Study						
Signal ID	**Intersection**	**Agency**	**Priority**	**Weekday Signal Operation**	**Potential for Additional Priority Based on Initial Review**	**UTA Assessment of Priority**
1014	South Temple & 400 W	SLC	Enabled	Free	Low	
Blue and Green Lines (North Temple & 400 W to 400 S & Main St)						
7126	300 W & South Temple	UDOT	Enabled	Coordinated	Low	Medium
1023	South Temple & 200 W	SLC	Enabled	Free	Low	
1149	150 W & South Temple (Ped Crossing)	SLC	Enabled	Free	Low	
1030	West Temple & South Temple	SLC	Enabled	Free	Low	
1036	50 W & South Temple (Ped Crossing)	SLC	Enabled	Free	Low	
1038	Main St & South Temple	SLC	Enabled	Free	Low	
1039	50 S & Main St (Ped Crossing)	SLC	Enabled	Free	Low	
1040	100 S & Main St	SLC	Enabled	Free	Low	
1041	150 S & Main St (Ped Crossing)	SLC	Enabled	Free	Low	
1042	200 S & Main St	SLC	Enabled	Free	Low	
1043	250 S & Main St (Ped Crossing)	SLC	Enabled	Free	Low	
1044	300 S & Main St	SLC	Enabled	Free	Low	
1147	350 S & Main St (Ped Crossing)	SLC	Enabled	Free	Low	
7243	400 S & Main St	UDOT	Enabled	Peer-to-Peer	Low	High
Red Line (University Medical Center to 400 S & Main St)						
7044	Wasatch Dr & Mario Capecchi Dr	UDOT	Preempt Enabled	Free		
7043	South Campus Dr & Mario Capecchi Dr	UDOT	Enabled	Free	Low	
7042	South Campus Dr & 1800 E	UDOT	Enabled	Free	Low	
7041	South Campus Dr & 1725 E	UDOT	Enabled	Free	Low	
7040	South Campus Dr & 1550 E (Ped Crossing)	UDOT	Enabled	Free	Low	
7039	South Campus Dr & 1500 E	UDOT	Enabled	Free	Low	

Table 28 - TRAX System Traffic Signal Priority Settings Summary Future of Light Rail Study						
Signal ID	Intersection	Agency	Priority	Weekday Signal Operation	Potential for Additional Priority Based on Initial Review	UTA Assessment of Priority
7224	500 S & 1300 E	UDOT	Enabled	Coordinated (AM/PM) Free (Off-peak)	Medium	
7253	500 S & 1100 E	UDOT	Enabled	Free	Medium	
7250	400 S & 900 E	UDOT	Enabled	Coordinated	Low	High
7249	400 S & 800 E	UDOT	Enabled	Coordinated	Low	
7180	400 S & 700 E	UDOT	Disabled	Coordinated	Low	High
7248	400 S & 600 E	UDOT	Enabled	Coordinated	Low	
7247	400 S & 500 E	UDOT	Enabled	Coordinated	Low	
7246	400 S & 400 E	UDOT	Enabled	Coordinated	Low	
7245	400 S & 300 E	UDOT	Enabled	Coordinated	Low	
7244	400 S & 200 E	UDOT	Enabled	Coordinated	Low	
7142	400 S & State St	UDOT	Enabled	Coordinated	Low	
7243	400 S & Main St	UDOT	Enabled	Peer-to-Peer	Low	
Blue, Green and Red Lines (400 S to Central Pointe Station)						
1150	450 S & Main St (Ped Crossing)	SLC	Enabled	Free	Low	
7252	500 S & Main St	UDOT	Enabled	Coordinated	Medium	
1148	550 S & Main St	SLC	Enabled	Free	Low	
7255	600 S & Main St	UDOT	Enabled	Coordinated	Medium	
1045	700 S & Main St	SLC	Enabled	Free	Medium	High
7134	700 S & West Temple	UDOT	Enabled	Coordinated	Low	
1027	700 S & 200 W	SLC	Enabled	Free	Medium	High
1028	800 S & 200 W	SLC	Enabled	Free	Low	
1168	200 S & 850 W (Ped Crossing)	SLC	Enabled	Free	Low	
1146	900 S & Main St	SLC	Enabled	Free	Low	
Green Line (Central Pointe Station to West Valley Central Station)						
4525	2320 S & 1070 W	WVC	Enabled	Free	High	
4526	2455 S & 1070 W	WVC	Enabled	Free	High	
7080	Redwood Rd & Research Way	UDOT	Preempt Enabled	Coordinated		
4528	2770 S & 1935 W	WVC	Enabled	Free	High	

Table 28 - TRAX System Traffic Signal Priority Settings Summary Future of Light Rail Study						
Signal ID	**Intersection**	**Agency**	**Priority**	**Weekday Signal Operation**	**Potential for Additional Priority Based on Initial Review**	**UTA Assessment of Priority**
4529	2900 S & 1935 W	WVC	Enabled	Free	High	
4530	3025 S & 2210 W	WVC	Enabled	Free	High	
4522	3100 S & 2210 W	WVC	Enabled	Free	High	
4532	3100 S &2625 W	WVC	Enabled	Free		
4502	3100 S & 2700 W	WVC	Enabled	Free	High	
4533	3360 S & 2700 W	WVC	Enabled	Free	High	
7287	3500 S & 2700 W	UDOT	Enabled	Coordinated	High	High
4534	Lehman Ave & 2700 W	WVC	Preempt Enabled	Coordinated		
Blue and Red Lines (Central Point Station to Fashion Place West)						
4852	5900 S & 300 W	Murray City	Preempt Enabled	Free		
4864	6100 S & 300 W	Murray City	Preempt Enabled	Free		
Red Line (Fashion Place West to Daybreak)						
4636	South Jordan Pkwy & Grandville Ave	South Jordan City	Preempt Enabled	Free		
4637	Lake Ave & Grandville Ave	South Jordan City	Preempt Enabled	Free		
4635	Black Twig Dr & Grandville Ave	South Jordan City	Preempt Enabled	Free		
4640	Rambutan Way & Grandville Ave	South Jordan City	Preempt Enabled	Free		
4641	Duckhorn Dr & Grandville Ave	South Jordan City	Preempt Enabled	Free		
Blue Line (Fashion Place West to Draper)						
4067	7720 S & 60 W (Queue Cutter)	Midvale City	Preempt Enabled	Free		
7000	9000 S & 150 E (Queue Cutter)	UDOT	Preempt Enabled	Coordinated		
4413	9400 S & 150 E (Queue Cutter)	Sandy City	Preempt Enabled	Coordinated		

Table 28 - TRAX System Traffic Signal Priority Settings Summary Future of Light Rail Study						
Signal ID	**Intersection**	**Agency**	**Priority**	**Weekday Signal Operation**	**Potential for Additional Priority Based on Initial Review**	**UTA Assessment of Priority**
4836	11400 S & 400 E (Queue Cutter)	Sandy City	Preempt Enabled	Coordinated		
7616	700 E & Kimballs Ln	UDOT	Preempt Enabled	Free		
4157	12300 S & 970 E	Draper City	Preempt Enabled	Free		

"Free" indicates Free Signal Operation typically used for signals where is not important to coordinate the arrival of vehicles between signals or where traffic volumes are lighter. When running free the signal does not have a set time that each of the phases turn green but instead serves vehicles on more of a first come first served basis. Free operation typically benefits TRAX since there is no need to keep the signal in sync with the signals around it and priority for the TRAX line can be given more easily.

"Coordinated" indicates traffic signals that are operating with coordination are set so that vehicles traveling in the coordinated direction(s) will arrive as the light green. Coordination is used to predetermine when phases will turn green and will prioritize the phases associated with the main movements. While coordination does not necessary delay TRAX, the signals that run coordination are more likely to have a heavy vehicle demand making the impacts of transit priority more severe.

"Peer-to-Peer" indicates programmed logic in service at the 400 S/Main St intersection to keep the signal in sync with both West Temple and State St. While the signal is set to "Free", this logic mimics coordination between intersections.

"Preemption" indicates preemption in place of priority. With preemption, the operations of the intersection traffic signal will be interrupted to allow the train to pass through the signal without stopping. Preemption is often used at more isolated traffic signals or locations where the trains are traveling at higher speeds.

Potential for Additional Priority was identified based on an initial review of traffic signal settings. Many of the traffic signals were rated low due to the following factors: (1) at pedestrian crossings early green can often not be given since it would require prematurely ending the pedestrian phase, (2) many of the signals already allow the maximum amount of early green time available (without reducing splits below 15 seconds) and have a substantial extension time, and (3) a few that may be limited due to heavy vehicle traffic which already exceeds the intersection capacity (e.g. 700 E & 400 S). While heavy vehicle traffic may not preclude additional priority it will make it difficult to avoid major impacts to the performance of the traffic signal.

The full intersection tables developed by Hatch LTK Team member Avenue Consultants is shown in Appendix C.

Some of the column headings shown in the appendix include:

- Estimated % Green Arrival – An estimate of how often the train will be able to arrive at the traffic signal and pass though without stopping assuming a random arrival. The determination of this estimate was based on the green time available for the train phases at the traffic signal and the cycle length, which is the sum of the time given to all movements.
- Estimated Ave Wait Time (s) – An estimate of the average amount of time that a train will have to stop at a traffic signal and wait before proceeding. Trains that are able to pass though the signal without stopping would have a wait time of 0 would not be included in this average.

As part of this scenario, some intersection priorities were amended to reflect the information supplied by UTA. Table 29 lists the changes to the intersection priorities for this scenario.

Table 29 – Future Build Scenario 3 (Additional Intersection Priority Improvements) Changes to Intersection Stopping Probabilities and Hold Times

Intersection	UTA Initial Priority Assessment	Dir	AM Peak Probability of Stop (Red Light)	AM Peak Hold Time (s)	Off Peak Probability of Stop (Red Light)	Off Peak Hold Time (s)	PM Peak Probability of Stop (Red Light)	PM Peak Hold Time (s)
Blue Line (Salt Lake Central – North Temple & 400W)								
200S & 600W	**High**	**NB**	10%	3	with same settings all day			
		SB	10%	3				
Red Line (University Medical Center – 400S & Main St)								
400S & 900E	**High**	**NB**	16%	6	15%	4	15%	5
		SB	33%	17	24%	7	29%	12
400S & 700E	**High**	**NB**	50%	30	49%	26	48%	29
		SB	50%	30	48%	26	51%	30
Blue Line and Green Line (North Temple & 400W – 400S & Main St)								
400S & 900E	**Medium**	**NB**	45%	19	38%	13	44%	20
		SB	21%	6	17%	4	21%	7
400S & 700E	**High**	**NB**	45%	11	59%	18	59%	18
		SB	45%	11	59%	18	59%	18
All Lines (400S – Central Pointe Station)								
700S & Main St	**High**	**NB**	20%	8	with same settings all day			
		SB	20%	6				
700S & 200W	**High**	**NB**	10%	3	with same settings all day			
		SB	10%	3				

Future Build Scenario 3 Simulation Results

Future Build Scenario 3 Simulation Results: On-Time Performance (OTP)

Each scenario was run five times, with the TrainOps variability feature turned on to produce a set of randomized simulation results. The train lateness threshold was set at 4 minutes and 59 seconds. Table 30 shows the Future Build Scenario 3 model was able to achieve an OTP of 96.1% for the combined average of the three TRAX Line (Red, Blue and Green). The combined OTP of the different runs was stable, varying in a range between 95.1% and 97.2%. The individual lines OTP ranged from 94.4% to 98.1%.

In Future Build Scenario 3, the 3.6% increase in OTP is likely due to the additional intersection priority improvements which decreases the amount of delay that trains experience at traffic lights.

Table 30 – Future Build Scenario 3 (Additional Intersection Priority Improvements) On-Time Performance

Future Build S3	TRAX Train Line			Combined Average
	Blue Line	Red Line	Green Line	
Run 1	98.1%	97.1%	96.1%	**97.2%**
Run 2	97.2%	95.7%	96.2%	**96.3%**
Run 3	95.1%	94.4%	96.0%	**95.1%**
Run 4	97.4%	94.5%	96.3%	**96.0%**
Run 5	97.0%	95.5%	95.1%	**95.9%**
Combined Average	**96.9%**	**95.4%**	**95.9%**	**96.1%**

Future Build Scenario 3 Simulation Results: String Charts

Delays can be observed when comparing the dashed lines of a scheduled train trip to the solid lines of the same simulated train trip. For example, in Figure 19 it can be seen that most northbound Blue Line trips seem to be running on-time until they reach Courthouse Station.

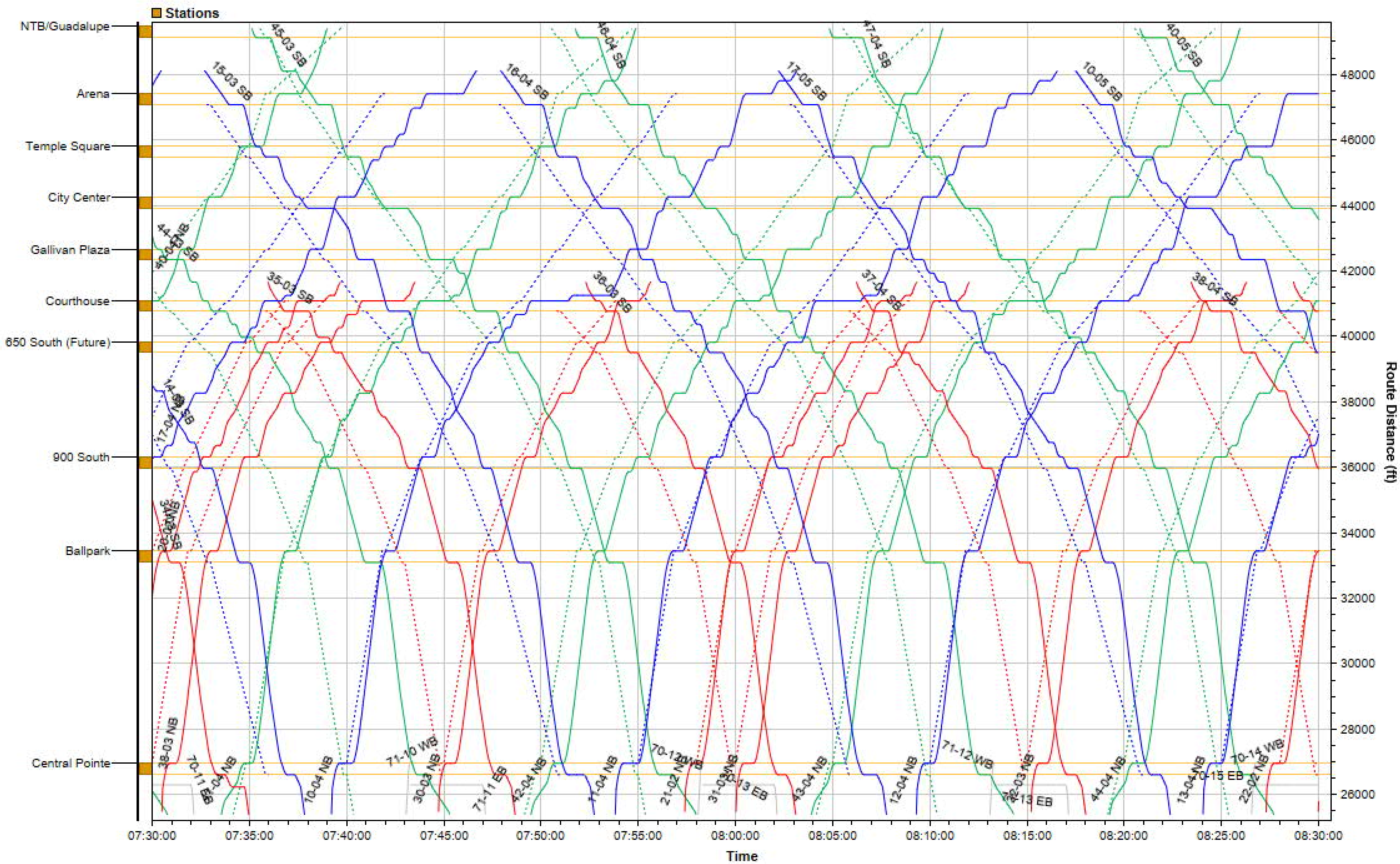

Figure 19 – Future Build Scenario 3 (Additional Intersection Priority Improvements)
Time-Distance ("String") Chart – Along the trunk section between Central Pointe and North Temple Bridge – 7:30 AM and 8:30 AM

Future Build Scenario 3 Simulation Results: Delay Graphic

In Figure 8, the areas more prone to delays were at the Green Line terminals (Airport and West Valley Central) and the segment between 900 South Station and Fort Douglas Station on the Red Line. In comparison to train delays, intersection delays were having a greater impact on the On-Time Performance of the trains. Train delays were mainly distributed around junctions (close to Courthouse Station and Central Pointe Station), which meant that more train congestion was seen in these areas in the simulation.

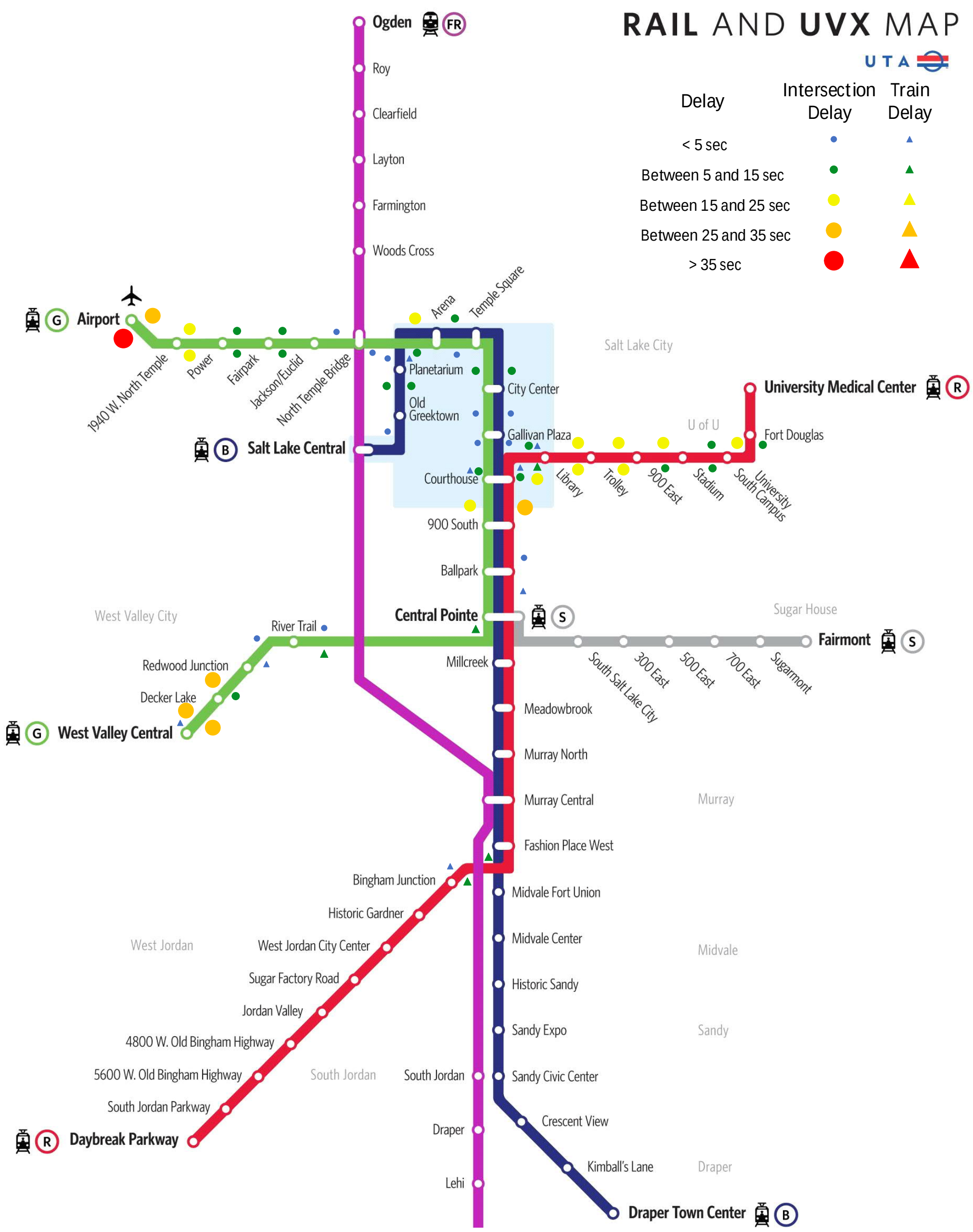

Figure 20 – Future Build Scenario 3 (Additional Intersection Priority Improvements) Delay Graphic

Future Build Scenario 3 Simulation Results: Stopped Signal Delay

Stopped signal delay occurs when a revenue train is brought to a stop by conflict with another trip or a traffic light. The stopped signal delay was calculated to show the average number of seconds a train is stopped per mile travelled. This is a normalized statistic to compare various simulation results with potentially different train counts or trip distances.

Table 31 presents the Future Build Scenario 3 stopped signal delay per mile, split by lines. When compared against the Future Baseline Scenario, the combined results are considerably less. This can be attributed to the increased train priority at additional traffic lights.

Table 31 – Future Build Scenario 3 (Additional Intersection Priority Improvements) Seconds of Stopped Delay per Mile Travelled

TRAX Train Line	Future Baseline		Future Build Scenario 3	
	Northbound (seconds)	Southbound (seconds)	Northbound (seconds)	Southbound (seconds)
Blue Line	6	5	5	4
Red Line	8	7	6	5
Green Line	19	18	15	12
Orange Line				
All Lines	**10**	**9**	**8**	**6**

Future Build Scenario 3 Simulation Results: Peak Fleet Requirement

Table 32 shows the fleet breakdown by line and by vehicle type. No additional fleet is required for this scenario.

Table 32 – Future Build Scenario 3 (Additional Intersection Priority Improvements) Peak Fleet Requirement

Future Baseline	Siemens SD100		Siemens S70		Combined	
	# Cars	# Trains	# Cars	# Trains	# Cars	# Trains
Blue Line	0	0	26	8	26	8
Red Line	0	0	45	13	45	13
Green Line	0	0	16	8	16	8
Combined	**0**	**0**	**87**	**29**	**87**	**29**

Future Build Scenario 4 (Granary District/West Downtown Network Improvements with New Orange Line)

Future Build Scenario 4 builds on the Future Baseline with an alternative alignment in Salt Lake City and a significant network expansion by adding a new Orange Line from the Airport to the University of Utah. This expansion takes advantage of the existing UTA-owned Ballpark Spur to expand northward from the TRAX trunk line just north of Ballpark Station to the Granary District in Salt Lake City and lengthening the track on 400 South. A new connection from the Airport using existing track on North Temple would travel on 400 West to meet the new track on 400 South. It includes five new stations west of the existing Main St corridor as well as an adjunct to the existing Courthouse Station but located on 400 South. Figure 21 shows the original concept development by the UTA Light Rail Business Unit.

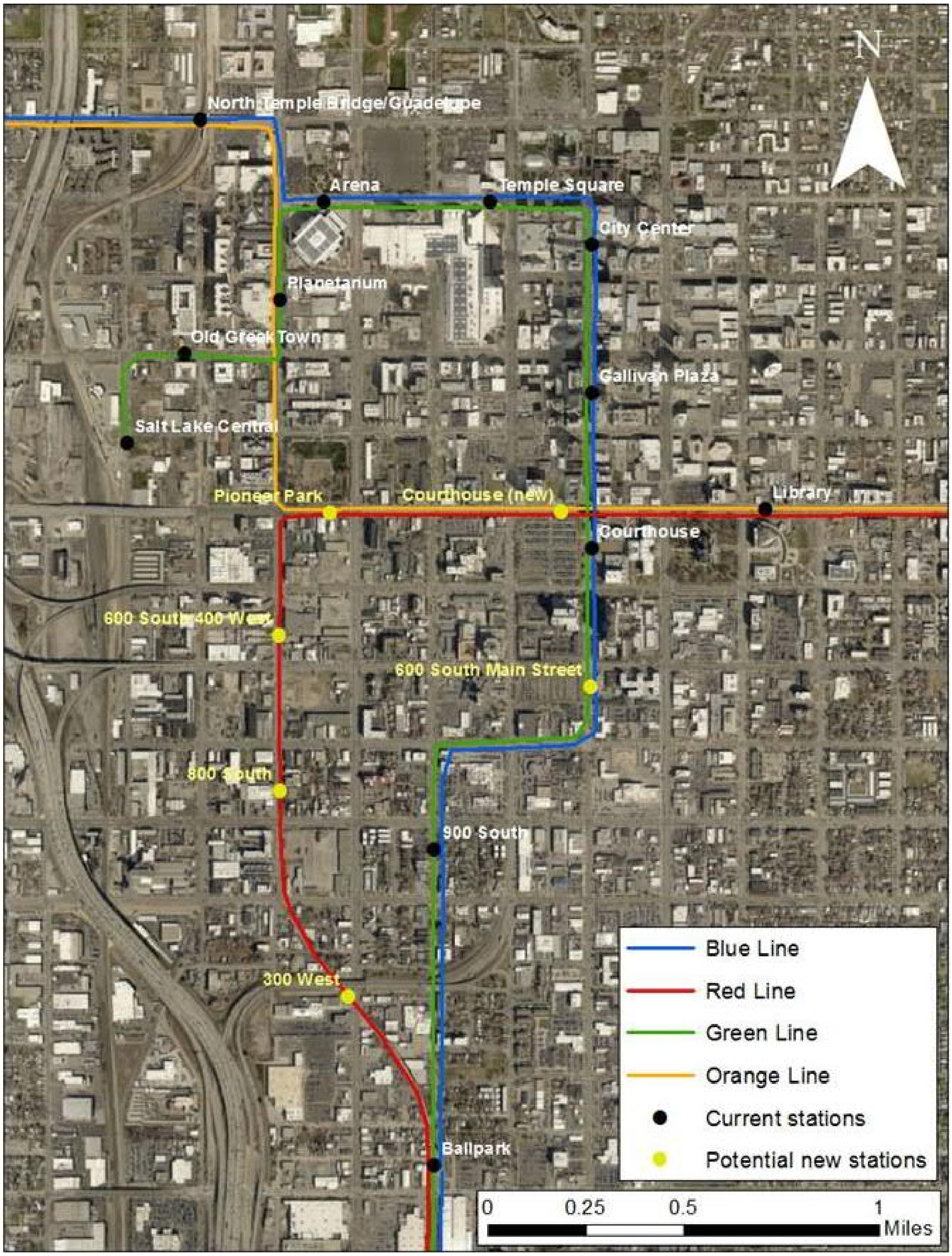

Figure 21 – Future Build Scenario 4 (Granary District/West Downtown Network Improvements with New Orange Line) New Track Layout (supplied by UTA)

Future Build Scenario 4 Fleet

For this scenario, the proposed infrastructure changes would likely occur at the same time that the SD100/SD160 fleet is retired, hence only Siemens S70 vehicles were used. Scenario 4 was simulated with four-car trains all day on the Blue, Red and Green Lines and two-car trains on the Orange Line.

Future Build Scenario 4 Infrastructure

Future Build Scenario 4 includes five new stations, with a new branch from Ballpark station extending up to and along 400W before turning onto 400S. Scenario 4 includes connections to existing half grand union on Main St, converting it into a full grand union. Because of intersection capacity concerns, the full grand union would normally be used only for straight movements with two services crossing two other services there. Figure 22 shows an overview of the concept design by Hatch LTK Team member HDR. Additional design details, including real estate issues identified at a conceptual level, are shown in Appendix E.

Scenario 4 includes extending double track on 400 South from Main Street to 400 West. The existing half grand union at the intersection of Main Street and 400 South is converted to a full grand union. Two new half grand unions are located at the intersection of 400 South/ 400 West, and at the intersection of 400 West/200 South.

Future Build Scenario 4 Infrastructure: Civil Speed Restrictions

Scenario 4's civil speed restrictions started with those of the Future Baseline. The civil speed limit for the new track on 400 South was set to 35 mph, consistent with automobile posted speed limits there. All other new tracks, including on 400 West were set to 25 mph. Diverging movements and 90-degree turns at street intersections were capped at 10 mph, consistent with UTA Light Rail operating criteria.

Future Build Scenario 4 Infrastructure: Wayside Signaling

Junction wayside signals and control lines for the new line in the Granary District were derived from similar junction configurations in the existing network. For example, the simulated control logic for the intersection at 200S/400W mimics the logic at the intersection of South Temple/N 400 W.

Future Build Scenario 4 Capital Cost

Table 33 displays the capital cost estimate for the Scenario 4 improvements, including infrastructure, vehicles, soft costs and unallocated contingency. The estimated capital cost for the Scenario 4 improvements is $195.7 million, of which $74.7 million is TRAX fleet expansion. Refer to Appendix B for information on the study's capital cost estimating methodology.

At the request of Light Rail Operations, the improvements shown in Table 33 were expanded to include two universal interlockings. These infrastructure elements are not shown in the concept drawings. These two interlockings with crossovers in both directions – one on 400 West somewhere between 800 South and 500 South, and one on 400 South between 300 West and West Temple – are needed to support reliable operations. These two new universal interlockings are consistent with the current crossovers spacing in the downtown area, and necessary due to complications resulting in emergency and special operations when going through the planned half grand unions and full grand union.

Table 33 – Scenario 4 Capital Cost Estimate					
10 GUIDEWAY AND TRACK ELEMENTS					
Sub Category	Item	Quantity	Unit	Unit Cost	Total Cost
10.01	Guideway: At-grade Exclusive ROW	0.55	Route-miles	$ 680,000	$ 374,000
10.03	Guideway: At-grade in Mixed Traffic	1.95	Route-miles	$ 1,750,000	$ 3,412,500
10.10	Track: Embedded	1.95	Route-miles	$ 5,750,000	$ 11,212,500
10.11	Track: Ballasted	0.55	Route-miles	$ 2,650,000	$ 1,457,500
10.12	Track: Special - New Half Grand Union	2	Each	$ 350,000	$ 700,000
10.12	Track: Special - Convert Existing Half to Full Grand Union	1	Each	$ 450,000	$ 450,000
10.12	Track: Special - No. 8 Turnout	4	Each	$ 150,000	$ 600,000
10.12	Track: Special - Double Junction	1	Each	$ 250,000	$ 250,000
10 SUBTOTAL					$ 18,456,500
10 ALLOCATED CONTINGENCY				30%	$ 5,536,950
10 TOTAL					**$ 23,993,450**
20 STATIONS, SHOPS, TERMINALS, INTERMODAL					
Sub Category	Item	Quantity	Unit	Unit Cost	Total Cost
20.01	At-grade Station, Stop, Shelter, Platform	6	Each	$ 1,150,000	$ 6,900,000
20 SUBTOTAL					$ 6,900,000
20 ALLOCATED CONTINGENCY				30%	$ 2,070,000
20 TOTAL					**$ 8,970,000**
40 SITEWORK AND SPECIAL CONDITIONS					
Sub Category	Item	Quantity	Unit	Unit Cost	Total Cost
40.01	Demolition, Clearing, Earthwork	2.50	Route-Miles	$ 500,000	$ 1,250,000
40.02	Site Utilities, Utility Relocation	2.50	Route-miles	$ 2,250,000	$ 5,625,000
40 SUBTOTAL					$ 6,875,000
40 ALLOCATED CONTINGENCY				30%	$ 2,062,500
40 TOTAL					**$ 8,937,500**
50 SYSTEMS					
Sub Category	Item	Quantity	Unit	Unit Cost	Total Cost
50.01	Overhead Contact System (See Separate Estimate)	1	LS	$ 6,392,000	$ 6,392,000
50.02	Switch Machines and Signals	1	LS	$ 2,500,000	$ 2,500,000
50.03	Intersection LRT/Traffic Signal Controller Interfaces	14	Each	$ 250,000	$ 3,500,000
50.04	Traction Power Substations	2.14	Route-miles	$ 1,850,000	$ 3,957,704
50 SUBTOTAL					$ 16,349,704
50 ALLOCATED CONTINGENCY				30%	$ 4,904,911
50 TOTAL					**$ 21,254,615**

Table 33 – Scenario 4 Capital Cost Estimate

60 RIGHT OF WAY, LAND, EXISTING IMPROVEMENTS

Sub Category	Item	Quantity	Unit	Unit Cost	Total Cost
60.01	Purchase of Part of Salvage Yard Paxton at Ave	0.10	Acre	$ 1,524,600	$ 152,460
60.01	Purchase of NE property NE corner of 900 S / 400 W	0.05	Acre	$ 1,524,600	$ 76,230
60.01	Purchase of property along 400 W btwn 800 S / 700 S	0.32	Acre	$ 1,524,600	$ 487,872
60.02	Partial demolition of building NE corner of 900 S / 400 W	1	LS	$ 250,000	$ 250,000
60 SUBTOTAL					$ 966,562
60 ALLOCATED CONTINGENCY				30%	$ 289,969
60 TOTAL					**$ 1,256,531**

70 VEHICLES

Sub Category	Item	Quantity	Unit	Unit Cost	Total Cost
70.01	Light Rail Vehicles (New Fleet of 128 vs Current of 114)	14	Car	$ 4,831,550	$ 67,641,700
	Based on Red & Blue at 4 Cars, Orange & Green at 2 Cars			$ -	$ -
70 SUBTOTAL					$ 67,641,700
70 ALLOCATED CONTINGENCY				10%	$ 6,764,170
70 TOTAL					**$ 74,405,870**

80 PROFESSIONAL SERVICES

Sub Category	Item	%of SCC 10 - 50	Total Cost
SCC 10 - 50 TOTAL			**$ 39,162,115**
80.01	Preliminary Engineering	3%	$ 1,174,863
80.02	Final Design	7%	$ 2,741,348
80.03	Project Management for Design and Construction	5%	$ 1,958,106
80.04	Construction Administration and Management	6%	$ 2,349,727
80.05	Insurance	3%	$ 1,174,863
80.06	Legal, Permits, Review Fees	2%	$ 783,242
80.07	Survey, Testing, Investigation, Inspection	2%	$ 783,242
80.08	Start-up Costs	2%	$ 783,242
80 TOTAL			**$ 11,748,634**

SUMMARY

Standard Cost Category		Total Cost
SCC 10: Guideway and Track Elements		$ 23,993,450
SCC 20: Stations, Stops, Terminals, Intermodal		$ 8,970,000
SCC 30: Support Facilities, Yards, Shops, Administration Buildings		$ -
SCC 40: Sitework and Special Conditions		$ 8,937,500
SCC 50: Systems		$ 21,254,615
SCC 60: Right of Way, Land, Existing Improvements		$ 1,256,531
SCC 70: Vehicles		$ 74,405,870
SCC 80: Professional Services		$ 11,748,634
SUBTOTAL		$ 150,566,600
UNALLOCATED CONTINGENCY	30%	$ 45,169,980
PROJECT TOTAL		**$ 195,736,580**

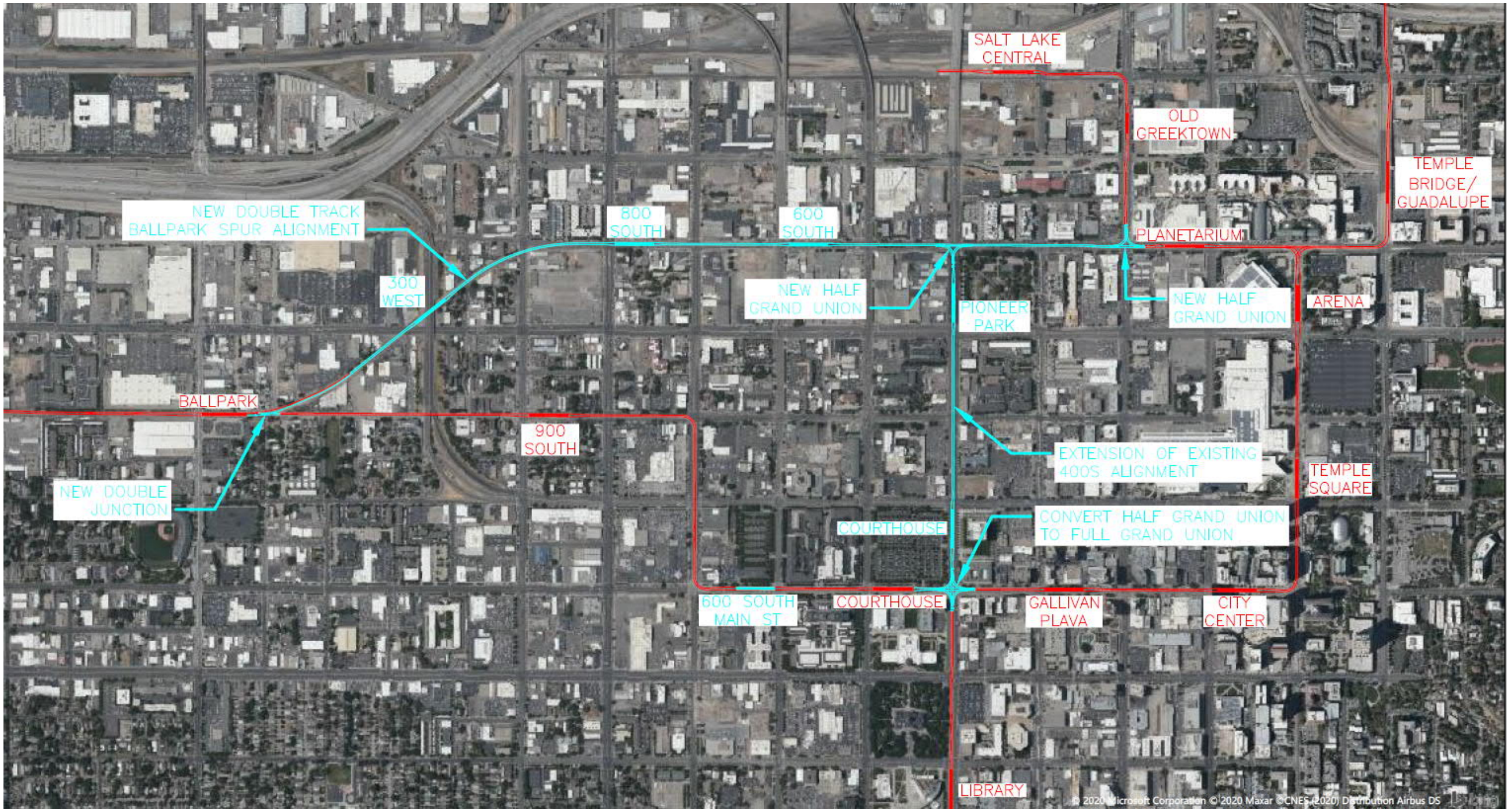

Figure 22 – Future Build Scenario 4 (Granary District/West Downtown Network Improvements with New Orange Line)

Future Build Scenario 4 Operational Data

For Future Build Scenario 4, the Blue Line serves the Airport while the Green Line serves Salt Lake Central, a reversal from today's service patterns. The Red Line diverges from the existing Trunk Line at Ballpark Station along a new set of double tracks on an unused former rail corridor up to and along 400W before turning onto 400S. The new infrastructure extends eastward to the new full grand union before crossing the existing Trunk Line and continuing to the University Medical Center. A new Orange line connects the University and the Airport. A summary of the four light rail lines is shown below:

- TRAX Blue Line: between Airport and Draper Town Center
- TRAX Red Line: between University Medical Center and Daybreak Parkway
- TRAX Green Line: between Salt Lake Central and West Valley Central
- TRAX Orange Line: between Airport and University Medical Center

The operational plan for Scenario 4 replicated that of the future baseline, where the TRAX Red, Blue and Green Line departed 1 minute earlier compared to the Existing Baseline schedule. The trunk section between Central Pointe Station and Courthouse Station was left unchanged in both directions. However, due to the diversion of Red Line to 400 S, the headway reverted to a longer 7-8 minute average headway with only the Blue and Green lines running. The new Granary District trunk between Pioneer Park and Main Street on 400 S were adjusted to 7-8 minute average headways with the Red and Orange lines running on this section.

Due to the significant changes to the operating plan, the change of dispatch time and travel times are not comparable to the Existing Baseline schedule. The operating plan maintains 7-8 average minute headways (as well as on the Airport and University Lines) on both trunks with 15 minute headways for each service.

Future Build Scenario 4 Operational Data: Dwells and Terminal Turn Time

For Future Build Scenario 4, the dwell time distribution for the scenario's five stations (300 West, 800 South, 600 South, Pioneer Park and Courthouse [new]) were assumed to have an average dwell time of 30 seconds, ranging from 15 seconds to 45 seconds. A summary of the changes to the dwell times is shown in Table 34.

Table 34 – Future Build Scenario 4 (Granary District/West Downtown Network Improvements with New Orange Line) Change to Dwell Time Distributions (in seconds)					
Distribution	**Status**	**Min (%)**	**Max (%)**	**Mean (%)**	**STD Dev (%)**
R-650 South-PM Peak-SB	Excluded in Future Build Scenario 4	17	39	26.36	12.61
R-650 South-PM Peak-NB		15	46	26.53	24.94
R-650 South-AM Peak-SB		15	33	23.52	13.29
R-650 South-AM Peak-NB		15	37	25.25	34.74
R-650 South-Off-Peak-SB		16	39	26.52	20.09
R-650 South-Off-Peak-NB		15	41	25.42	41.48
R-900 South-PM Peak-SB		17	39	26.36	12.61
R-900 South-PM Peak-NB		15	46	26.53	24.94
R-900 South-AM Peak-SB		15	33	23.52	13.29
R-900 South-AM Peak-NB		15	37	25.25	34.74
R-900 South-Off-Peak-SB		16	39	26.52	20.09
R-900 South-Off-Peak-NB		15	41	25.42	41.48
R/O-New Stations-all day-NB	Added to Future Build Scenario 4	15	45	30.0	15.0
R/O-New Stations-all day-SB		15	45	30.0	15.0

Future Build Scenario 4 Operational Data: Intersection Priorities

For this scenario, the majority of the stopping probabilities and hold times at traffic lights were based on the same specifications as the Future Baseline Scenario. Due to the introduction of a new Orange Line, certain changes were made to the intersection priorities for this scenario as shown in .

Table 35 – Future Build Scenario 4 (Granary District/West Downtown Network Improvements with New Orange Line)
Changes to Intersection Stopping Probabilities and Hold Times

Intersection	Dir	AM Peak		Off Peak		PM Peak	
		Probability of Stop (Red Light)	Hold Time (s)	Probability of Stop (Red Light)	Hold Time (s)	Probability of Stop (Red Light)	Hold Time (s)
Orange Line (Pioneer Park Station – Courthouse Station (New))							
400S & Trunk	NB	30%	11	40%	18	40%	18
	SB	30%	11	40%	18	40%	18
400S & Main Street	WB	30%	11	40%	18	40%	18
	EB	30%	11	40%	18	40%	18
West Temple & 400S	WB	44%	14	with same settings all day			
	EB	44%	14				
200W & 400S	NB	27%	7	with same settings all day			
	SB	27%	7				
300W & Trunk	NB	38%	16	33%	11	38%	16
	SB	18%	5	15%	4	17%	6
300W & 400S	WB	51%	21	44%	15	50%	22
	EB	24%	7	20%	5	22%	8
400W & 400S	WB	53%	31	with same settings all day			
	EB	53%	37				
Courthouse (New) & 400S Ped Crossing	WB	20%	7	with same settings all day			
	EB	20%	7				

**Table 35 – Future Build Scenario 4 (Granary District/West Downtown Network Improvements with New Orange Line)
Changes to Intersection Stopping Probabilities and Hold Times**

Intersection	Dir	AM Peak		Off Peak		PM Peak	
		Probability of Stop (Red Light)	Hold Time (s)	Probability of Stop (Red Light)	Hold Time (s)	Probability of Stop (Red Light)	Hold Time (s)
Orange Line (800S & 400W – 400W& 200S)							
800S & 400W	NB	33%	9	with same settings all day			
	SB	33%	9				
700S & 400W	NB	20%	5	with same settings all day			
	SB	20%	5				
600S & 400W	NB	79%	48	49%	27	80%	48
	SB	54%	33	31%	17	30%	18
500S & 400W	NB	44%	26	35%	19	40%	24
	SB	69%	41	61%	33	50%	30
400S & 400W	NB	53%	31	with same settings all day			
	SB	53%	37				
300S & 400W	NB	21%	5	with same settings all day			
	SB	21%	5				
400W & 200S	NB	53%	31	with same settings all day			
	SB	53%	37				
800S Station Ped Crossing	NB	20%	7	with same settings all day			
	SB	20%	7				
450S & Trunk Ped Crossing	NB	20%	8	with same settings all day			
	SB	20%	8				
Orange Line (Ballpark Station – 800S & 400W)							
Paxton Ave & Ballpark	NB	Uses Pre-emption instead of Priority at this Signal					
	SB						
300W & Ballpark	NB	Uses Pre-emption instead of Priority at this Signal					
	SB						
American Ave & Ballpark	NB	Uses Pre-emption instead of Priority at this Signal					
	SB						
900S & Ballpark	NB	Uses Pre-emption instead of Priority at this Signal					
	SB						

Future Build Scenario 4 Simulation Results

Future Build Scenario 4 Simulation Results: On-Time Performance (OTP)

Each scenario was run five times, with the TrainOps variability feature turned on to produce a set of randomized simulation results. The train lateness threshold was set at 4 minutes and 59 seconds. Table 36 shows the Future Build Scenario 4 model was able to achieve an OTP of 95.5% for the combined average of the three TRAX Line (Red, Blue and Green) plus the addition on the new Orange Line. The individual lines OTP ranged from 92.3% to 97.6%, which were deemed acceptable.

Table 36 – Future Build Scenario 4 (Granary District/West Downtown Network Improvements with New Orange Line) On-Time Performance

Future Build S4	TRAX Train Line				Combined Average
	Blue Line	Red Line	Green Line	Orange Line	
Run 1	95.7%	96.2%	96.2%	96.7%	**96.2%**
Run 2	96.4%	95.4%	94.5%	92.4%	**95.0%**
Run 3	97.6%	94.5%	95.0%	93.3%	**95.4%**
Run 4	96.7%	93.5%	94.8%	92.3%	**94.5%**
Run 5	97.1%	97.0%	95.1%	95.3%	**96.4%**
Combined Average	**96.7%**	**95.3%**	**95.1%**	**94.0%**	**95.5%**

Future Build Scenario 4 Simulation Results: String Charts

Delays can be observed when comparing the dashed lines of a scheduled train trip to the solid lines of the same simulated train trip. For Future Build Scenario 4, the track re-alignment created two different trunk sections. Figure 23 shows the same truck section as before, but in this scenario only the Blue Line and Green Line trips are running on it. The chart still shows the Red Line and Orange Line trips, but for the trunk section, these trips are on the new track (denoted with stations including "[new]"). Figure 24 shows the new trunk section through the Granary District.

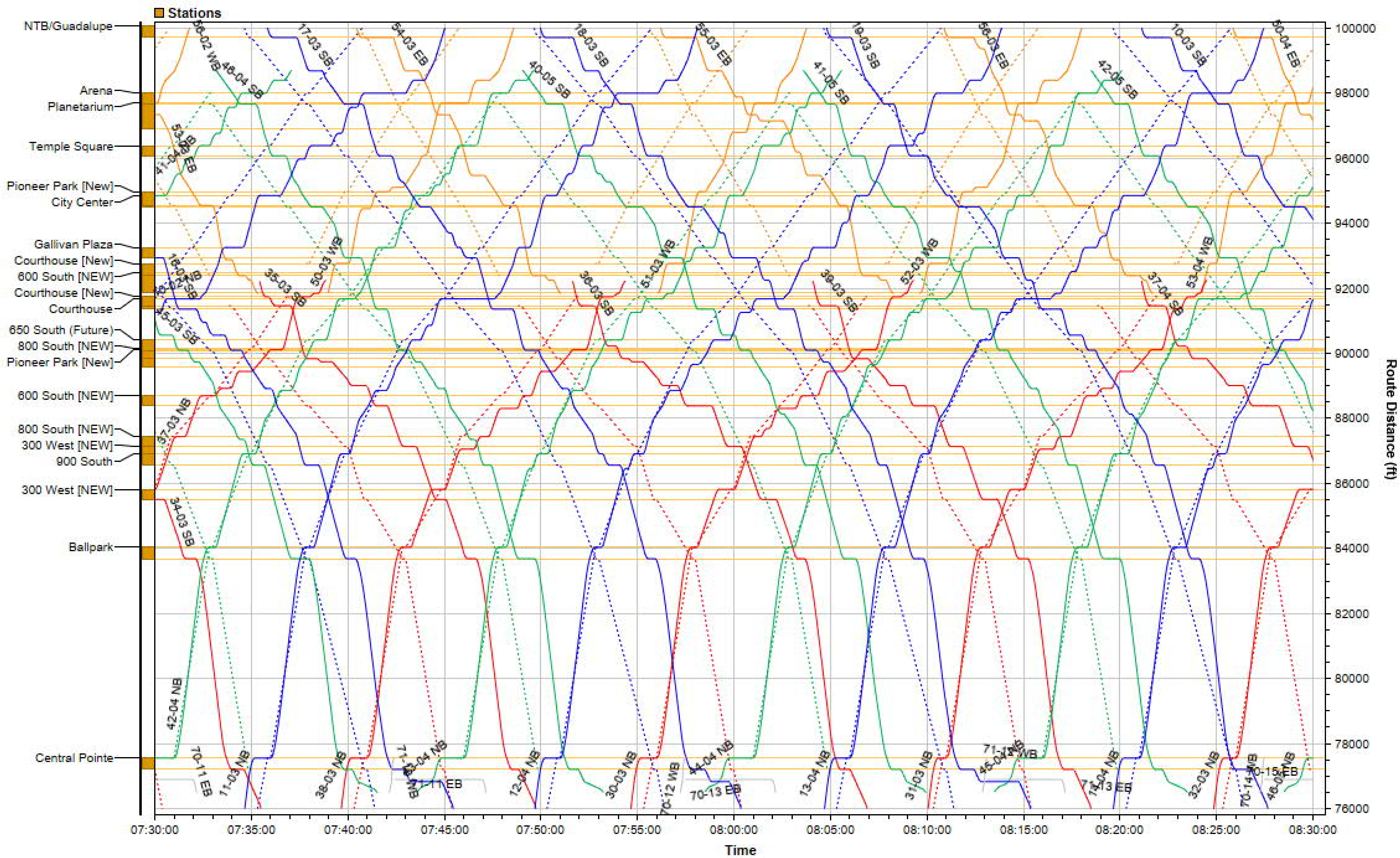

Figure 23 – Future Build Scenario 4 (Granary District/West Downtown Network Improvements with New Orange Line) Along the trunk section between Central Pointe and North Temple Bridge – 7:30 AM and 8:30 AM

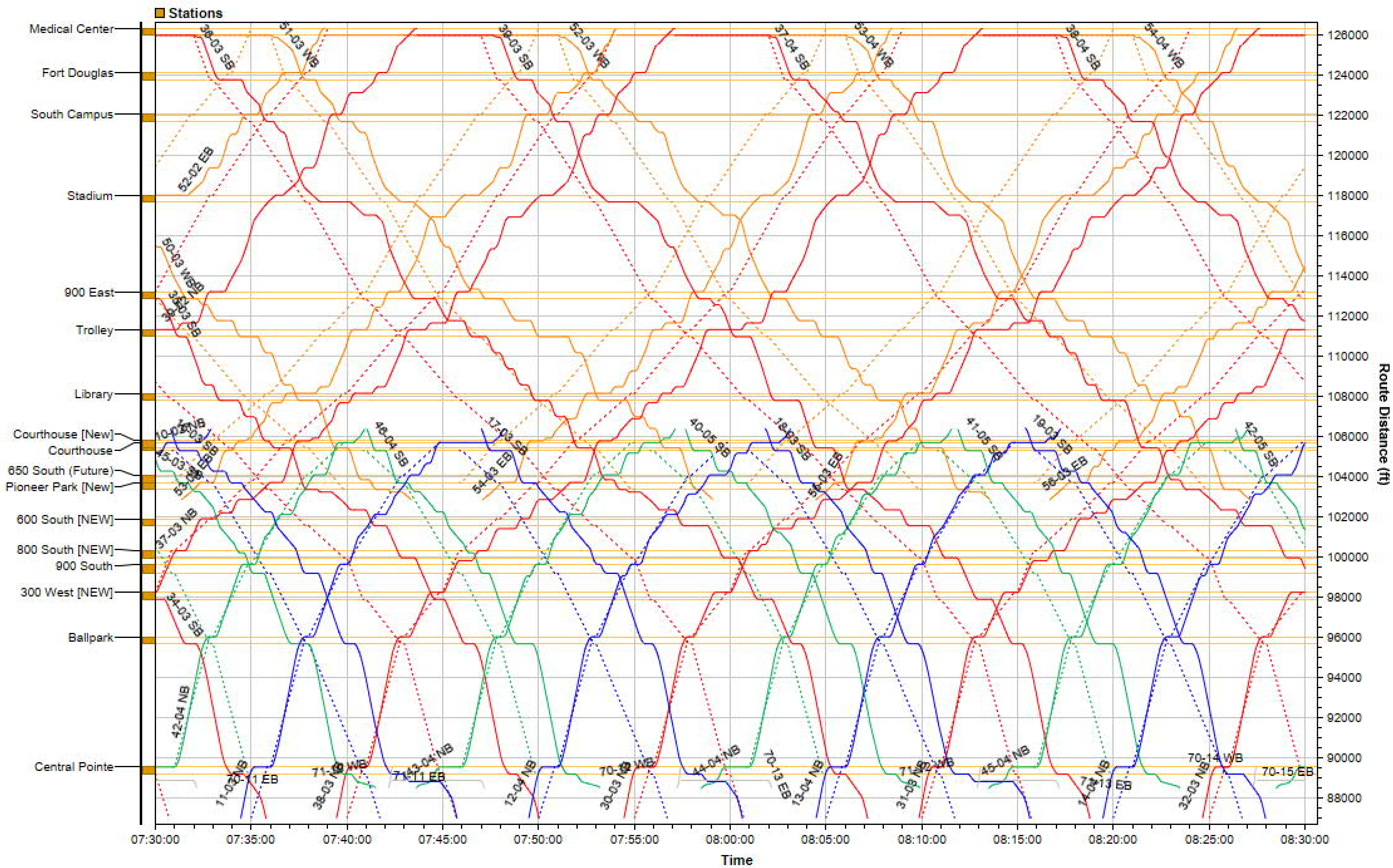

Figure 24 – Future Build Scenario 4 (Granary District/West Downtown Network Improvements with New Orange Line) Along the Trunk Line between Pioneer Park and Library – 7:30 AM and 8:30 AM

Future Build Scenario 4 Simulation Results: Delay Graphic

Figure 25 shows a summary of the simulated stop delays; the Red Line and Orange Line experience significant intersection delays between Library and Stadium given the doubling of train volumes along 400 S.

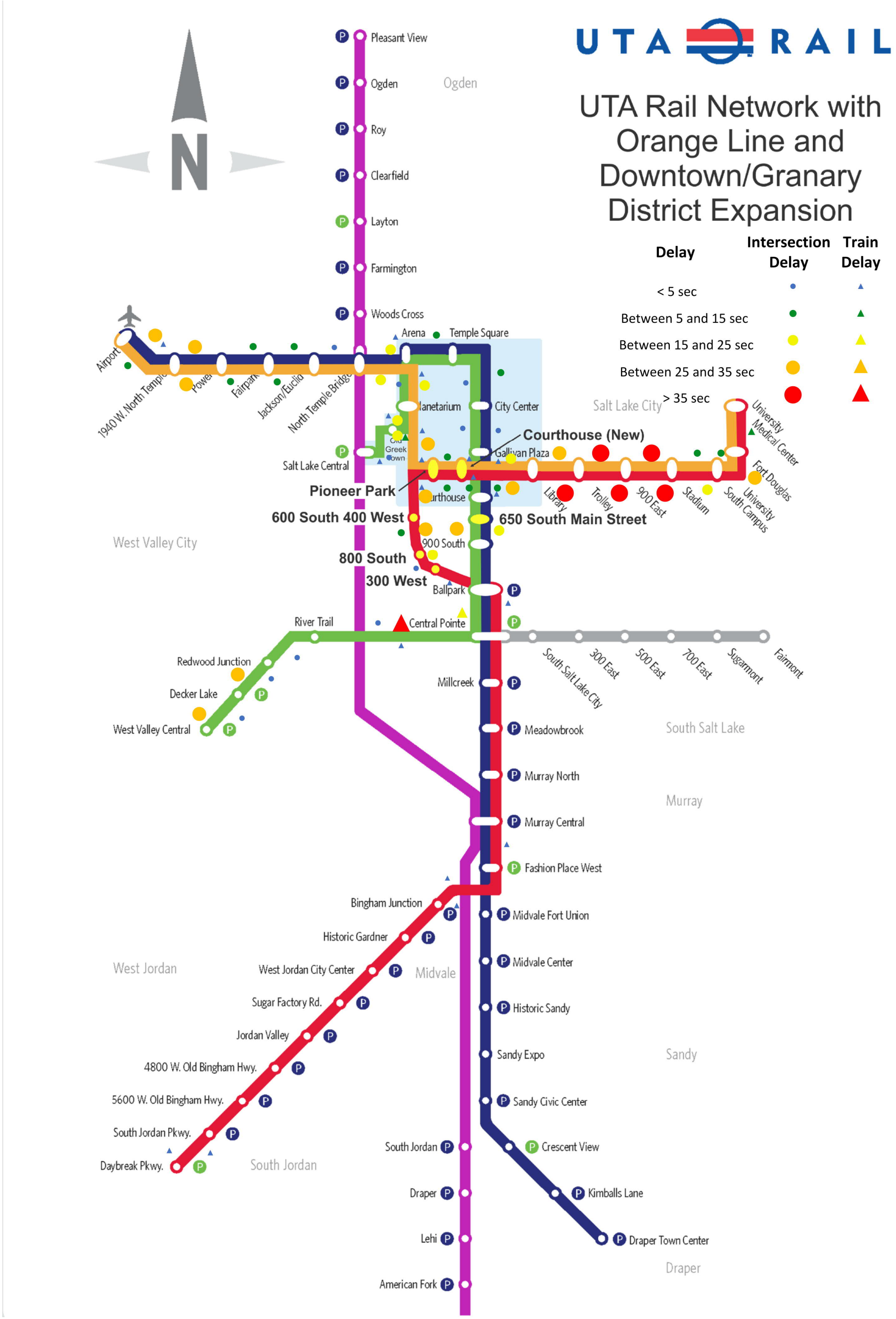

Figure 25 – Future Build Scenario 4 (Granary District/West Downtown Network Improvements with New Orange Line) Delay Graphic

The Orange Line and Blue Line also experience intersection delays near the Airport terminal, another location where train volumes double versus the Future Baseline.

Future Build Scenario 4 Simulation Results: Stopped Signal Delay

Stopped signal delay occurs when a revenue train is brought to a stop by conflict with another trip or a traffic light. The stopped signal delay was calculated to show the average number of seconds a train is stopped per mile travelled. This is a normalized statistic to compare various simulation results with potentially different train counts or trip distances.

Table 37 presents the Future Build Scenario 4 stopped signal delay per mile, split by lines. When compared against the Future Baseline Scenario, the combined results are considerably higher. This can be attributed to the addition of a fourth line and new track layout.

Table 37 – Future Build Scenario 4 (Granary District/West Downtown Network Improvements with New Orange Line)
Seconds of Stopped Delay per Mile Travelled

TRAX Train Line	Future Baseline Northbound (seconds)	Future Baseline Southbound (seconds)	Future Build Scenario 4 Northbound (seconds)	Future Build Scenario 4 Southbound (seconds)
Blue Line	6	5	8	7
Red Line	8	7	10	6
Green Line	19	18	15	22
Orange Line			23	24
All Lines	**10**	**9**	**12**	**11**

Future Build Scenario 4 Simulation Results: Peak Fleet Requirement

The equipment cycles were evaluated to determine the peak fleet requirement for the Future Build Scenario 4 simulation. Table 38 shows the breakdown by line and by vehicle type. As expected, the number of train counts increased from 29 trains in the Future Baseline Scenario to 33 trains due to the addition of the Orange Line.

When the 20% spare margin is added to the 106-car peak fleet requirement, the resultant overall fleet requirement of 128 cars exceeds the current light rail fleet total (excluding the three S70 streetcars) of 114 cars. Therefore, this scenario requires a capital investment of 14 cars. Should UTA opt for a new longer standard car length, the corresponding number of cars will be less but the overall required capital investment will be approximately the same.

Table 38 – Future Build Scenario 4 (Granary District/West Downtown Network Improvements with New Orange Line)
Peak Fleet Requirement

Future Baseline	Siemens SD100		Siemens S70		Combined	
	# Cars	# Trains	# Cars	# Trains	# Cars	# Trains
Blue Line	0	0	40	10	40	10
Red Line	0	0	40	10	40	10
Green Line	0	0	14	7	14	7
Orange Line	0	0	12	6	12	6
Combined	**0**	**0**	**106**	**33**	**106**	**33**

Future Build Scenario 5 (Granary District/West Downtown Network Improvements and Research Park Ext. with New Orange Line)

Future Build Scenario 5 is identical to Build Scenario 4 except it includes a new terminal station at Research Park on the Orange Line.

Future Build Scenario 5 Fleet

For this scenario, the proposed infrastructure changes would likely occur at the same time that the SD100/SD160 fleet is retired, hence only Siemens S70 was used as future vehicle.

Future Build Scenario 5 Infrastructure

Future Build Scenario 5 utilized the same infrastructure as Scenario 4 with a new branch extending from South Campus Drive to the Research Park Precinct and a new Research Park station (Figure 26). The University of Utah asked UTA to investigate a new TRAX station to serve the Research Park Precinct. This new future station named as Research Park Station was modeled to be located in front of an existing parking lot on Arapeen Drive next to 505 Wakara Way, as shown in Figure 26.

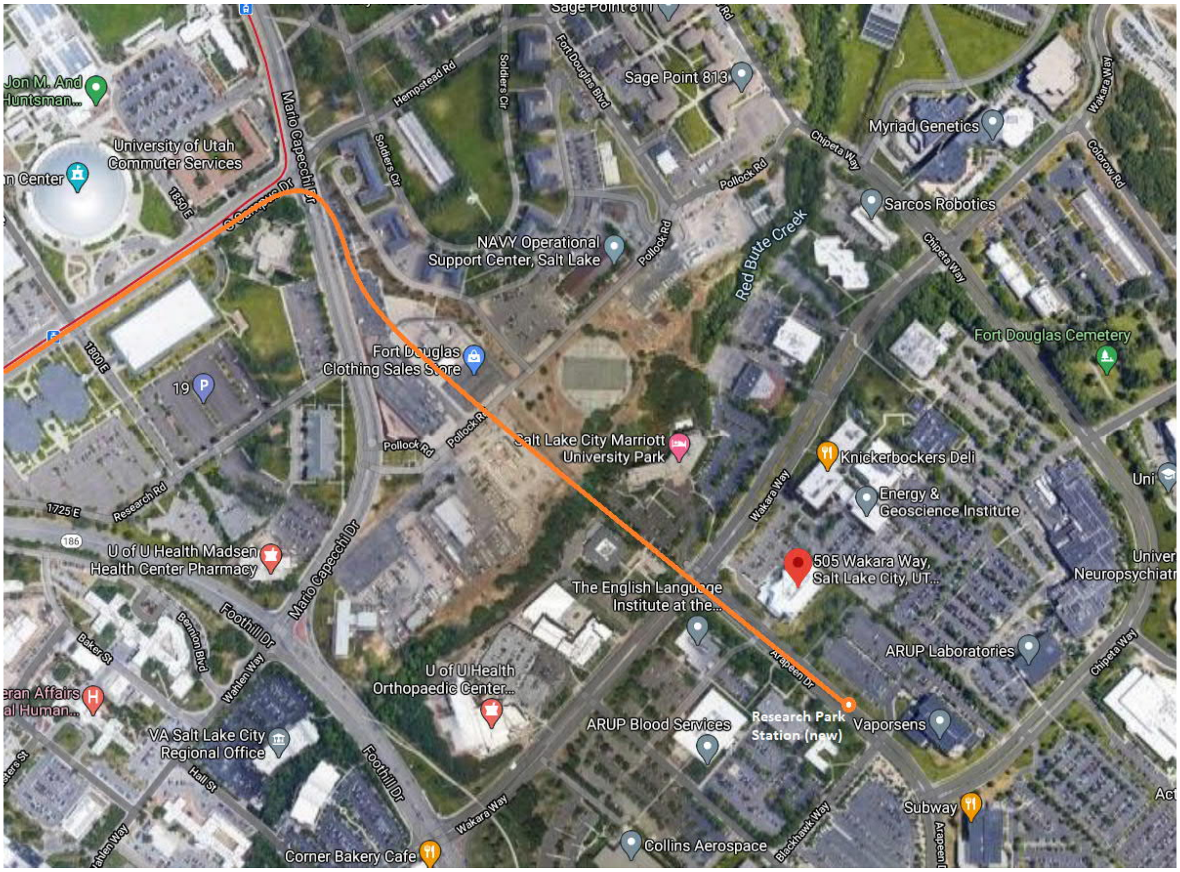

Figure 26 – Future Build Scenario 5 Research Park Extension Served by New Orange Line with Red Line Junction

Future Build Scenario 5 Infrastructure: Civil Speed Restrictions

For Future Build Scenario 5, in general, the civil speed limits were based on Future Build Scenario 4. The civil speed on the new tracks between South Campus Drive to Arapeen Drive was set at 35 mph. The turnout speed at the split with the Red Line was set to 10 mph, consistent with UTA Engineering Criteria.

Future Build Scenario 5 Infrastructure: Wayside Signaling

For Future Build Scenario 5, the wayside signals and control lines were the same as Future Build Scenario 4, except at the intersection of South Campus Drive and Mario Capecchi Drive where a new simulated junction was installed to allow the service to be split between University Medical Center and Research Park destinations. The signal and control lines at the intersection of South Campus Drive and Mario Capecchi Drive mimicked the configuration at the intersection of South Temple and N 400 W. The outbound (eastbound) trains at this intersection were allowed to travel to Research Park (straight route), to travel to Fort Douglas and University Medical Center (diverging route) or stop if intersection traffic signal phasing called for a conflicting (non-light rail) route.

Future Build Scenario 5 Operational Data

For the Future Build Scenario 5, the operating lines were similar to Scenario 4 except for the Orange Line which branched off to Research Park, instead of continuing to the University Medical Centre. A summary of the four operating lines is given below:

+ TRAX Blue Line: between Airport and Draper Town Center
+ TRAX Red Line: between University Medical Center and Daybreak Parkway
+ TRAX Green Line: between Salt Lake Central and West Valley Central
+ TRAX Orange Line: between Airport and Research Park

The operational plan for Scenario 5 replicated that of the Scenario 4, except for the Orange Line which terminates at Research Park station instead of the University Medical Center.

Due to the amount of changes to the operating plan, the change of dispatch time and travel times are not comparable to the Existing Baseline schedule. The operating plan maintains 7-8 minute headways on both trunk lines and a 15-minute headway for each rail service.

Future Build Scenario 5 Operational Data: Intersection Priorities

For this scenario, the stopping probabilities and hold times at traffic lights were based on the same specifications as Scenario 4. New stopping probabilities and hold times were introduced as shown in Table 39.

Table 39 – Future Build Scenario 5 (Granary District/West Downtown Network Improvements and Research Park Ext. with New Orange Line) Changes to Intersection Stopping Probabilities and Hold Times							
Intersection	Dir	AM Peak		Off Peak		PM Peak	
		Probability of Stop (Red Light)	Hold Time (s)	Probability of Stop (Red Light)	Hold Time (s)	Probability of Stop (Red Light)	Hold Time (s)
Orange Line (Pioneer Park Station – Courthouse Station (New))							
Wakara Way & Arapeen Dr	WB	53%	37	with same settings all day			
	EB	53%	37				
Pollock Rd & Orange Line	NB	Uses Pre-emption instead of Priority at this Signal					
	SB						

Future Build Scenario 5 Simulation Results

Future Build Scenario 5 Simulation Results: On-Time Performance (OTP)

Each scenario was run five times, with the TrainOps variability feature turned on to produce a set of randomized simulation results. The train lateness threshold was set at 4 minutes and 59 seconds. Table 40 shows the Future Build Scenario 5 model was able to achieve an OTP of 94.9% for the combined average of the three TRAX Line (Red, Blue and Green) plus the addition on the new Orange Line. The individual lines OTP ranged from 91.4% to 98.0%, which were deemed acceptable.

Table 40 – Future Build Scenario 5 (Granary District/West Downtown Network Improvements and Research Park Ext. with New Orange Line) On-Time Performance					
Future Build S4	TRAX Train Line				Combined Average
	Blue Line	Red Line	Green Line	Orange Line	
Run 1	98.0%	92.5%	95.7%	95.3%	**95.4%**
Run 2	97.3%	93.4%	95.6%	95.5%	**95.4%**
Run 3	97.3%	90.5%	95.5%	94.8%	**94.3%**
Run 4	96.8%	92.7%	95.8%	95.4%	**95.0%**
Run 5	97.7%	91.4%	94.6%	94.2%	**94.5%**
Combined Average	**97.4%**	**92.1%**	**95.4%**	**95.1%**	**94.9%**

Future Build Scenario 5 Simulation Results: String Charts

Delays can be observed when comparing the dashed lines of a scheduled train trip to the solid lines of the same simulated train trip. Just like in Future Build Scenario 4, Future Build Scenario 5 has the track re-alignment creating two different trunk sections. Figure 27 shows the same truck section as before, but in this scenario only the Blue Line and

Green Line trips are running on it. The chart still shows the Red Line and Orange Line trips, but for the trunk section, these trips are on the new track (denoted with stations including "[new]"). Figure 28 shows the new trunk section. The Red Line continues to the Medical Center, while the Orange Line goes to the new Research Park terminal (not shown on the chart).

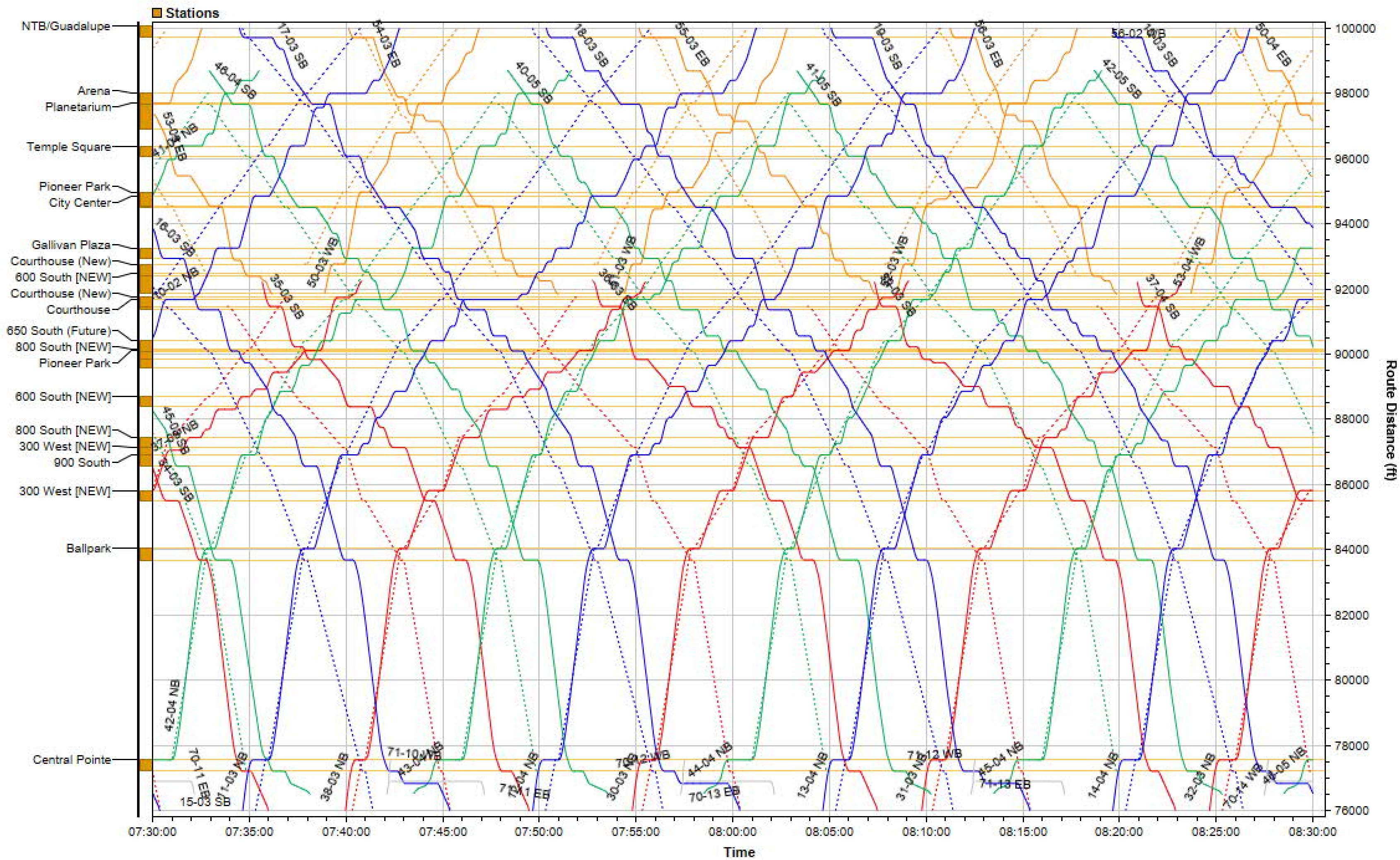

Figure 27 – Future Build 5 (Granary District/West Downtown Network Improvements and Research Park Ext. with New Orange Line) – Time-Distance ("String") Chart – Along the trunk section between Central Pointe and North Temple Bridge – 7:30 AM and 8:30 AM

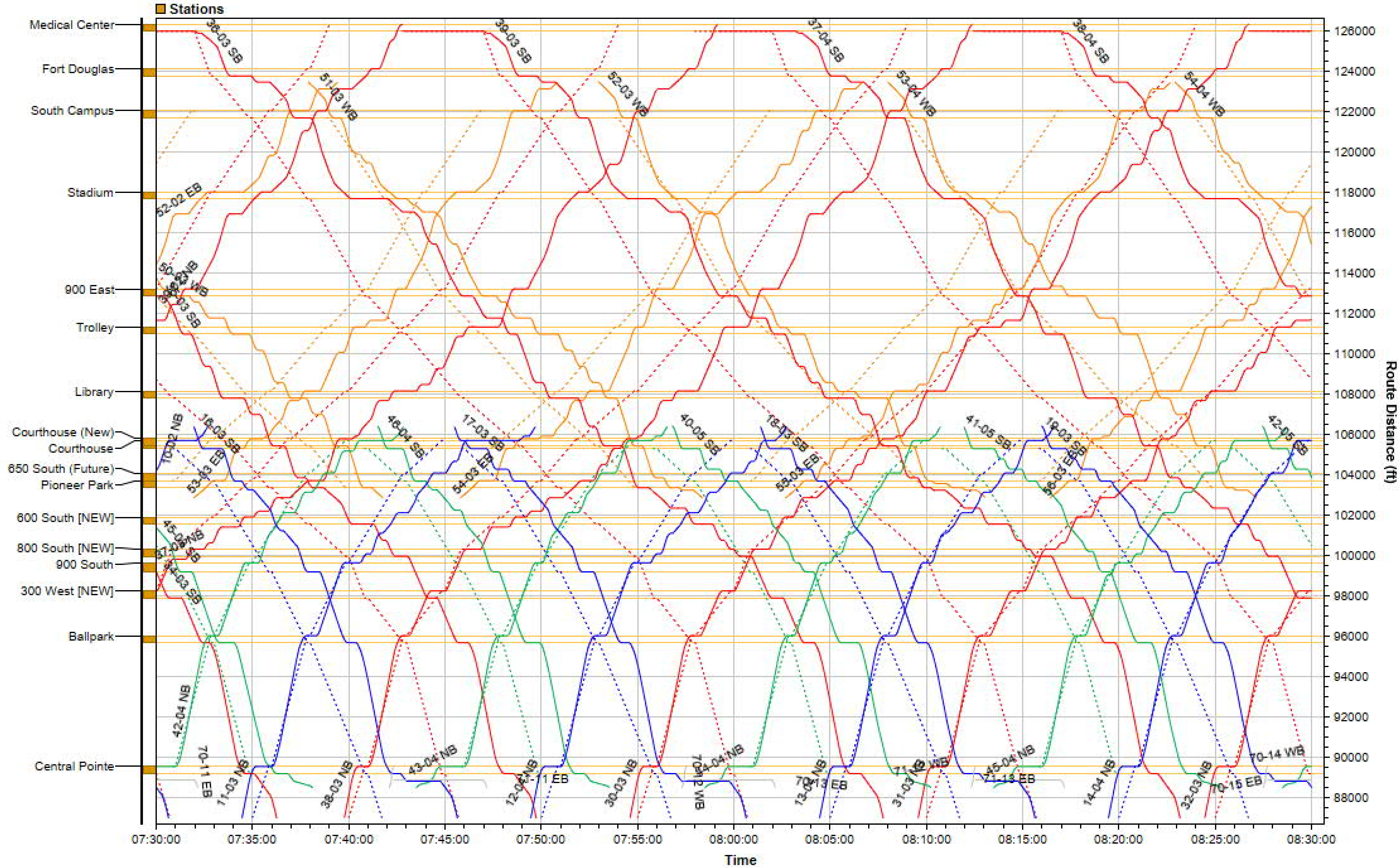

Figure 28 – Future Build 5 (Granary District/West Downtown Network Improvements and Research Park Ext. with New Orange Line) – Time-Distance ("String") Chart – Along the Trunk Line between Pioneer Park and Library – 7:30 AM and 8:30 AM

Future Build Scenario 5 Simulation Results: Stopped Signal Delay

Stopped signal delay occurs when a revenue train is brought to a stop by conflict with another trip or a traffic light. The stopped signal delay was calculated to show the average number of seconds a train is stopped per mile travelled. This is a normalized statistic to compare various simulation results with potentially different train counts or trip distances.

Table 41 presents the Future Build Scenario 5 stopped signal delay per mile, split by lines. When compared against the Future Baseline Scenario, the combined results are considerably higher. This can be attributed to the doubling of train frequency on the University and Airport Lines, coupled with intersection delay probabilities on these lines.

Table 41 – Future Build Scenario 5 (Granary District/West Downtown Network Improvements and Research Park Ext. with New Orange Line) Seconds of Stopped Delay per Mile Travelled

TRAX Train Line	Future Baseline		Future Build Scenario 5	
	Northbound (seconds)	Southbound (seconds)	Northbound (seconds)	Southbound (seconds)
Blue Line	6	5	7	7
Red Line	8	7	10	7
Green Line	19	18	15	21
Orange Line			26	25
All Lines	**10**	**9**	**12**	**12**

Future Build Scenario 5 Simulation Results: Peak Fleet Requirement

The equipment cycles were evaluated to determine the peak fleet requirement for the Future Build Scenario 5 simulation. Table 42 shows the breakdown by line and by vehicle type. As expected, the number of train counts increased from 29 trains in the Future Baseline Scenario to 33 trains due to the addition of the Orange Line. The number of train and car counts are the same as Future Build Scenario 4.

When the 20% spare margin is added to the 106-car peak fleet requirement, the resultant overall fleet requirement of 128 cars exceeds the current light rail fleet total (excluding the three S70 streetcars) of 114 cars. Therefore, this scenario requires a capital investment of 14 cars. Should UTA opt for a new longer standard car length, the corresponding number of cars will be less but the overall required capital investment will be approximately the same.

Table 42 – Future Build Scenario 5 (Granary District/West Downtown Network Improvements and Research Park Ext. with New Orange Line) Peak Fleet Requirement						
	Siemens SD100		**Siemens S70**		**Combined**	
Future Baseline	**# Cars**	**# Trains**	**# Cars**	**# Trains**	**# Cars**	**# Trains**
Blue Line	0	0	40	10	40	10
Red Line	0	0	40	10	40	10
Green Line	0	0	14	7	14	7
Orange Line	0	0	12	6	12	6
Combined	**0**	**0**	**106**	**33**	**106**	**33**

Future Build Scenario 6 (Existing Network with 12-Minute Headways on all 3 Lines)

The purpose of Future Build Scenario 6 is to use the infrastructure from the Future Baseline scenario and to run the operating plan with 12 minute headway for each TRAX line and 4 minute headways within the trunk. It includes the new 650 South Station and a relocated Airport Station. There were no changes to station dwell times, minimum terminal turn times, civil speed restrictions or intersection priorities.

This scenario may require traction power system improvements as it increases train frequencies on all segments of the TRAX network. Concurrent with the Future of Light Rail Study, UTA conducted a Light Rail Traction Power Load Flow Study, the results of which are presented in "TRAX Traction Power System Improvements" section below. The traction power study evaluated an overlaid Orange Line operating between the University and Salt Lake Central but otherwise did not investigate increased train volumes on the Trunk Line.

This work began by evaluating signal wakes of each TRAX signal to understand if 4-minute intervals between trips are technically feasible at each wayside signal location. The light simulation signal wake evaluation uses single train modeling to determine the trains per hour capacity at each North/South Trunk Line signal.

North/South Trunk Line Signal Capacity Analysis

The North/South Line signal capacity analysis is based on the existing speed profile and 4-car train performance. For Red Line operations S70 consists were used while SD100 consists were used on the Blue Line, consistent with current fleet assignments. The analysis used 30-second fixed dwell times at each station.

While closely-spaced TRAX trains can continue to proceed with yellow (Caution) signal aspects, the signal capacity analysis is based on green (Proceed) signal aspects. Train Operators typically slow when passing Caution aspects so they do not represent "steady state" operating conditions. The TrainOps light simulation produces signal clearing times ("signal wakes") at each signal. To provide for some operating variability, a 25% operating margin was added to the signal clearing times. The resultant value, divided into 60 minutes, yields the trains per hour capacity at each signal.

Scenario 6 seeks to operate a train every four minutes on the North/South Line where all three services share track. This is equivalent to 15 trains per hour. Where only the Red and Blue Lines operate, the two services will still need to operate four minutes apart with an eight-minute gap so that Green Line trips can be inserted at Central Pointe. Therefore, the required Scenario 6 North/South Line capacity between Fashion Place West and Central Pointe is still effectively 15 trains per hour, even if only 10 trains per hour (with gaps) are scheduled in this segment in Scenario 6. On the TRAX branches themselves, Scenario 6 calls for 12-minute headways or a capacity of 5 trains per hour.

Figure 29 displays the simulated capacities of each northbound signal on the Blue Line between Draper Terminal and the junction with the Red Line at Fashion Place West. The height of these bars represents practical trains per hour (that is, capacities that include the 25% operating margin) with the lowest bars representing the most capacity-constrained locations. The height of the bars varies as signal spacing and the number of station stops within the limits of each signal's limits of control also vary. The capacities of all signals shown in Figure 29 are well above the 5 trains per hour future growth schedule reflected in Scenario 6 and therefore indicate a high degree of operating reliability in this segment.

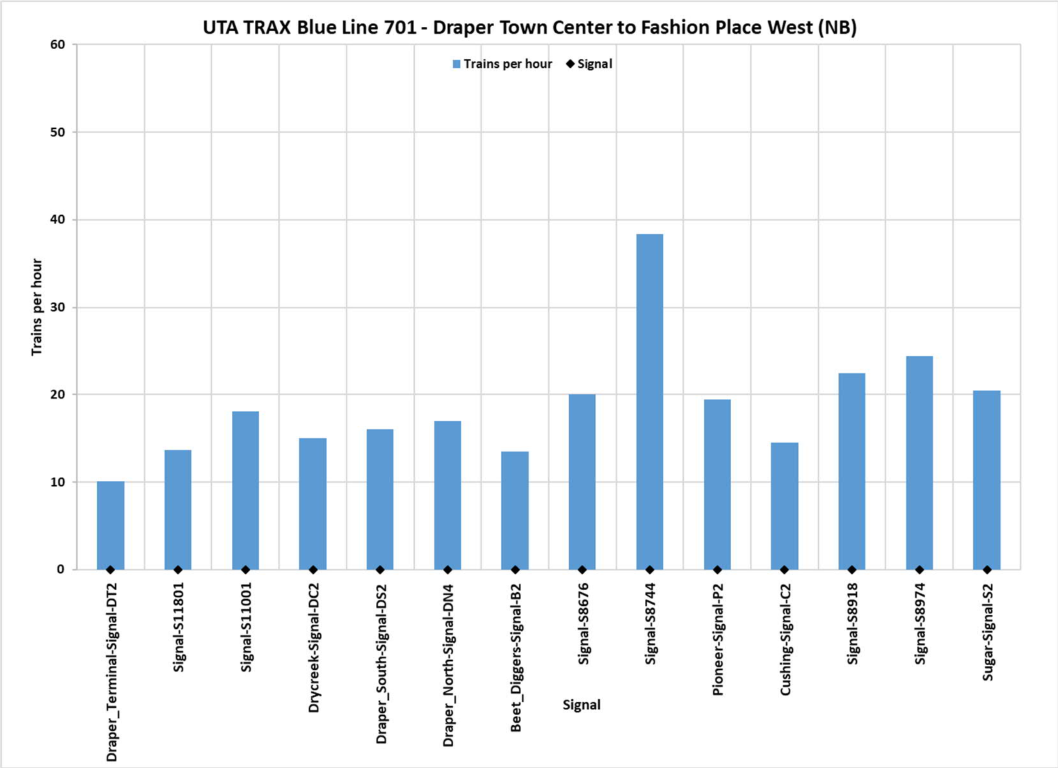

Figure 29 – Blue Line Signal Capacity – Northbound

Figure 30 displays the signal capacities of the North/South Line between the Red/Blue Lines merge at Fashion Place West, the Green Line merge at Central Pointe (Union Interlocking) and the transition from signaled track to street running at Ballpark Station. In Scenario 6, this segment must support 15 trains per hour. The results shown in Figure 30 show that all but two signals support the required train capacity. Automatic Signal S9324 and Central Interlocking Signal CI2 are slightly below the required capacity, meaning that some train delays would be expected in this area under Scenario 6.

The Red Line branch signal capacities between Daybreak Parkway and the junction with the Blue Line at Fashion Place West are shown in Figure 31. The signal capacities are markedly lower than the northbound Blue Line branch capacities but still sufficient to support the Scenario 6 Red Line capacity of 5 trains per hour.

Figure 32 displays the signal capacities for the southbound Blue Line from Fashion Place West to its Draper terminus. The signal bars in the figure have the same geographic orientation as the northbound Blue Line capacities shown in Figure 29 so, in this case, the train is traveling from right to left. Consistent with northbound Blue Line capacities, all signals support at least 10 trains per hour, double the increased level of service included in Scenario 6 in this segment.

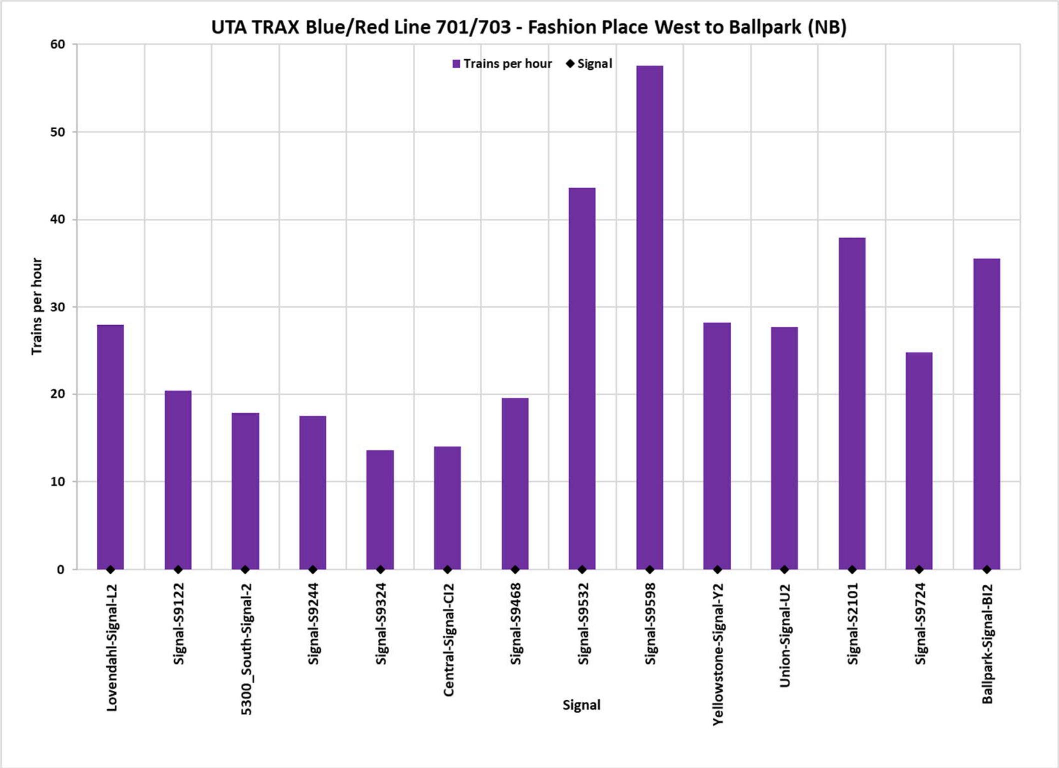

Figure 30 – Trunk Line Signal Capacity - Northbound

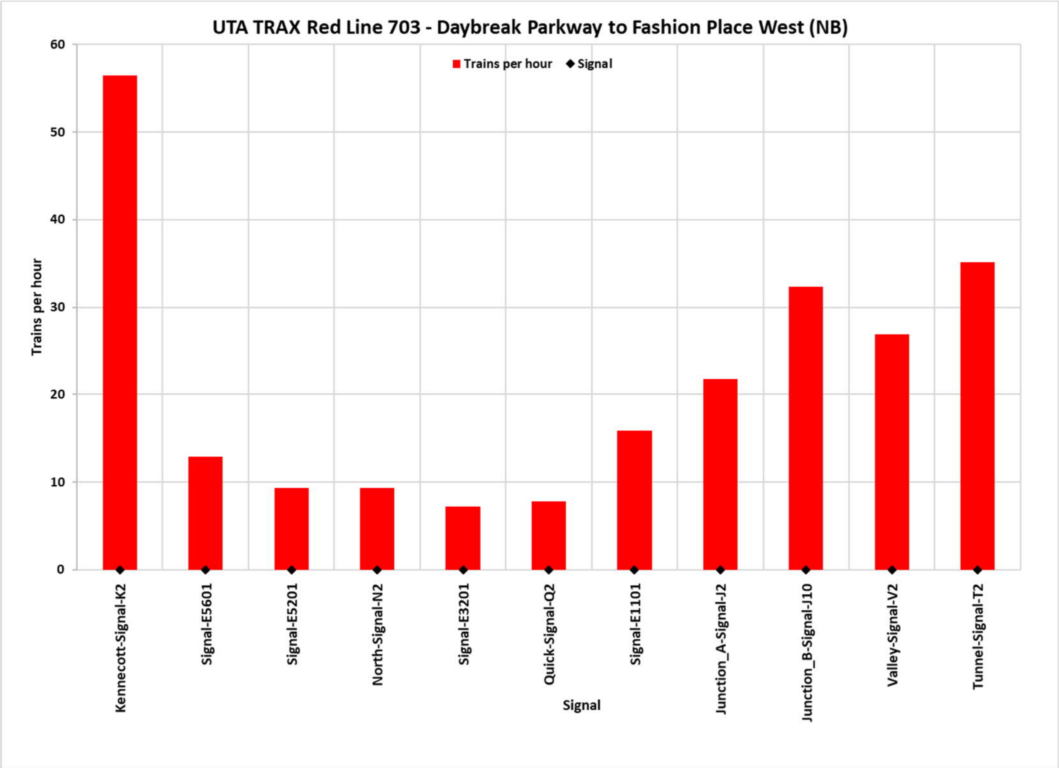

Figure 31 – Red Line Signal Capacity - Northbound

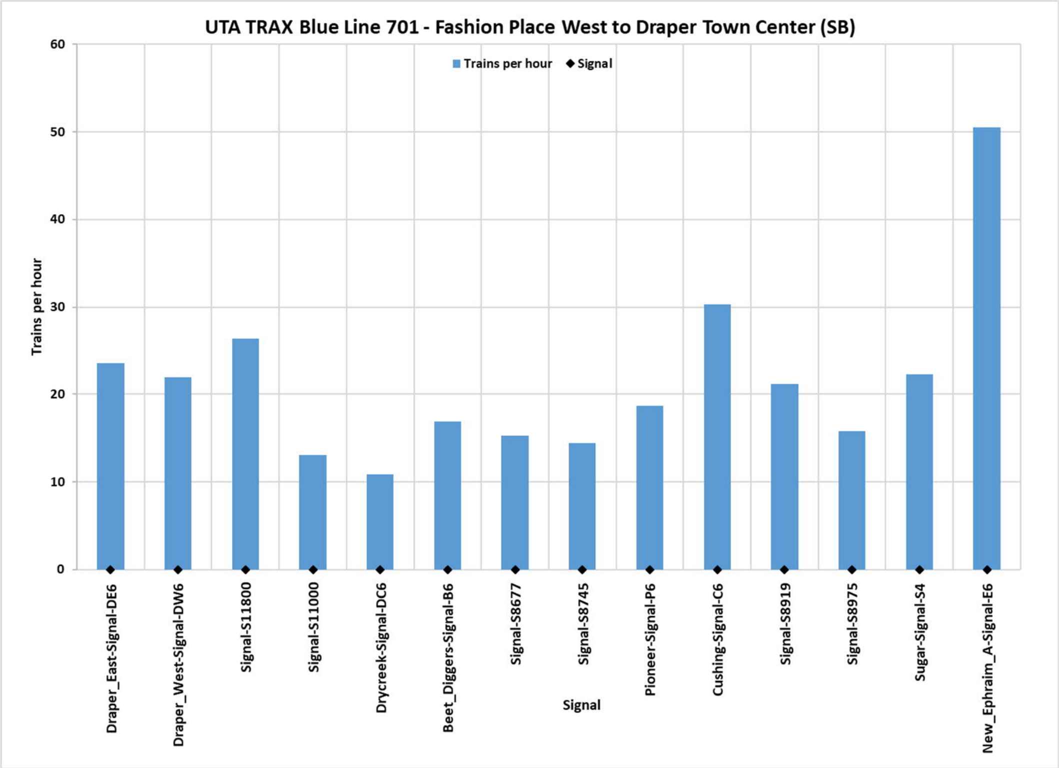

Figure 32 – Blue Line Signal Capacity - Southbound

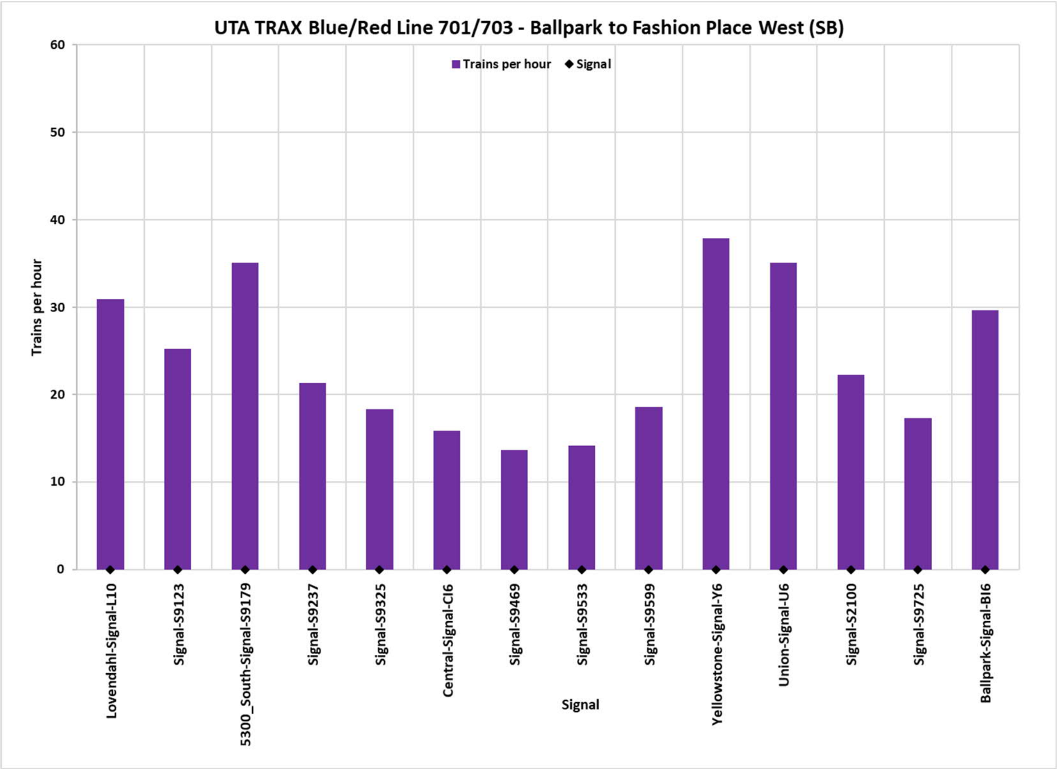

Figure 33 – Trunk Line Signal Capacity – Southbound

Figure 33 displays the results of the signal wake analysis for North/South Trunk Line signals between Ballpark, Central Pointe and Fashion Place West Stations. The figure shows show two automatic signals – S9469 and S9533 – that have capacities slightly below the required 15 trains per hour capacity called for in Scenario 6. Some delays would be expected here as trains would occasionally operate under Caution aspects rather than Proceed aspects that allow maximum track speed. In addition to the two automatic signals, Central Interlocking Signal CI6 has a practical capacity just above 15 trains per hour, indicating limited operating margin.

Figure 34 displays the southbound Red Line branch signal capacities between Fashion Place West (on right) and the Daybreak Parkway terminus (on left). The Red Line branch capacities are generally lower than the analogous locations on the Blue Line but nonetheless capable of supporting the Scenario 6 scheduled train volume of 5 trains per hour in this segment.

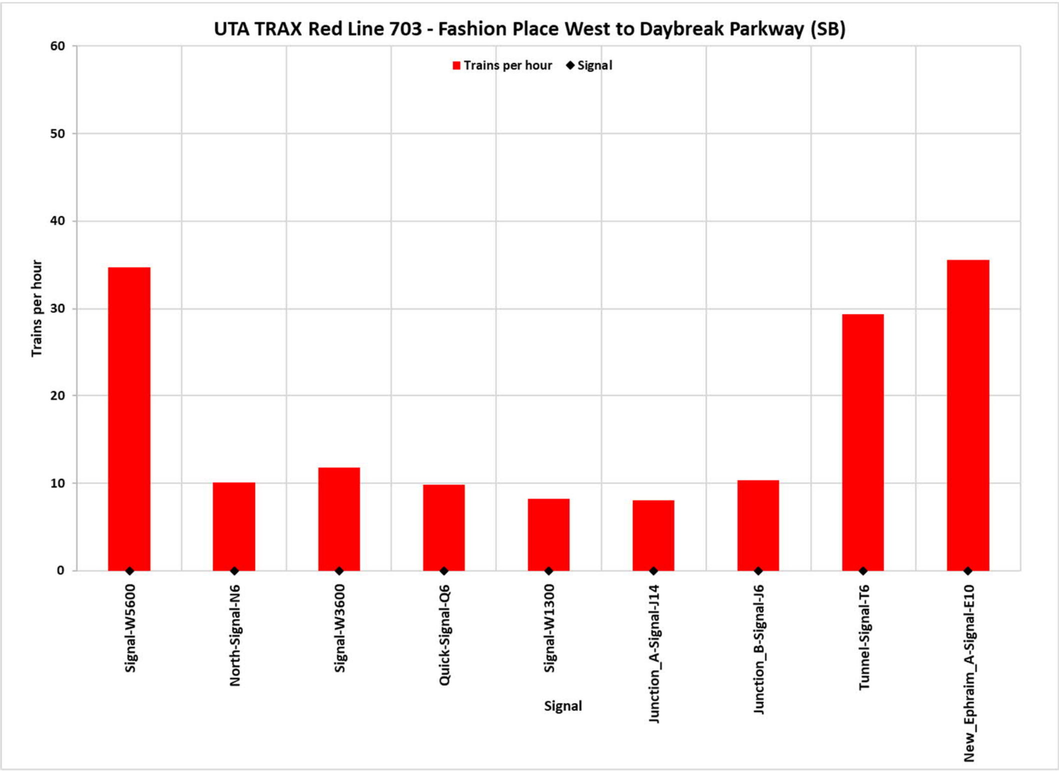

Figure 34 – Red Line Signal Capacity - Southbound

While the TrainOps light simulation did not model the traction power system as part of the Future of Light Rail Study, UTA provided a separate traction power load flow analysis for review by the Hatch LTK Team.

Future Build Scenario 6 Operational Data

For the Future Build Scenario 6, the operating plan was modified to run with 4 minute headways on the Trunk Line and a 15 minute headway on the branches.

Due to the significant changes to the operating plan, the change of dispatch time is not comparable to the Existing Baseline schedule. The change of travel times are summarized in Table 43.

Table 43 – Future Build Scenario 6 (Existing Network with 12-Minute Headways on all 3 Lines) Change in Terminal-Terminal Scheduled Travel Times

Travel Time Changes* (min)					
Blue NB	Blue SB	Red NB	Red SB	Green NB	Green SB
+1	+1	+1	+1	+2	+2

*Compared to Existing Baseline schedule.

"-" indicated amount of time removed, "+" indicates amount of additional time added

Future Build Scenario 6 Simulation Results

Future Build Scenario 6 Simulation Results: On-Time Performance (OTP)

Each scenario was run five times, with the TrainOps variability feature turned on to produce a set of randomized simulation results. The train lateness threshold was set at 4 minutes and 59 seconds. Table 44 shows the Future Build Scenario 6 model was able to achieve an OTP of 94.7% for the combined average of the three TRAX Line (Red, Blue and Green). The individual lines OTP ranged from 90.3% to 97.5%, which were deemed acceptable.

Table 44 – Future Build Scenario 6 (Existing Network with 12-Minute Headways on all 3 Lines) On-Time Performance

Future Build S6	TRAX Train Line			Combined Average
	Blue Line	Red Line	Green Line	
Run 1	93.8%	96.1%	92.4%	**94.3%**
Run 2	94.6%	97.5%	91.0%	**94.7%**
Run 3	94.8%	97.0%	93.8%	**95.3%**
Run 4	93.5%	95.7%	90.3%	**93.5%**
Run 5	96.0%	97.5%	92.8%	**95.7%**
Combined Average	**94.5%**	**96.7%**	**92.1%**	**94.7%**

Future Build Scenario 6 Simulation Results: String Charts

Delays can be observed when comparing the dashed lines of a scheduled train trip to the solid lines of the same simulated train trip. For example, in Figure 35 it can be seen that most southbound Red Line trips are running late.

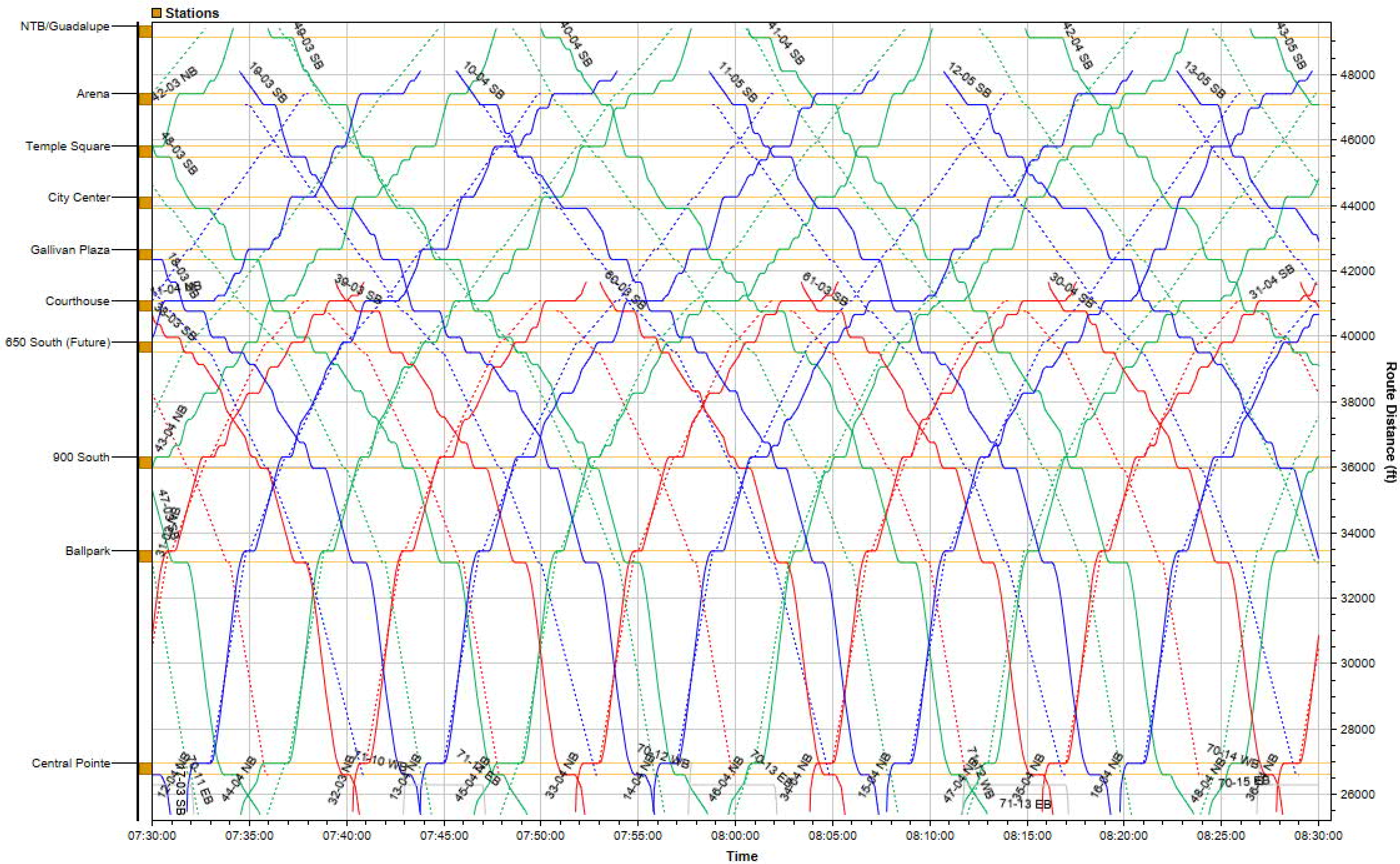

Figure 35 – Future Build Scenario 6 (Existing Network with 12-Minute Headways on all 3 Lines) – Time-Distance ("String") Chart – Along the trunk section between Central Pointe and North Temple Bridge – 7:30 AM and 8:30 AM

Future Build Scenario 6 Simulation Results: Delay Graphic

Figure 36 shows the areas prone to delays were very similar to the Existing Baseline. The Green Line terminals (Airport and West Valley Central) and the segment between 900 South Station and Fort Douglas Station on the Red Line were experiencing delays greater than 25 seconds at almost similar frequency as the existing network. In comparison to train delays, intersection delays have a greater impact on the On-Time Performance of the trains in Scenario 6, consistent with other scenarios.

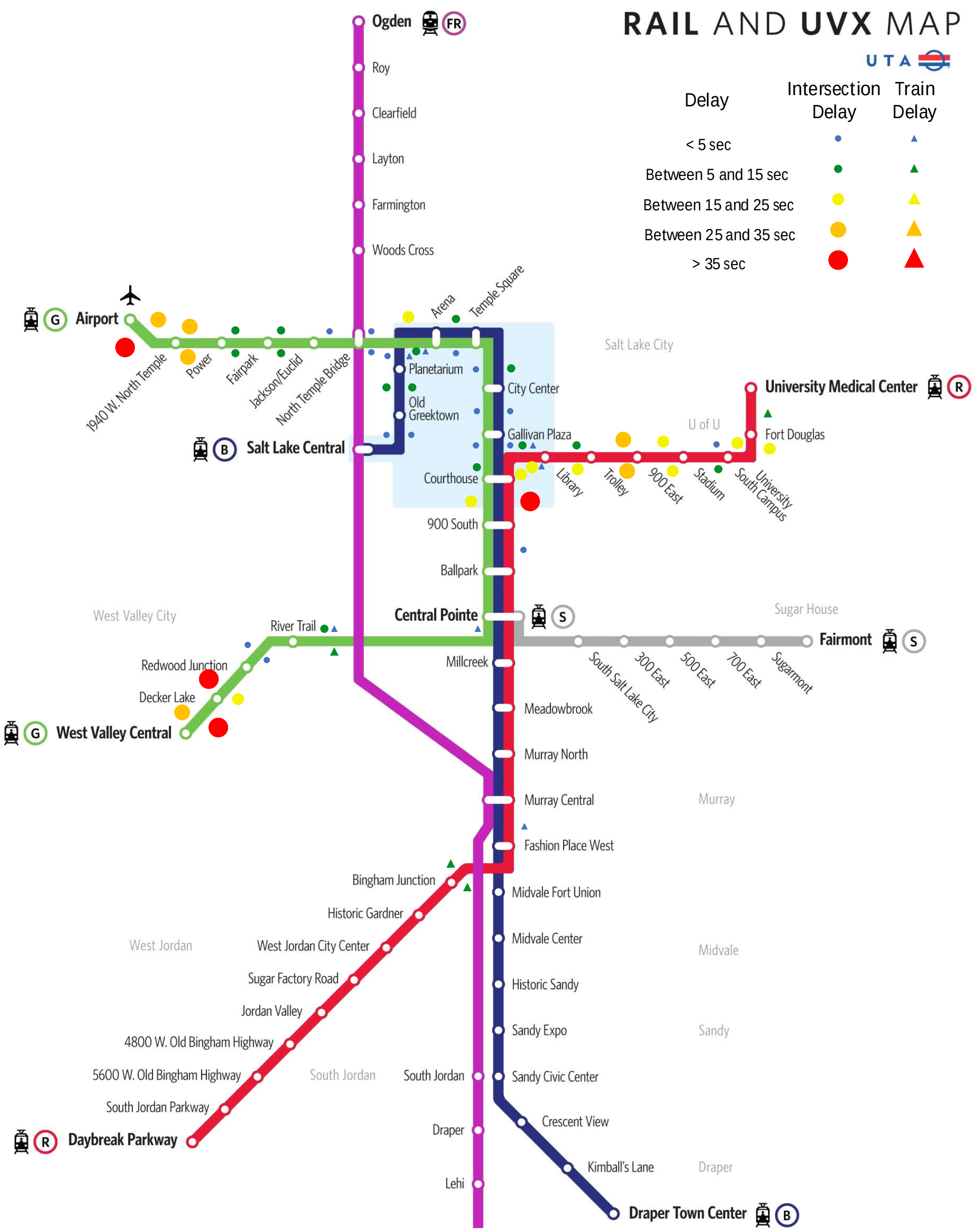

Figure 36 – Future Build Scenario 6 (Existing Network with 12-Minute Headways on all 3 Lines) – Delay Graphic

Train delays were mainly distributed around junctions (close to Arena, Courthouse Station and Central Pointe Stations). The relatively low train capacities of automatic signals S9324, S9469 and S9533, as well as Central Interlocking signals described in the earlier signal wake analysis results did not cause noticeable delays in the Scenario 6 network simulation.

Future Build Scenario 6 Simulation Results: Stopped Signal Delay

Stopped signal delay occurs when a revenue train is brought to a stop by conflict with another trip or a traffic light. The stopped signal delay was calculated to show the average number of seconds a train is stopped per mile travelled. This is a normalized statistic to compare various simulation results with potentially different train counts or trip distances.

Table 45 presents the Future Build Scenario 6 stopped signal delay per mile, split by lines. When compared against the Future Baseline Scenario, the combined results are the same for the northbound trains and 1 second less for the southbound trains.

Table 45 – Future Build Scenario 6 (Existing Network with 12-Minute Headways on all 3 Lines) Seconds of Stopped Delay per Mile Travelled

TRAX Train Line	Future Baseline		Future Build Scenario 6	
	Northbound (seconds)	Southbound (seconds)	Northbound (seconds)	Southbound (seconds)
Blue Line	6	5	6	4
Red Line	8	7	7	6
Green Line	19	18	20	18
Orange Line				
All Lines	**10**	**9**	**10**	**8**

Future Build Scenario 6 Simulation Results: Peak Fleet Requirement

The equipment cycles were evaluated to determine the peak fleet requirement for the Future Build Scenario 6 simulation. Table 46 shows the breakdown by line and by vehicle type. Additional trains are required to meet a headway of 4-minutes on the Trunk line and 12-minutes on the branch lines. The number of car counts increased as expected with the Red Line and Blue Line running 4-car trains all day, while the Green Line was running with 2-cars all day.

When the 20% spare margin is added to the 108-car peak fleet requirement, the resultant overall fleet requirement of 130 cars exceeds the current light rail fleet total (excluding the three S70 streetcars) of 114 cars. Therefore, this scenario requires a capital investment of 16 cars. Should UTA opt for a new longer standard car length, the corresponding number of cars will be less but the overall required capital investment will be approximately the same.

Table 46 – Future Build Scenario 6 (Existing Network with 12-Minute Headways on all 3 Lines) Peak Fleet Requirement						
	Siemens SD100		Siemens S70		Combined	
Future Baseline	**# Cars**	**# Trains**	**# Cars**	**# Trains**	**# Cars**	**# Trains**
Blue Line	0	0	40	10	40	10
Red Line	0	0	48	12	48	12
Green Line	0	0	20	10	20	10
Combined	**0**	**0**	**108**	**32**	**108**	**32**

Discussion of Results

Each of the scenarios has its own advantages and operating challenges. Looking at the average on-time performance (OTP) shown in Table 47, all of the scenarios are an improvement over the Future Baseline Scenario. The two scenarios with the highest OTP are Scenario 2 (with the increase to curve speeds) and Scenario 3 (with the increase to train priorities at traffic light intersections).

Table 47 – Summary – Average On-Time Performance (OTP)

TRAX Train Line	Future Baseline	Future Build Scenario 1	Future Build Scenario 2	Future Build Scenario 3	Future Build Scenario 4	Future Build Scenario 5	Future Build Scenario 6
Blue Line	96.0%	96.3%	97.3%	96.9%	96.7%	97.4%	94.5%
Red Line	89.1%	90.6%	96.6%	95.4%	95.3%	92.1%	96.7%
Green Line	92.6%	95.2%	93.9%	95.9%	95.1%	95.4%	92.1%
Orange Line					94.0%	95.1%	
All Lines	**92.5%**	**93.8%**	**96.1%**	**96.1%**	**95.5%**	**94.9%**	**94.7%**

Looking at Peak Fleet Requirements (Table 48), Future Build Scenario 4 and Future Build Scenario 5 will require a significant investment in fleet. Future Build Scenario 6 will require the most investment.

Table 48 – Summary of Peak Fleet Requirement

	Siemens SD100		Siemens S70		Combined	
	# Cars	# Trains	# Cars	# Trains	# Cars	# Trains
Future Baseline	26	8	61	21	87	29
Future Build Scenario 1	0	0	87	29	87	29
Future Build Scenario 2	0	0	87	29	87	29
Future Build Scenario 3	0	0	87	29	87	29
Future Build Scenario 4	0	0	106	33	106	33
Future Build Scenario 5	0	0	106	33	106	33
Future Build Scenario 6	0	0	108	32	108	32

Table 49 – Summary of Peak Fleet Requirement by Line

		Siemens SD100		Siemens S70		Combined	
		# Cars	# Trains	# Cars	# Trains	# Cars	# Trains
Future Baseline	**Blue Line**	26	8	0	0	26	8
	Red Line	0	0	45	13	45	13
	Green Line	0	0	16	8	16	8
	Orange Line						
	Combined	**26**	**8**	**61**	**21**	**87**	**29**

Table 49 – Summary of Peak Fleet Requirement by Line							
		Siemens SD100		**Siemens S70**		**Combined**	
		# Cars	**# Trains**	**# Cars**	**# Trains**	**# Cars**	**# Trains**
Future Build Scenario 1	**Blue Line**	0	0	26	8	26	8
	Red Line	0	0	45	13	45	13
	Green Line	0	0	16	8	16	8
	Orange Line						
	Combined	**0**	**0**	**87**	**29**	**87**	**29**
Future Build Scenario 2	**Blue Line**	0	0	26	8	26	8
	Red Line	0	0	45	13	45	13
	Green Line	0	0	16	8	16	8
	Orange Line						
	Combined	**0**	**0**	**87**	**29**	**87**	**29**
Future Build Scenario 3	**Blue Line**	0	0	26	8	26	8
	Red Line	0	0	45	13	45	13
	Green Line	0	0	16	8	16	8
	Orange Line						
	Combined	**0**	**0**	**87**	**29**	**87**	**29**
Future Build Scenario 4	**Blue Line**	0	0	40	10	40	10
	Red Line	0	0	40	10	40	10
	Green Line	0	0	14	7	14	7
	Orange Line	0	0	12	6	12	6
	Combined	**0**	**0**	**106**	**33**	**106**	**33**
Future Build Scenario 5	**Blue Line**	0	0	40	10	40	10
	Red Line	0	0	40	10	40	10
	Green Line	0	0	14	7	14	7
	Orange Line	0	0	12	6	12	6
	Combined	**0**	**0**	**106**	**33**	**106**	**33**
Future Build Scenario 6	**Blue Line**	0	0	40	10	40	10
	Red Line	0	0	48	12	48	12
	Green Line	0	0	20	10	20	10
	Orange Line						
	Combined	**0**	**0**	**108**	**32**	**108**	**32**

Table 50 shows the summary of the seconds of stopped delay experienced by trains per mile traveled. Future Build Scenario 3 shows the largest improvement, but that is to be expected as the scenario was based on reducing time spend waiting at traffic intersection lights. As shown in Table 51, Future Build Scenario 4 and Future Build Scenario 5 have increased stopped delay per distance traveled with the addition of the Orange Line and doubling of frequency on the Airport and University Lines.

Scenario 6, with an all-day, system-wide increase in service from 12 trains per hour to 15 trains per hour on the North/South Trunk Line, was found to operate reliably. Although some signals on the trunk line have little to no residual train capacity when the system operates at four-minute intervals, these locations did not cause noticeable delays in the TrainOps light simulation.

Table 50 – Summary of Seconds of Stopped Delay per Mile Travelled

	Northbound	Southbound
Future Baseline	10	9
Future Build Scenario 1	9	8
Future Build Scenario 2	10	8
Future Build Scenario 3	8	6
Future Build Scenario 4	12	11
Future Build Scenario 5	12	12
Future Build Scenario 6	10	8

Table 51 – Summary of Seconds of Stopped Delay per Mile Travelled by Line

		Northbound	Southbound
Future Baseline	**Blue Line**	6	5
	Red Line	8	7
	Green Line	19	18
	Orange Line		
	All Lines	**10**	**9**
Future Build Scenario 1	**Blue Line**	6	4
	Red Line	7	7
	Green Line	15	13
	Orange Line		
	All Lines	**9**	**8**
Future Build Scenario 2	**Blue Line**	6	5
	Red Line	8	6
	Green Line	19	17
	Orange Line		
	All Lines	**10**	**8**
Future Build Scenario 3	**Blue Line**	5	4
	Red Line	6	5
	Green Line	15	12
	Orange Line		
	All Lines	**8**	**6**

Table 51 – Summary of Seconds of Stopped Delay per Mile Travelled by Line			
		Northbound	**Southbound**
Future Build Scenario 4	**Blue Line**	8	7
	Red Line	10	6
	Green Line	15	22
	Orange Line	23	24
	All Lines	**12**	**11**
Future Build Scenario 5	**Blue Line**	7	7
	Red Line	10	7
	Green Line	15	21
	Orange Line	26	25
	All Lines	**12**	**12**
Future Build Scenario 6	**Blue Line**	6	4
	Red Line	7	6
	Green Line	20	18
	Orange Line		
	All Lines	**10**	**8**

Additional Capital Improvement Concepts

Union Turnback Track and Green Line Wye Connection

Currently, all TRAX trains needing to go south from, or north to, the Jordan River Service Center on the main North/South line have to pull into Central Pointe Station for the operator to change ends. This process takes approximately four minutes and, with a train passing through the station every 2 to 3 minutes on average, can cause system delays. The proposed project would allow for such trains to avoid this special maneuver by constructing a track connection in the southwest quadrant of the junction between the North/South Line and the Green Line.

The project would also construct a four-car siding or turnback track on the west side of the North/South Line. This track would serve three operational purposes:

+ Support holding a non-revenue train destined for the Green Line or destined for the North/South Line until a delay-free operating slot is available without delaying following revenue trains on the line being exited,
+ Allow the staging of a special events train for Ballpark Station or other downtown stations without blocking the North/South Line,
+ Temporarily holding a train that was unexpectedly removed from service due to a vehicle issue until it can be operated (or towed) to Midvale or Jordan River.

The UTA Light Rail Business Unit desires this project and it is currently included on the future State of Good Repair list. However, the project is not presently scheduled or funded. The project was not included in the Phase 1 simulation scenarios because it does not provide quantifiable benefits to revenue train operations. The project would not directly improve travel time or capacity. However, the project would improve system reliability, as measured by OTP, as well as operational flexibility. The project would improve operational efficiency by eliminating the time-consuming reversing move at Central Pointe Station for both morning train put-ins and evening train lay-ups. It would also eliminate the reversing move for non-revenue train movements that commonly occur as vehicles are shuttled between Jordan River and Midvale Service Centers. The project could be included in one or more Phase 2 scenarios.

The concept design was refined during Phase 1 and is shown in Figure 37. The existing R.C. Willey Appliance Warehouse freight siding would need to be relocated to the south in order to provide sufficient room for the siding/turnback track. The siding/turnback track is connected to the mainline with No. 6 turnouts, suitable for light rail operations but not usable by freight trains (such as freight locomotive running around its train to change direction). The turnout at the south end of the siding/turnback track is located south of the grade crossing while a maximum length (four-car) train would fit north of the crossing. The southbound interlocked home signal would be located immediately north of the grade crossing and would be interfaced with the crossing warning systems such that the flashers would activate and gates would descend as soon as the TRAX dispatcher cleared a southbound route from the siding/turnback track. For northbound trains accessing the siding/turnback track from the south, the existing Yellowstone Interlocking crossovers on the North/South Line would be used so that the northbound train would operate a short section on the normally-southbound track before diverging to the new track.

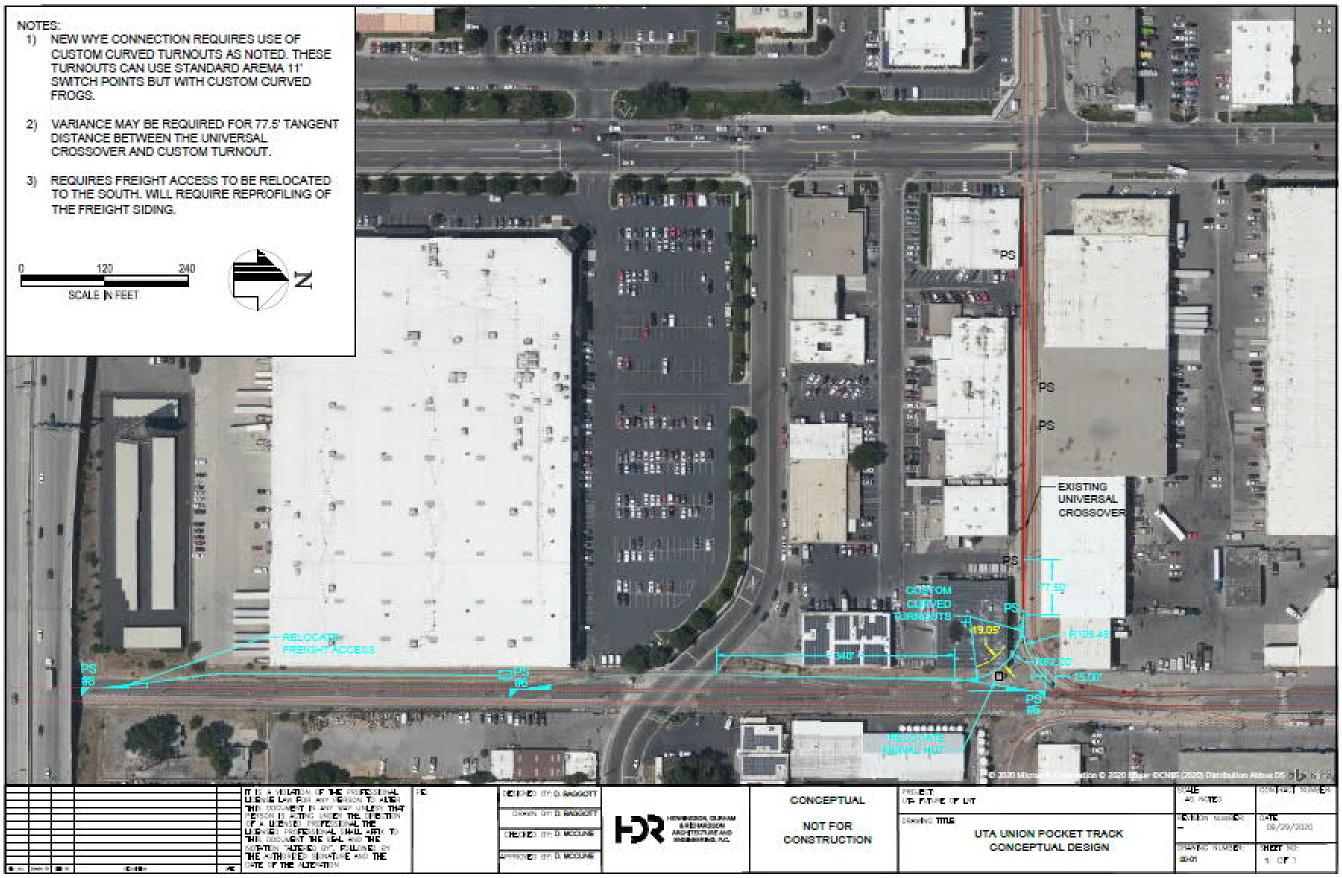

Figure 37 – Union Turnback Track and Green Line Wye Connection Concept Model

The use of custom curved turnouts for the Green Line connection is necessary in order to retain the existing Green Line universal crossover located immediately west of the proposed project. Such custom turnouts are not industry-standard items and would require additional spare parts inventory at UTA.

Table 52 – Union Turnback Track and Green Line Wye Connection Capital Cost Estimate					
10 GUIDEWAY AND TRACK ELEMENTS					
Sub Category	**Item**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
10.01	Guideway: At-grade Exclusive ROW	0.15	Route-miles	$ 680,000	$ 102,000
10.11	Track: Ballasted	1600	Track-feet	$ 600	$ 960,000
10.12	Track: Special - New #6 Turnout	2	Each	$ 100,000	$ 200,000
10.12	Track: Special - New #8 Turnout	1	Each	$ 150,000	$ 150,000
10.12	Track: Special - Custom Curved Turnout	3	Each	$ 125,000	$ 375,000
	Reprofiling of Freight Access Track	800	Each	$ 300	$ 240,000
10 SUBTOTAL					$ 2,027,000
10 ALLOCATED CONTINGENCY				30%	$ 608,100
10 TOTAL					**$ 2,635,100**

Table 52 – Union Turnback Track and Green Line Wye Connection Capital Cost Estimate

20 STATIONS, SHOPS, TERMINALS, INTERMODAL					
Sub Category	**Item**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
				$ -	$ -
20 SUBTOTAL					$ -
20 ALLOCATED CONTINGENCY				30%	$ -
20 TOTAL					**$ -**
40 SITEWORK AND SPECIAL CONDITIONS					
Sub Category	**Item**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
40.01	Demolition, Clearing, Earthwork	0.15	Route-Miles	$ 500,000	$ 75,000
40.02	Site Utilities, Utility Relocation	0.15	Route-miles	$ 2,250,000	$ 337,500
40 SUBTOTAL					$ 412,500
40 ALLOCATED CONTINGENCY				30%	$ 123,750
40 TOTAL					**$ 536,250**
50 SYSTEMS					
Sub Category	**Item**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
50.01	Overhead Contact System	1	LS	$ 705,626	$ 705,626
50.02	Signals	1	LS	$ 2,691,288	$ 2,691,288
				$ -	$ -
50 SUBTOTAL					$ 3,396,914
50 ALLOCATED CONTINGENCY				30%	$ 1,019,074
50 TOTAL					**$ 4,415,988**
60 RIGHT OF WAY, LAND, EXISTING IMPROVEMENTS					
Sub Category	**Item**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
60.01	Purchase of Part of property at new pocket track curve	0.10	Acre	$ 1,524,600	$ 152,460
60.02	Partial demolition of building	1	LS	$ 250,000	$ 250,000
60 SUBTOTAL					$ 402,460
60 ALLOCATED CONTINGENCY				30%	$ 120,738
60 TOTAL					**$ 523,198**
70 VEHICLES					
Sub Category	**Item**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
				$ -	$ -
				$ -	$ -
70 SUBTOTAL					$ -

Table 52 – Union Turnback Track and Green Line Wye Connection Capital Cost Estimate			
70 ALLOCATED CONTINGENCY		0%	$ -
70 TOTAL			**$ -**
	80 PROFESSIONAL SERVICES		
SCC 10 - 50 TOTAL			**$ 4,952,238**
Sub Category	**Item**	**%of SCC 10 - 50**	**Total Cost**
80.01	Preliminary Engineering	3%	$ 148,567
80.02	Final Design	7%	$ 346,657
80.03	Project Management for Design and Construction	5%	$ 247,612
80.04	Construction Administration and Management	6%	$ 297,134
80.05	Insurance	3%	$ 148,567
80.06	Legal, Permits, Review Fees	2%	$ 99,045
80.07	Survey, Testing, Investigation, Inspection	2%	$ 99,045
80.08	Start-up Costs	2%	$ 99,045
80 TOTAL			**$ 1,485,671**
	Summary		
Standard Cost Category			**Total Cost**
SCC 10: Guideway and Track Elements			$ 2,635,100
SCC 20: Stations, Stops, Terminals, Intermodal			$ -
SCC 30: Support Facilities, Yards, Shops, Administration Buildings			$ -
SCC 40: Sitework and Special Conditions			$ 536,250
SCC 50: Systems			$ 4,415,988
SCC 60: Right of Way, Land, Existing Improvements			$ 523,198
SCC 70: Vehicles			$ -
SCC 80: Professional Services			$ 1,485,671
SUBTOTAL			**$ 9,596,207**
UNALLOCATED CONTINGENCY		30%	$ 2,878,862
PROJECT TOTAL			**$ 12,475,069**

The $12.5 million total estimated cost of the project is shown in Table 52. The major cost components are trackwork, signals and Overhead Contact System (OCS). The estimate includes $402,000 (prior to allocation of contingencies) for property taking and partial demolition of the building in the southwest quadrant of the connection. The cost of reconstructing the R. C. Willey freight siding is included but no financial compensation to the property owner for this change is assumed. The conceptual extent of the taking is shown in the concept drawing. The total estimated cost of the project includes 30% unallocated contingency for each of the standard FTA cost categories as well as 30% allocated continency for professional services and other "soft" costs.

Potential Double-ended Center Pocket Track near Fairpark Station

Hatch LTK developed a sketch plan of potential double-ended 400-foot long center pocket track near Fairpark Station on the Green Line. The center pocket track would have been located between the 1000 West and 900 West intersections. The scenario investigated trains not operating to the Airport and instead turning back on the center track, allowing through Airport service to operate without delay in both directions, even under disrupted operations. Multiple existing examples of similar operations were presented. UTA met with Salt Lake City and its own Light Rail Business Unit. It was determined this this option would not move forward due to the operating challenge of a pocket track between two active lines as well as the impact to the land use and community.

However, UTA Light Rail Operations would like to see a new interlocking with universal crossovers (crossovers between the two main tracks in both directions) in this area. One potential location is between Power and Fairpark Stations. This is currently the longest street-running section between crossovers on the TRAX system, and operations are currently adversely impacted during special or abnormal operations in this area. Operational recovery from disruptions would be additionally challenged with the addition of the Orange Line. The Orange Line addition, included in Phase 1 Scenarios 4 and 5, would double the train volume between downtown and the Airport. This project is included on the future State of Good Repair list, but is currently not funded or scheduled for implementation.

TRAX Traction Power System Improvements

UTA commissioned a two-part traction power load flow study in 2020 that was performed independent of the Future of Light Rail Study. The results were shared with the Hatch LTK Team and provide insights into the ability of the TRAX traction power system to support existing and future light rail service levels.

In addition to evaluating the robustness of the existing traction power system, the study was designed to inform the specification of replacement DC substations for the 18 units installed on the original Blue Line. These substations were furnished by Impulse, are more than 20 years old and approaching the end of their normal life cycle (the remaining substations on TRAX were manufactured more recently by Siemens and are approximately six to 10 years old).

The traction power study did not evaluate closer train headways than operate at present so it does not provide insights into the feasibility of operating Scenario 6’s 4-minute trunk headways instead of the current 5-minute trunk headways. However, the study did investigate two service enhancements:

+ Increasing train length on the Green Line from the present 2-car consist to 4 cars, and
+ Operation of a new Orange Line service on existing UTA tracks between the University and Salt Lake Central (note that this Orange Line differs from that investigated in Future of Light Rail’s Scenarios 4 and 5 described earlier).

The traction power system load flow model covered about 80 to 85 % of the TRAX system. The outlying segments of the Mid-Jordan, West Valley and Airport Lines were not modeled as they are the newest segments of the network and support only a single service on each line. The study did not estimate any capital costs for traction power State of Good Repair or capital improvements.

Traction Power System Pass/Fail Performance Criteria

For operations with all substations in-service, the minimum train voltage from the load flow simulations was considered unacceptable if it fell below 600 Vdc. For contingency operations (where a substation is out of service due to a failure or while undergoing routine maintenance), the train voltage must not fall below 525 Vdc for a significant time period. This criterion reflects a trade-off between the traction power system's capital cost and the operating reliability of the TRAX network.

Another pass/fail criterion in the load flow study was that no substation transformer/rectifier unit can be overloaded based on industry standard criteria. Overloading risks thermal damage and premature failure of the unit.

Traction Power Load Flow Model Results and Key Findings

The study expresses concern about the loading of the downtown single contact wire configuration. This is a 1.7-mile portion of the line where the overhead contact wire is reinforced with an underground feeder connected to the contact wire via cable risers at intervals of about 500 feet.

The study notes that the normal simulated operations find that train voltages routinely fall below the 600 Vdc threshold but stay above the 525 Vdc cut-off where performance is significantly affected. The study noted that, under contingency operations, the minimum train voltage criteria was met for all substation outage conditions. For special event operations, the minimum voltage requirements were not satisfied when any one of eight substations were out-of-service. The three most concerning substation contingency cases were when SRN3, SRC7 or SRN13 were off-line.

The study did not find any substation overloading. However, with the Orange Line in service, Substations SRC7, SRT2 and SRD1 were found to be operating for the evening peak period at 96 to 98 percent of their nominal current rating, which is very close to being overloaded.

Phase 2 of the study recommends that a minimum of nine of the original Impulse substations be replaced with larger units, resolving the overloading conditions found in the Phase 1 modeling. In addition, all new substations are recommended to have a higher nominal voltage and improved voltage regulation characteristics versus the units being replaced. They are also recommended to have a capacity rating of 2000 kW which, again, reflects upgrades versus the units being replaced.

Overhead Contact System Key Findings

The study finds that the OCS is adequate from thermal load point of view, except for a short contact-wire-only section at the “University Junction” half grand union at the Main St/ University Blvd intersection. This thermal overloading occurs only when the OCS sectionalizing gaps are closed. The study notes that overheating of the contact wire is undesirable, potentially resulting in premature failure of the wire. The study presents two alternatives for resolving the potential overheating issue.

Improving TRAX Span of Service

Introduction

The starting and ending times of TRAX service are currently constrained due to rail freight operations on the North/South Line and the Red Line between its junction with the North/South Line and Daybreak. This "span of service" limitation is a legacy of the legal agreements between the rail freight carriers and the UTA that provided right-of-way for these TRAX segments. The presence of rail freight carriers means that these line segments are under the regulatory purview of the Federal Railroad Administration (FRA). Because the TRAX light rail vehicles are not designed to mainline railroad crash worthiness standards (and many other regulatory considerations), time-based ("temporal") separation of rail freight and TRAX operations is required.

Span of service is important because limited operating hours may discourage both work and non-work trips on TRAX. For example, early and late shift workers include medical personnel, airport workers, warehouse, and service industry jobs. Workers on some shifts may need to be at work early (5 to 6 a.m.) while others may need to work late, with transportation home needed after 11 p.m. or midnight. Span of service is also important in terms of travel flexibility for customers making non-work trips; they want to be assured of reliable transportation home at the conclusion of an entertainment or sporting event that has a variable end time.

While not explicitly a span of service issue because of their non-revenue operation, UTA presently experiences some constraints on vehicle maintenance efficiency due to its inability to shuttle TRAX trains between Jordan River and Midvale Service Centers overnight. Some maintenance procedures, such as well truing, are only available at one facility.

To understand how TRAX span of service compares with similar light rail operations in the West, Hatch LTK reviewed the pre-COVID weekday operating plans of 10 light rail properties. This review, summarized in Table 53, determined:

+ Earliest system end of service time to get from any outlying station to a popular downtown station (Hatch LTK surveyed the schedule for all stations and reported only the earliest of these last times), and
+ Earliest end of service time to get from that popular downtown station to any outlying station. (Hatch LTK surveyed the schedule for all stations and reported only the earliest of these last times).

Table 53 – Western United States Light Rail Span of Service Peer Review

City/Agency	Earliest System Last Time to Travel from All Outlying Stations to Downtown	Earliest System Last Time to Travel from Downtown to All Outlying Stations
San Jose VTA	9:20	9:49
San Diego MTS*	11:18	10:13
Sacramento RT	9:30	10:19
Portland TriMet MAX	10:42	10:59
Salt Lake City UTA*	10:26	11:03

Table 53 – Western United States Light Rail Span of Service Peer Review		
City/Agency	**Earliest System Last Time to Travel from All Outlying Stations to Downtown**	**Earliest System Last Time to Travel from Downtown to All Outlying Stations**
Minneapolis Metro	11:17	11:26
Houston Metro	11:24	11:53
Cleveland RTA	11:38	12:00
Dallas DART	11:27	12:08
St. Louis MetroLink	11:07	12:11
Denver RTD	11:11	12:14
Los Angeles County MTA	11:33	12:22
Seattle SoundTransit Link	12:00	12:42

** Light rail properties with freight temporal separation*

In general, UTA's span of service is in the middle of the peer properties surveyed. Its span of service is comparable to that of San Diego Trolley, which also has significant temporal separation operating constraints due to overnight freight operation.

Existing Temporal Separation Agreements with Freight Railroads

The current TRAX temporal separation constraints stem from right-of-way acquisition agreements with freight railroads for two segments of the network. The first is the TRAX North/South Line (Blue, Red and Green Lines) from 1700 South to 6400 South. Freight trains enter the alignment from Union Pacific Railroad tracks through Sampler Siding, located just south of Murray Central station at approximately 5300 South. Figure 38 shows a portion of the TRAX system map with yellow dots on the North/South Line representing current freight-related switches connecting to UTA tracks.

The second temporal freight separation segment is the TRAX Red Line from 650 West to 5600 West (Old Bingham Highway Station). Freight trains can enter the alignment from two locations – on the east through Freight Interlocking (connecting to the Savage B&G Railroad Yard at approximately 650 West), and on the west through North Interlocking (connecting to the Garfield Branch Line at approximately 4000 West).

Figure 38 – North/South Line Active Freight Switches (Shown as Yellow Dots)

Analysis of Existing Freight Operations on TRAX

For the Future of Light Rail Study, UTA provided 106 days of freight dispatch data from late 2019 and early 2020. An analysis of the data found that the freight carrier, Salt Lake Southern (SLS), operated on the North/South Line on 22 of the sampled 106 days, generally Mondays and Wednesdays. Per its agreement with UTA, SLS has a five-hour operating window between midnight and 5:00 a.m. Of the 22 days of operation sampled, the actual TRAX operating windows used were:

+ Minimum North/South Line operating window used: 0:35
+ Average North/South Line operating window used: 1:54
+ Maximum North/South Line operating window used: 3:24

In contrast to the relatively light freight operation on the North/South Line, the analysis of the same 106 days of freight dispatch data indicated that the Red Line hosted 170 freight trains during this time period. This is about eight times the North/South Line volume and consisted of two freight trains per weeknight on most nights. In contrast to the gradual transition of North/South industrial properties to commercial and residential use, the Red Line freight customers are generally growing with expanded operations and increasing freight volumes. These customers include Interstate Brick, Butterfield Lumber, BMC, SME Steel, and Frito-Lay.

The Red Line also provides the only rail freight access to two freight spurs, the Bagley Spur and the Garfield Spur. In addition to SLS, the Savage, Bingham and Garfield Railroad has legal rights to operate in this area. The Garfield Spur provides access to Kennecott Copper and can have two different trains (operated by separate companies) at the same time. TRAX dispatchers, who are FRA qualified, perform these dispatching functions in addition to handling the safe movement of light rail trains.

Solutions for Increasing TRAX Span of Service

Hatch LTK investigated several strategies for increasing span of service on the North/South Line used by Blue, Red and Green Line trains. The Red Line from 650 West to 5600 West (Old Bingham Highway Station) was not investigated as freight operations are significant and no opportunities other than costly reconstruction of the light rail line (or freight line) on a separate alignment appear feasible.

For the North/South Line, one possible solution given declining freight demand would be to enter into a legally-binding agreement with all of the freight customers (active and those who are inactive but retain freight sidings) to forego future rail freight service. UTA would need to negotiate with the SLS and its corporate parent (Genesee & Wyoming) for impacts to their business. In addition, UTA would need to petition for formal abandonment of the line and obtain approval by the Surface Transportation Board. There is no assurance of such approval and UTA would continue to risk the possibility that a separate rail entity would petition to replace SLS freight service on the line. As such, this possible solution is not recommended for advancement.

Instead, a negotiated approach with the Genesee & Wyoming to reduce the freight operating window (thereby increased the light rail operating window) is recommended for the North/South Line. This negotiation needs to be supported with a more detailed analysis of freight operations than the 106-day sample evaluated by Hatch LTK. This greater level of detail of current freight operations recorded at TRAX Central Control to support future negotiations would include:

+ Freight train time on and time off (as is done today),
+ Number of locos/number of cars,
+ Industries served and duration,
+ Specific routes (interlocking crossovers) used.

With this data analysis in hand, several most demanding case freight operating scenarios could be developed for discussion with Genesee & Wyoming. UTA could then attempt to negotiate to reduce North/South Line freight window from the current five hours. Red, Blue and Green Line light rail service could operate later and potentially start earlier.

UTA Light Rail Operations noted that an increase in TRAX span of service may impact maintenance efficiencies in non-temporally separated segments of the light rail network.

It may also be possible to negotiate a reduction in temporal separation to three early mornings per week – Mondays, Wednesdays, Fridays. This would not have a direct span of service benefit to UTA customers but would open North/South Line windows on Tuesday and Thursday early mornings for predictable additional maintenance windows. It would also allow for more flexible light rail vehicle shuttling between Midvale and Jordan River Service Centers.

Separately, UTA could pursue abandonment of freight service north of 2200 South which would eliminate any span of service constraints on Green Line operation (and potential future Orange Line operation). At present, there is only one in-service freight switch, serving Intermountain Wood Products, in this TRAX segment. This freight customer, should it wish to continue receiving or shipping freight by rail, could use the public "Team Track" siding near 3300 South (while expecting some compensation from UTA for this loss of shipping convenience) . With such a change, UTA would have the flexibility to operate 24-hour service overnight on the Green Line. Such service has been considered in the past on the Airport Line segment but was deemed to have required a satellite rail vehicle maintenance facility. With abandonment of freight service north of 2200 South, the full Green Line would have access to the Jordan River Service Center at all times, eliminating the need for a satellite maintenance facility.

TRAX Fleet Plan

Purpose of the TRAX Fleet Plan

As part of Phase 1 of the Future of Light Rail Study, Hatch LTK developed a Fleet Plan for UTA Light Rail. The purpose of the Fleet Plan is to ensure future sufficient, reliable and cost-effective light rail fleet. As part of cost-effectiveness considerations, the Fleet Plan considers fleet capital costs, maintenance costs and shop (Midvale and Jordan River Service Centers) implications.

Other considerations in developing the Fleet Plan are to ensure federal eligibility for capital funding of future line extensions and other service expansions. The Fleet Plan considers fleet alternatives that increase quality of service. These alternatives include longer vehicles that reduce maintenance complexity (because there are fewer operating controls to maintain) and encourage greater passenger separation, an important consideration in recovering from the COVID-19 pandemic.

Table 54 shows the current TRAX fleet including the three vehicles configured for operation on the Sugar House Streetcar Line. The typical life expectancy of a light rail vehicle is 30 to 35 years so the SD100 and SD160 vehicles will be due for retirement and replacement in 10 to 15 years.

Table 54 – Current TRAX Fleet

Model	Manufacturer	Quantity	In-Service Date	Configuration
SD100	Siemens	23	1999	High Floor
SD160	Siemens	17	2001	High Floor
S70	Siemens	74	2011	70% Low Floor
S70 Streetcar	Siemens	3	2011	70% Low Floor

Train Length Considerations

All three light rail models that comprise today's UTA light rail fleet are 81 feet in length. With a maximum train length of four cars, many elements of the UTA light rail infrastructure – station platforms, yard tracks, terminal tracks, maintenance facilities – are designed around a 324-foot train length. It is important that any future UTA fleet be consistent with this train length. Global light rail vehicle trends in recent years have been towards longer light rail cars; this is not necessarily inconsistent with the UTA-standard 324-foot train length. As shown in Figure 39, this length can be satisfied with four 81-foot cars, three 108-foot cars or two 162-foot cars. The longer car lengths are accommodated with additional articulations, increasing the existing UTA two-segment vehicles to three or four segments. The articulations and axle configuration shown in Figure 39, for the 108-foot and 162-foot generic new fleet are examples only; many other body and truck arrangements exist within the designs of global light rail vehicle suppliers.

As light rail operators around the globe move to longer vehicles, UTA is likely to receive greater supplier interest and more cost-competitive bids with a vehicle specified to be in the 108-foot or 162-foot length. Recent light rail vehicle procurements in Ottawa and Toronto have been in this range. The Massachusetts Bay Transportation Authority in

Boston, operator of one of the largest light rail fleets in the U.S., is currently planning a procurement close to the 108-foot car length. In addition to small but quantifiable capital cost benefits, there are maintenance cost savings and enhanced passenger comfort/safety benefits to a car length longer than the current UTA 81-foot standard.

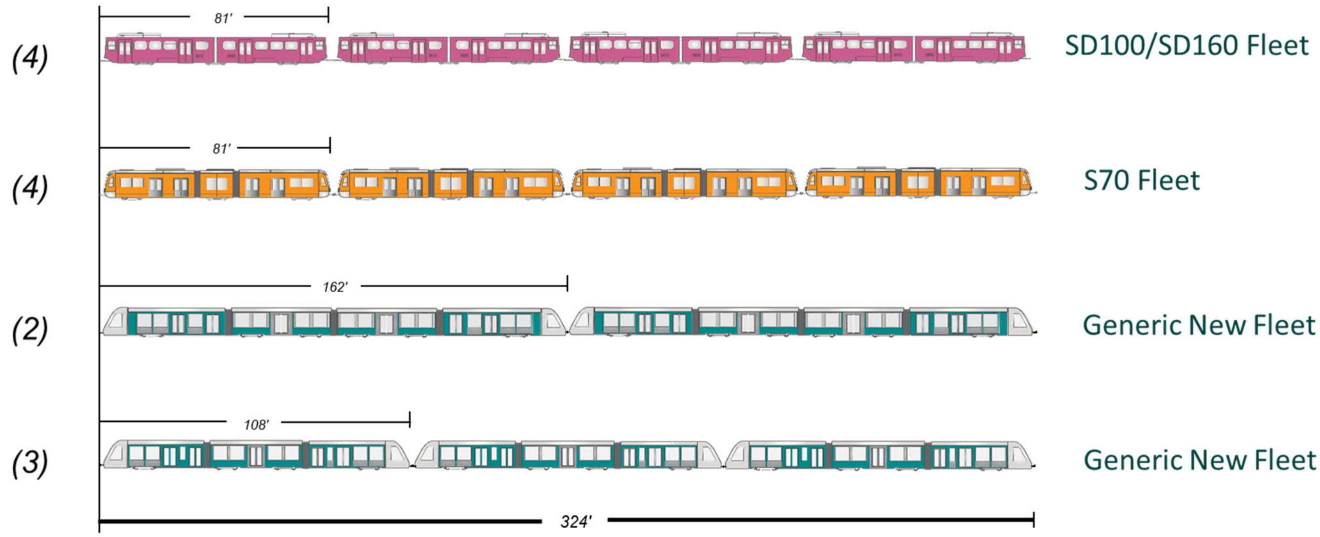

Figure 39 – Equivalent Train Consists – Maximum Length Train (324')

Car Floor Height and Accessibility Considerations

Today's UTA fleet consists of high floor models (SD100 and SD160) and 70% low floor models (S70). Accessibility for high floor models is achieved through the use of a "high block" boarding platform that provides access to the front portion of the train. A stand-alone bridging plate deployed by the Train Operator is used to address the small gap between high block and car for those UTA customers using mobility devices. Stations on the Blue Line (including the North/South Line) and a limited number of other locations are equipped with high blocks.

The newer 70% low floor vehicles, used in all Red and Green Line trains, allow level or nearly-level boarding at each car in the train. A deployable motorized bridging plate is available to customers using mobility devices at all doors. The 70% low floor cars provide greater accessibility by providing access to all cars in the train, eliminating congestion on the high block boarding platform as well as dependence on the Train Operator to manually deploy a bridging plate.

Although there are no active plans to extend Blue Line service, an important consideration with respect to replacement of the SD100/SD160 high floor fleet is eligibility for potential FTA funding. The FTA no longer considers the use of high blocks to represent a fully-accessible solution. Therefore, UTA would need to replace its high floor fleet with a partially or fully low floor fleet in order to secure FTA funding for any potential Blue Line extension in the future.

In addition, UTA Light Rail Operations indicates that high block boarding locations can suffer from crowding, especially during special events and the holiday season. In addition to customers using mobility devices, high blocks are used by customers experiencing difficulty in climbing stairs, those with large suitcases and those with strollers. Similarly, these customers can experience crowding in the light rail vehicle as they must remain within communicating distance of the Train Operator in order to ensure that the bridging plate is manually deployed at their destination station.

The 70% low floor models also provide modestly lower dwell times than do the high floor vehicles. Hatch LTK utilized a large 2019-2020 dataset of UTA APC data to compare average dwell times of more than 15,000 trips operating in each direction for each of the three lines. With such a large dataset, variability in terms of intersection delay and other external factors is eliminated in the dwell time comparison. Table 55 shows that the high floor trains on the Blue Line typically have dwells three to four seconds longer than the 70% low floor trains on the Red and Green Lines. The only exception is southbound Green Line operation at Ballpark Station where Green Line operations have extended dwells due to the need for Train Operators to make a required route call, a distinction not relevant to high block versus platform length accessibility boarding.

Table 55 – UTA APC-Recorded Dwell Time Differences – High Floor Trains vs. 70% Low Floor Trains

Station	Service	Observations	Average Dwell (Seconds)
900 South	Green NB	15661	25.7
	Red NB	16842	25.5
	Blue NB	17499	29.1
	Green SB	15609	25.5
	Red SB	16913	26.2
	Blue SB	17525	29.1
Ballpark	Green NB	15691	24.5
	Red NB	16905	23.9
	Blue NB	17529	27.5
	Green SB	15796	44.0*
	Red SB	17024	26.9
	Blue SB	17562	29.6

** Extended due to required route call*

The shorter Red and Green Line dwells would translate into a minute or more of travel time savings for Blue Line operation when applied to the entire line from end-to-end. This is due to elimination of Train Operator duties associated with the high block as well as greater overall boarding efficiency for customers who do not need to negotiate steps up or down.

Midvale and Jordan River Service Center Longer Car Length Considerations

Potential replacement of the 81-foot high-floor fleet with a 108-foot or 162-foot light rail vehicle has implications for how light rail maintenance activities are performed at the Midvale and Jordan River Service Centers. These issues are somewhat specific to each facility and are described in the following sections.

Longer Car Length Implications for Midvale Service Center

The Midvale Service Center's LRV maintenance shop includes nine tracks. Six of the tracks (Tracks 1 through 6) extend the full length of the 340-foot building and through the north and south end walls. The three remaining tracks (Tracks 7 through 9) enter through the north wall and continue south to a point roughly two-thirds of the way through the building, approximately 235 feet. Figure 40 displays an overview of the Midvale facility with typical deployment of 81-foot cars shown in yellow. Specific track usage is as follows:

+ Track 1 is the westernmost track at the Midvale facility. It is mostly walled off from the rest of the shop and is used for daily servicing and cleaning of the trains before they are put into revenue service.
+ Track 2 is the designated wash track, with an enclosed LRV wash bay in the south and middle segments and a transfer track turntable to facilitate washing of detached truck assemblies. The north end of Track 2 has a flat floor and an elevated mezzanine work platform, and apparently is used as a seat cleaning/changeout bay.
+ Track 3 is a general maintenance and repair track with a partially enclosed bay at the south end, an open flat-track bay in the middle, and an elevated mezzanine work platform at the north end. It has a transfer track turntable that provided access to the former wheel truing machine location, but also could accommodate truck changeout in the Track 3 middle bay if a portable jack system were available.
+ Track 4 is another general maintenance and repair track featuring a flat floor, a transfer track turntable, and a continuous 310-foot elevated work platform. The middle bay of Track 4 is equipped with a fixed in-floor hoist for truck changeout, and the north bay could also be used for truck replacement if a portable jack system were available.
+ Track 5 is a service and inspection track primarily used for scheduled preventive maintenance. It features a continuous 310-foot elevated work platform, and the north and south bays have open pit floors for undercar access.
+ Track 6 is another service and inspection track with a continuous elevated work platform and open pit floors in the north and south bays. Track 6 also is adjacent to the mezzanine level storage areas for cartop HVAC equipment and pantographs. It appears that mezzanine level equipment handling is limited to fixed-position jib cranes on Track 6.
+ Track 7 is a stub-end track with a continuous 230-foot elevated work platform. The middle bay of Track 7 is the current location of the in-floor wheel truing machine, and the north bay is a flat floor with a transfer track turntable.
+ Track 8 is a stub end track that could serve a variety of LRV maintenance functions. The middle bay is an open flat track, and the north bay has a transfer track turntable, an open-pit floor and a 116-foot elevated work platform.
+ Track 9 is the westernmost track within the Midvale shop. It is identical to Track 8.

The layout of Midvale is largely designed around the existing TRAX fleet of 81-foot LRVs. Servicing a new fleet of longer cars would require significant accommodations or reconstruction in several areas. For the proposed 108-foot cars, the following MRSC impacts or modifications have been identified, as shown in Figure 41:

+ Track 1 would still be usable for daily service and cleaning of the 108-foot LRVs in train consists of one, two or three cars.
+ Track 2 would still be usable as the wash track for exterior cleaning of the 108-foot cars. The seat cleaning/changeout bay at the north end of Track 2 could continue in that function, however, when a 108-foot car occupies that bay it would prohibit use of the adjacent transfer track turntable. If the transfer track cannot

be blocked, then the rear of a longer LRV parked in the north bay would extend out the north end of the shop building.

- Track 3 would still be usable as a general maintenance and repair track, although there would be room for just two of the 108-foot cars. The partially enclosed south bay is not long enough to hold an entire 108-foot LRV. A car positioned in the Track 3 north bay would block the transfer track. This most likely would restrict use of the north bay to minor, short-term maintenance tasks.
- Track 4 would still be usable as a general maintenance and repair track for up to two of the 108-foot cars. The existing in-floor vehicle hoist would not be compatible with the longer LRVs, and would need to be reconstructed or removed and replaced with a portable jack system in the south and middle portions of Track 4. Like Track 3, a 108-foot car positioned in the Track 4 north bay would block the transfer track. This most likely would restrict use of the north bay to minor, short-term maintenance tasks.
- Tracks 5 and 6 would need reconstruction to continue functioning as service and inspection tracks for preventive maintenance activities on the 108-foot cars. The in-floor service pits in the north and south bays would need to be lengthened by approximately 30 feet each, which would create additional barriers to internal circulation and would require removal of the existing transfer track crossing. To improve access to cartop equipment, the existing fixed-position jib cranes on the Track 6 mezzanine would be replaced with monorail cranes along the south half of both Track 5 and Track 6.
- Track 7 would need to be extended by approximately 15 feet to accommodate the rear trucks of the 108-foot cars on the existing in-floor wheel truing machine. This can be seen in Figure 42, which zooms into Track 7 and adjacent tracks while showing the service locations of the 108-foot cars. This extension would impact the ancillary rooms directly south of the current Track 7 endpoint. Since this is the only UTA wheel truing machine, the lengthening of Track 7 may be required if a longer car is adopted anywhere in the TRAX system. If extending Track 7 is not feasible, then it would be necessary to remove the trucks from the longer cars and send the detached units through the wheel truing machine.
- Tracks 8 and 9 would need reconstruction to accommodate the 108-foot LRV. The in-floor maintenance pits in the north bays would need to be lengthened by approximately 30 feet, which would create additional barriers to circulation and would require removal of the transfer track turntables. The remainder of Tracks 8 and 9 would not be long enough to accommodate a second car on each track. Both tracks would need to be extended by approximately 15 feet. This would impact the ancillary rooms directly south of the current Track 8 and 9 endpoints.

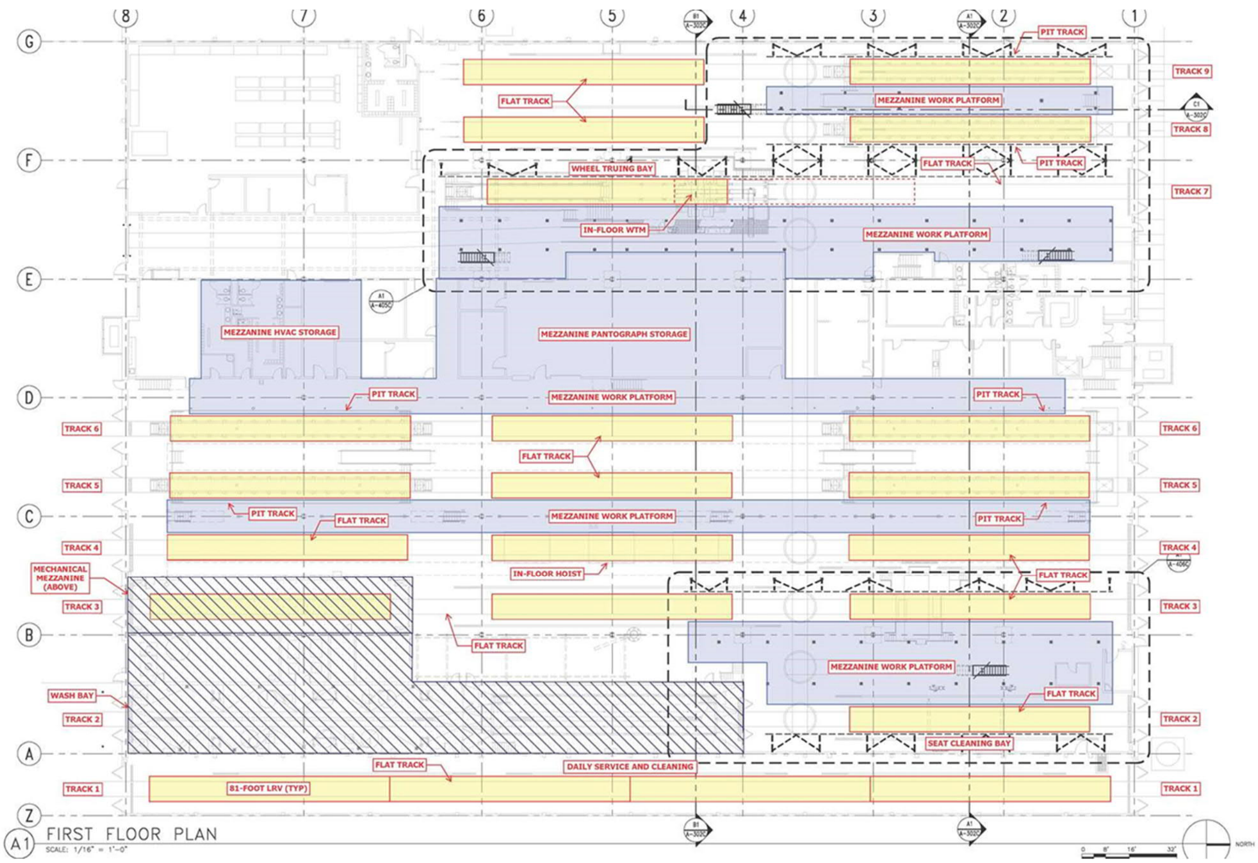

Figure 40 – Midvale Service Center – LRV Maintenance Overview – 81' Cars

For the proposed 162-foot cars, the following Midvale impacts or modifications have been identified, as shown in Figure 43:

- Track 1 would still be usable for daily service and cleaning of the 162-foot LRVs in train consists of one or two cars.
- Track 2 would still be usable as the wash track for exterior cleaning of the 162-foot cars. The seat cleaning/changeout bay at the north end of Track 2 could continue in that function, however, when a 162-foot car occupies that bay it would prohibit use of the adjacent transfer track turntable and would create an internal circulation barrier. If the transfer track cannot be blocked, then the rear of an LRV parked in the north bay would extend out the north end of the shop building.
- Track 3 would have limited use as a general maintenance and repair track for the 162-foot cars. The partially enclosed south bay is not long enough to hold an entire car, and the location of the transfer track does not leave enough length for a single car in either the middle or north bays. A car positioned in the Track 3 middle or north bay would block the transfer track and create an internal circulation barrier. This most likely would limit use of Track 3 to minor, short-term maintenance tasks.
- Track 4 would still be usable as a general maintenance and repair track for a single 162-foot car. The existing in-floor vehicle hoist would not be compatible with the longer LRVs, and would need to be reconstructed or

removed and replaced with a portable jack system in the south and middle portions of Track 4. The north bay of Track 4 is not long enough to hold a second 162-foot LRV.

- Tracks 5 and 6 would need extensive reconstruction to function as service and inspection tracks for preventive maintenance activities on the 162-foot cars. The existing in-floor pits at the south end would need to be extended by approximately 80 feet, and that would accommodate just one car per track. Providing two service and inspection bays on each track would require a 40-foot expansion of the existing building and would create a significant barrier for internal circulation. In either case, to improve access to cartop equipment the existing fixed-position jib cranes on the Track 6 mezzanine would be replaced with monorail cranes along both Track 5 and Track 6.
- Track 7 would need to be extended by approximately 70 feet to accommodate the rear trucks of the 162-foot cars on the existing in-floor wheel truing machine. This extension would severely impact the ancillary rooms directly south of the current Track 7 endpoint. Since this is the only UTA wheel truing machine, the lengthening of Track 7 may be required if a longer car is adopted anywhere in the TRAX system. If extending Track 7 is not feasible, then it would be necessary to remove the trucks from the longer cars and send the detached units through the wheel truing machine. Even if Track 7 were lengthened to the south, the tail of a 162-foot car would extend out the north end of the building when the front truck is over the wheel truing machine.

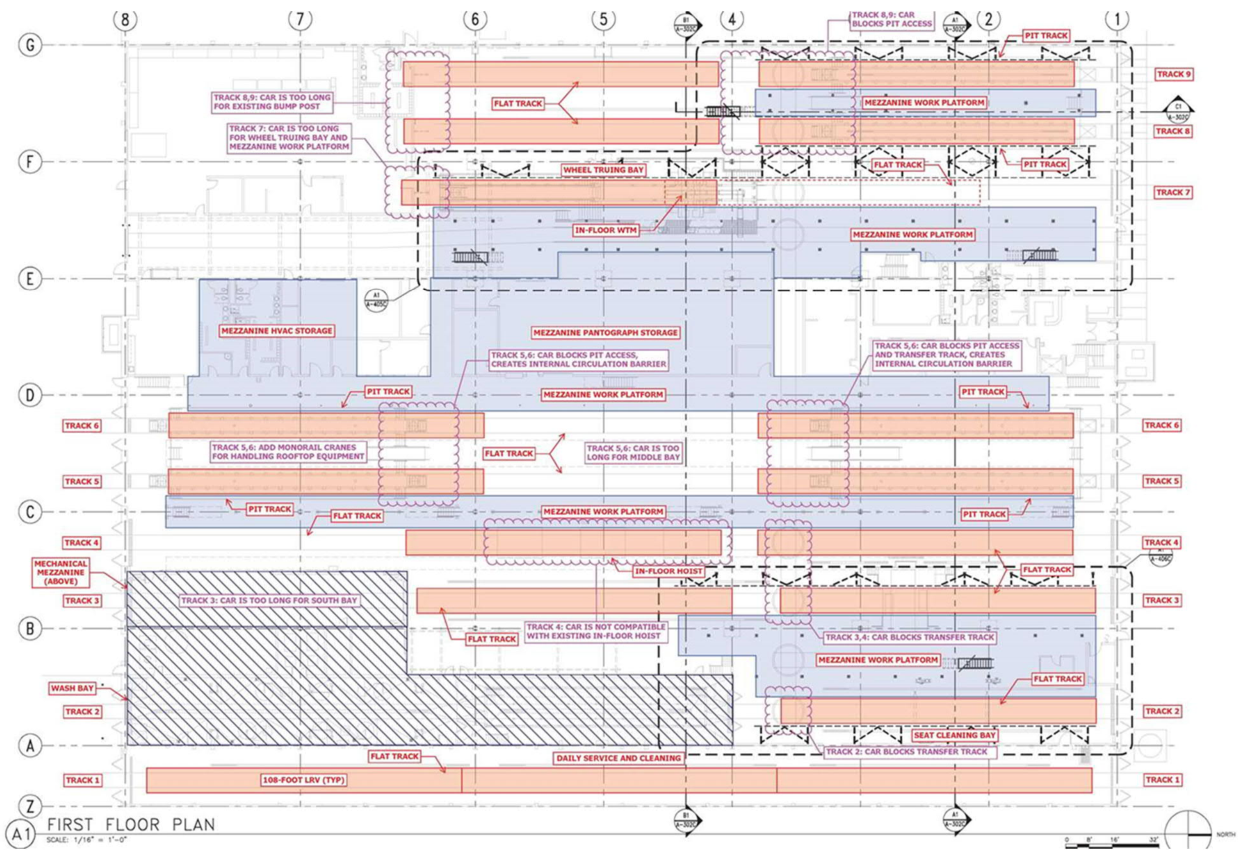

Figure 41 – Midvale Service Center – LRV Maintenance Overview – 108' Cars

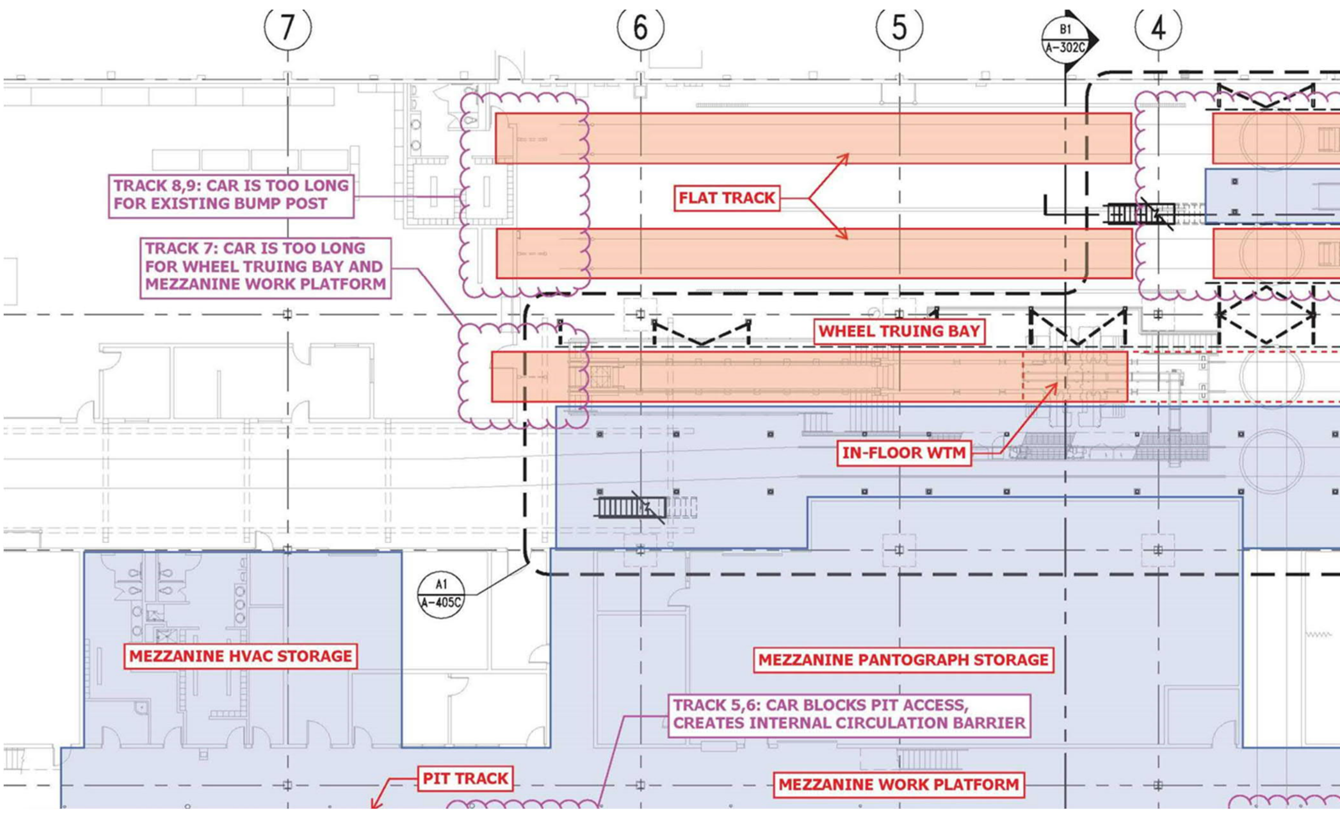

Figure 42 – Midvale Service Center – 108' Cars – Zoom

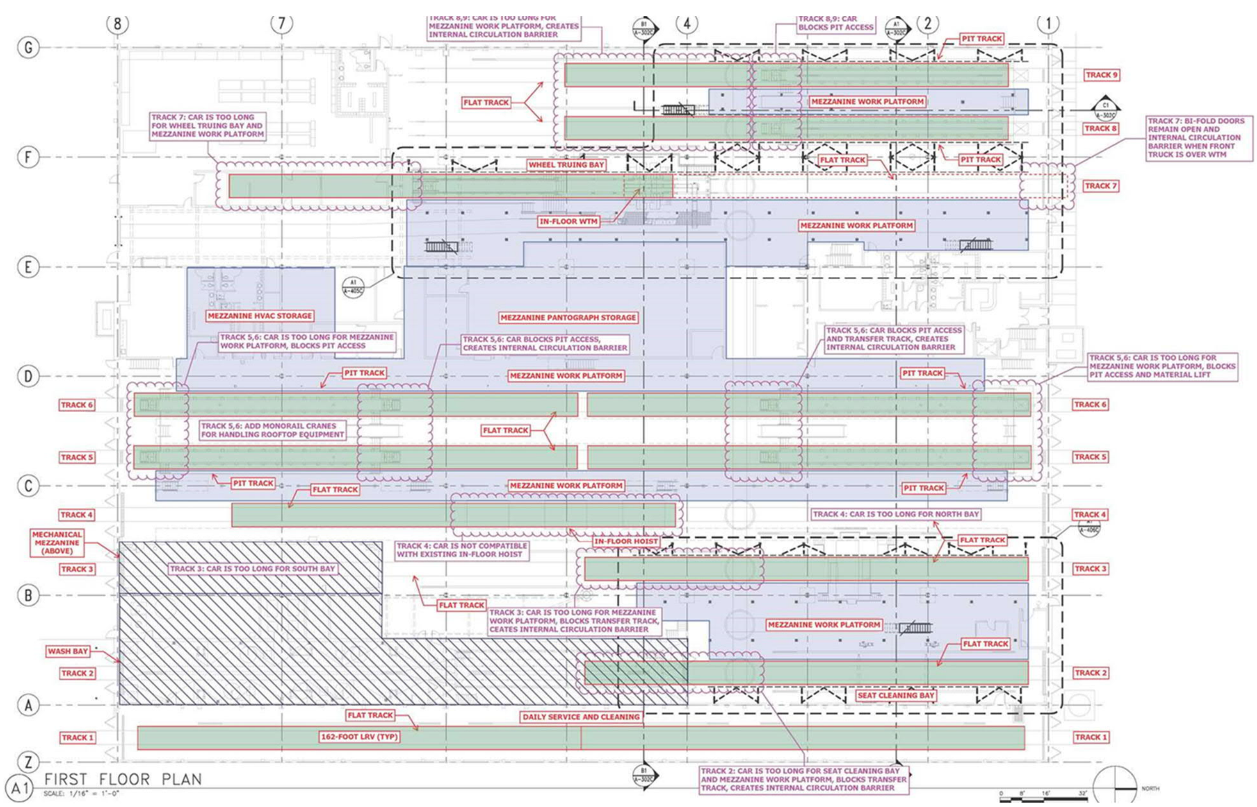

Figure 43 – Midvale Service Center – LRV Maintenance Overview – 162' Cars

- Tracks 8 and 9 would need significant reconstruction to accommodate the 162-foot LRV. The in-floor maintenance pits in the north bays would need to be lengthened by approximately 80 feet, which would create additional barriers to circulation and would require removal of the transfer track turntables. The existing mezzanine work platform between Tracks 8 and 9 would need to be extended approximately 50 feet. The resulting configuration would accommodate just a single car on each track.

Longer Car Length Implications for Jordan River Service Center

The Jordan River Service Center LRV maintenance shop includes seven tracks that run through the 400-foot length of the building and through the north and south end walls. They are identified as Tracks 9 through 15, as shown in Figure 44:

- Track 9 is the easternmost track in the Jordan River shop. The south/middle portion of the track is equipped with a drop table and portable car jacks for changing LRV trucks and transferring them to and from the nearby truck shop. The north end of Track 9 is directly adjacent to the mezzanine-level HVAC Shop and Pantograph Shop, with LRV rooftop access and two overhead bridge cranes.
- Track 10 is a general maintenance and repair track with a continuous 320-foot elevated work platform for LRV rooftop access. The middle segment of Track 10 was constructed with an open pit specifically configured for a future wheel truing machine, but the equipment has not been procured or installed. The north end is served by the two bridge cranes for changing HVAC units, pantographs and other LRV rooftop equipment.
- Track 11 is a second general maintenance and repair track that shares an elevated work platform with Track 10. The track has no pits or special in-floor equipment. Like Track 10, the north end is served by the two bridge cranes for changing HVAC units, pantographs and other LRV rooftop equipment.
- Track 12 is a service and inspection track primarily used for scheduled preventive maintenance. It features a continuous 350-foot in-floor pit equipped for work beneath the vehicles and a 320-foot elevated platform for LRV rooftop access.
- Track 13 is a second service and inspection track, identical to Track 12.
- Track 14 is an open flat track that is most likely used for daily servicing and cleaning.
- Track 15 is the westernmost track inside the Jordan River shop. It is a dedicated wash track specially equipped for interior cleaning and exterior washing of the LRVs.

Hatch LTK investigated required Jordan River modifications needed to support 108-foot LRVs, as shown in Figure 45:

- Track 9 would still provide access to the in-floor drop table with the 108-foot LRV. Use of the portable car jack system to supplement the drop table would not be possible; there is not enough length on Track 9 north of the drop table, and there appears to be insufficient vertical clearance to the south. The north end of Track 9 would still provide direct access to the HVAC Shop and the Pantograph Shop, but positioning the 108-foot car for full overhead crane coverage occasionally would create an internal circulation barrier.
- Tracks 10 and 11 would still be usable as general maintenance and repair tracks. However, as with the north end of Track 9, positioning the 108-foot car for full overhead crane coverage occasionally would create an internal circulation barrier.
- Tracks 12 and 13 would still be usable as the service and inspection tracks for scheduled preventive maintenance.

- Track 14 would still be usable for daily service and cleaning of the 108-foot LRVs in train consists of one, two or three cars.
- Track 15 would still be usable as the wash track for interior cleaning and exterior washing of the 108-foot LRVs.

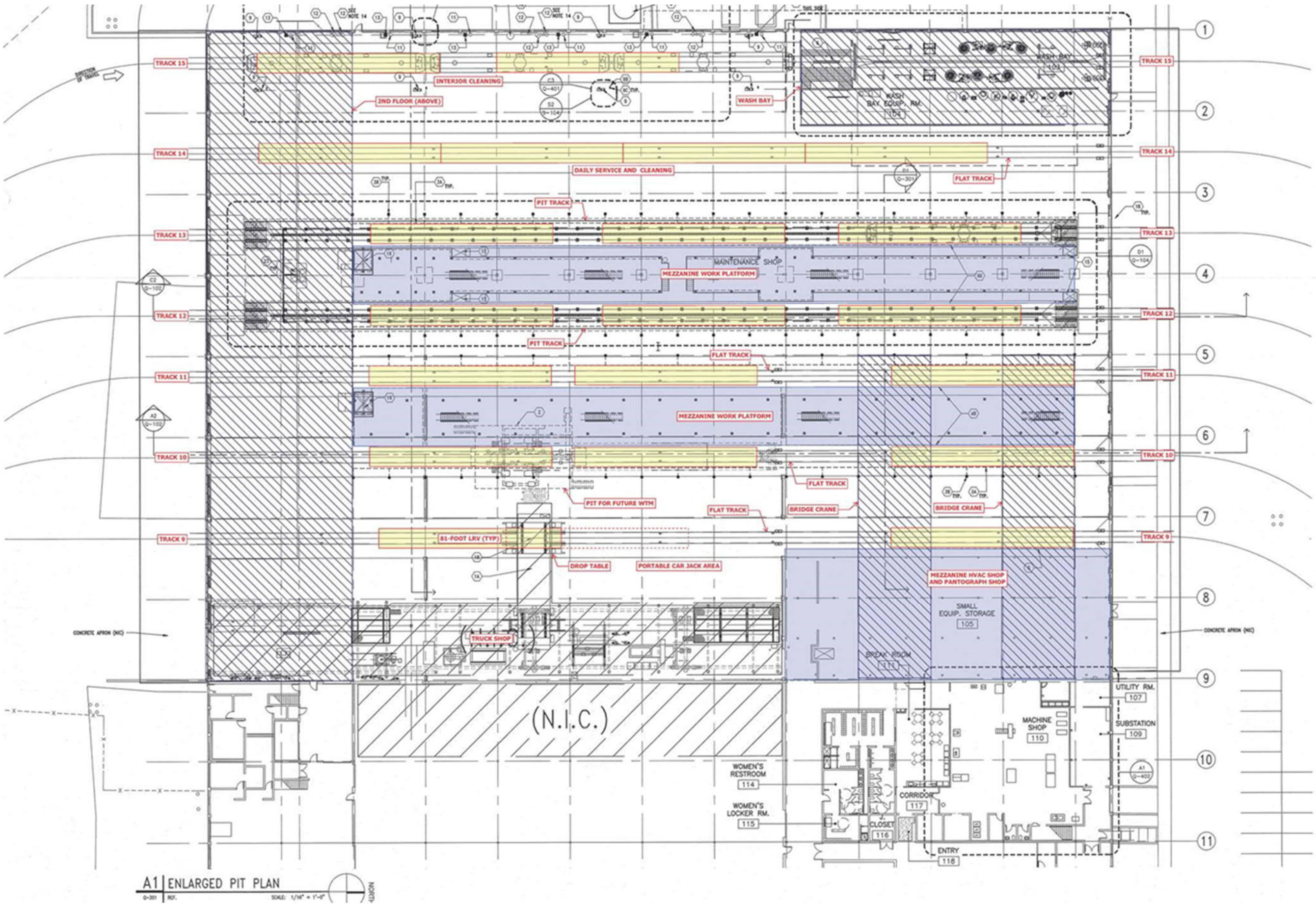

Figure 44 – Jordan River Service Center – LRV Maintenance Overview – 81' Cars

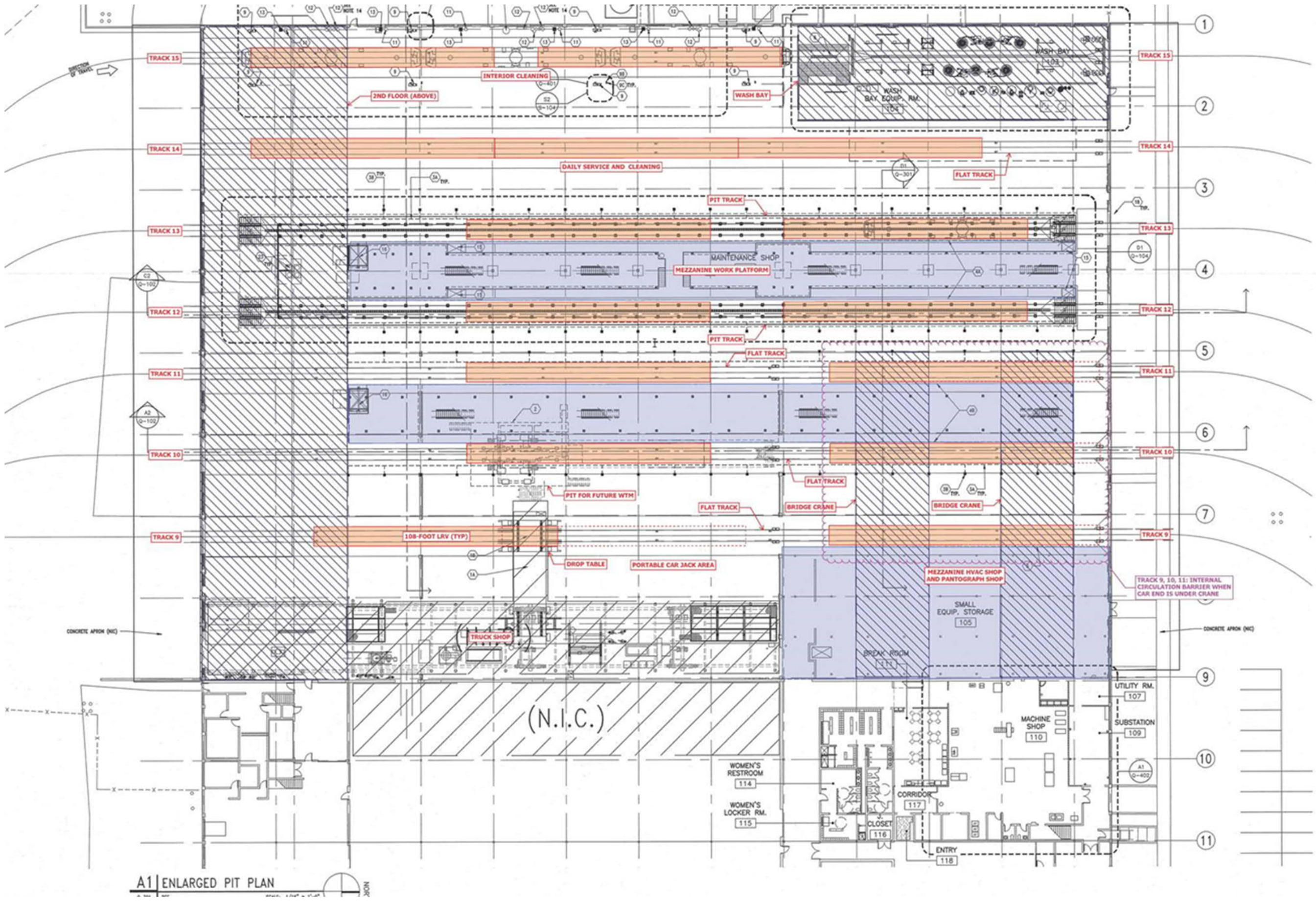

Figure 45 – Jordan River Service Center – LRV Maintenance Overview – 108' Cars

Operation of Jordan River with 162-foot LRVs is shown in Figure 46 and would require the following modifications:

+ The south and middle segments of Track 9 would still provide access to the in-floor drop table with the 162-foot LRV, but it would have ongoing impacts requiring compromises. When the leading truck of the 162-foot LRV is over the drop table, the back of the car would extend out the south end of the building, requiring the Track 9 south bi-fold doors to remain open and creating an internal circulation barrier at that end of the shop. Similarly, when the rear truck of the 162-foot car is over the drop table, the front of the car would occupy and effectively preclude use of the north end of Track 9.
+ When it is available, the north end of Track 9 would still provide direct access to the HVAC Shop and the Pantograph Shop. However, positioning the 162-foot car for full overhead crane coverage occasionally would require that the Track 9 north bi-fold track doors remain open, and would create an internal circulation barrier. It also appears that this could partially block the exterior circulation roadway crossing north of the shop building.
+ The OCS section insulators and insulated track joints separating the middle and north segments of Track 9 would need to be relocated approximately 35 feet south to safely accommodate the 162-foot cars.

+ Tracks 10 and 11 would still be usable as general maintenance and repair tracks. However, as with the north end of Track 9, positioning the 162-foot car for full overhead crane coverage occasionally would require that the north bi-fold track doors remain open, and would create an internal circulation barrier. In addition, these tracks would require the same OCS section insulator and insulated track joint relocation noted for Track 9.
+ Tracks 12 and 13 would still be usable as the service and inspection tracks for scheduled preventive maintenance of the 162-foot cars.
+ Track 14 would still be usable for daily service and cleaning of the 162-foot LRVs in train consists of one or two cars.
+ Track 15 would still be usable as the wash track for interior cleaning and exterior washing of the 162-foot LRVs.

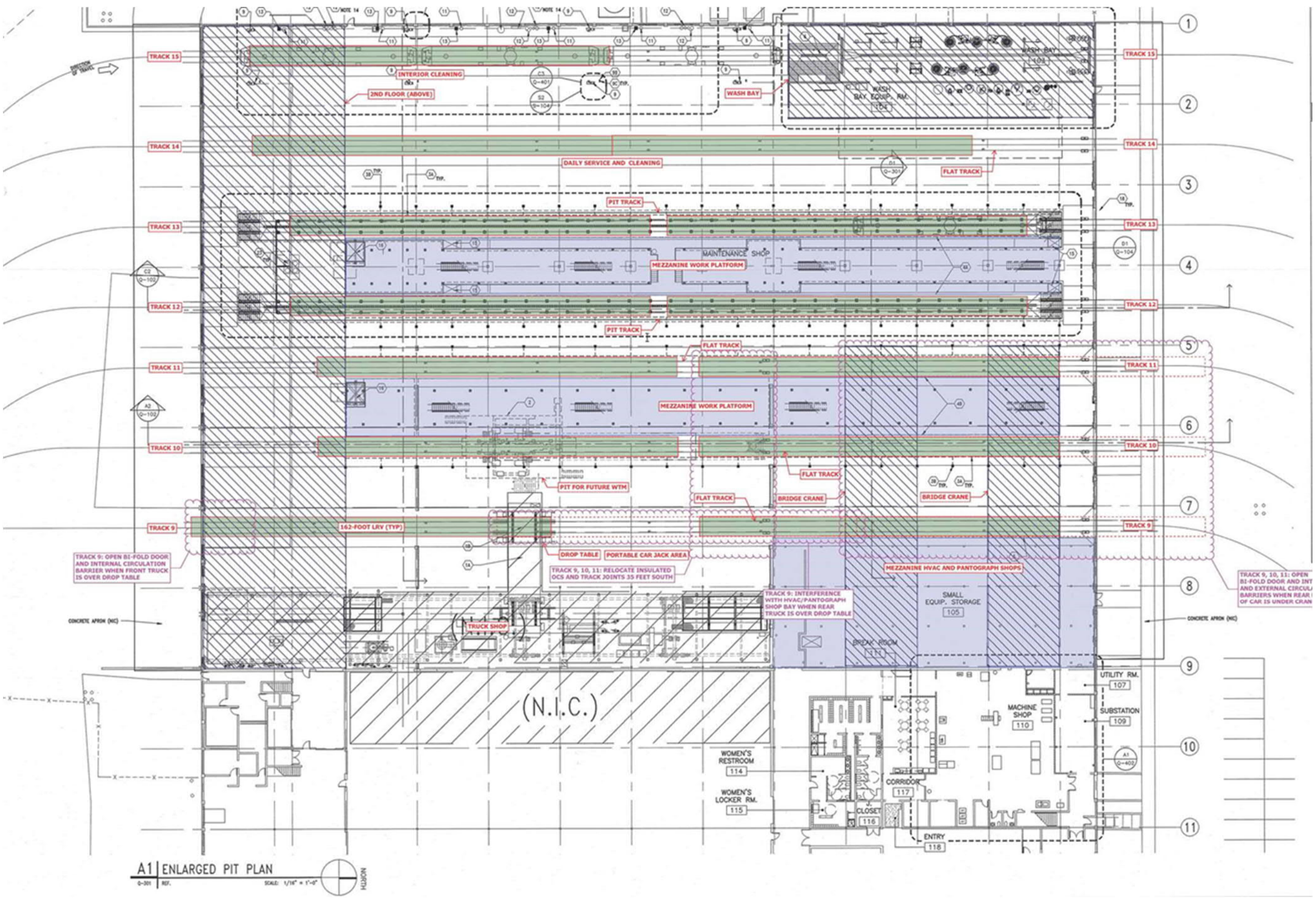

Figure 46 – Jordan River Service Center – LRV Maintenance Overview – 162' Cars

Based on the foregoing, the introduction of longer cars to the UTA light rail network would have significant implications for how they are maintained. The most feasible solution to accommodate longer cars appears to be to reassign the existing S70 fleet from Jordan River to Midvale upon retirement of SD100/SD160 fleet. The new longer cars would then be assigned to Jordan River, which appears to require significantly fewer modifications to support the new fleet.

UTA's reliance on a single wheel truing machine at a location that is designed for 81-foot cars would also require resolution. Options include relocating the existing wheel truing machines from Midvale to the Jordan River Track 10 location that was specifically designed for such a machine, modifying the Midvale wall and track constraints at the existing wheel truing machine location or procuring a second machine.

TRAX Fleet Plan Conclusions and Recommendations

Based on the foregoing considerations, Figure 47 presents the overall UTA Fleet Plan decision tree. This decision tree takes into consideration whether the Blue Line, currently equipped with high floor cars, and/or the Red or Green Line, currently equipped with 70% low floor cars, will be extended. As noted earlier, the Blue Line fleet would need to be replaced should UTA wish to remain eligible for federal funding of any planned light rail extensions.

The decision tree also addresses maintenance facility considerations with respect to maintaining 108-foor or 162-foot light rail vehicles. It also considers whether UTA might wish to sell its S70 fleet to another light rail property so as to be able to procure an all-new standardized fleet. Finally, it considers whether there is a cost-effective way to perform a life extension overhaul of the SD100/SD160 fleets to extend reliable operation to 2040, thereby deferring fleet replacement. Experience at other light rail properties shows that well-maintained light rail vehicles have a 30 to 35 year life span, meaning that SD100/SD160 reliable operation through 2040 is unlikely, no matter how thorough the UTA maintenance is.

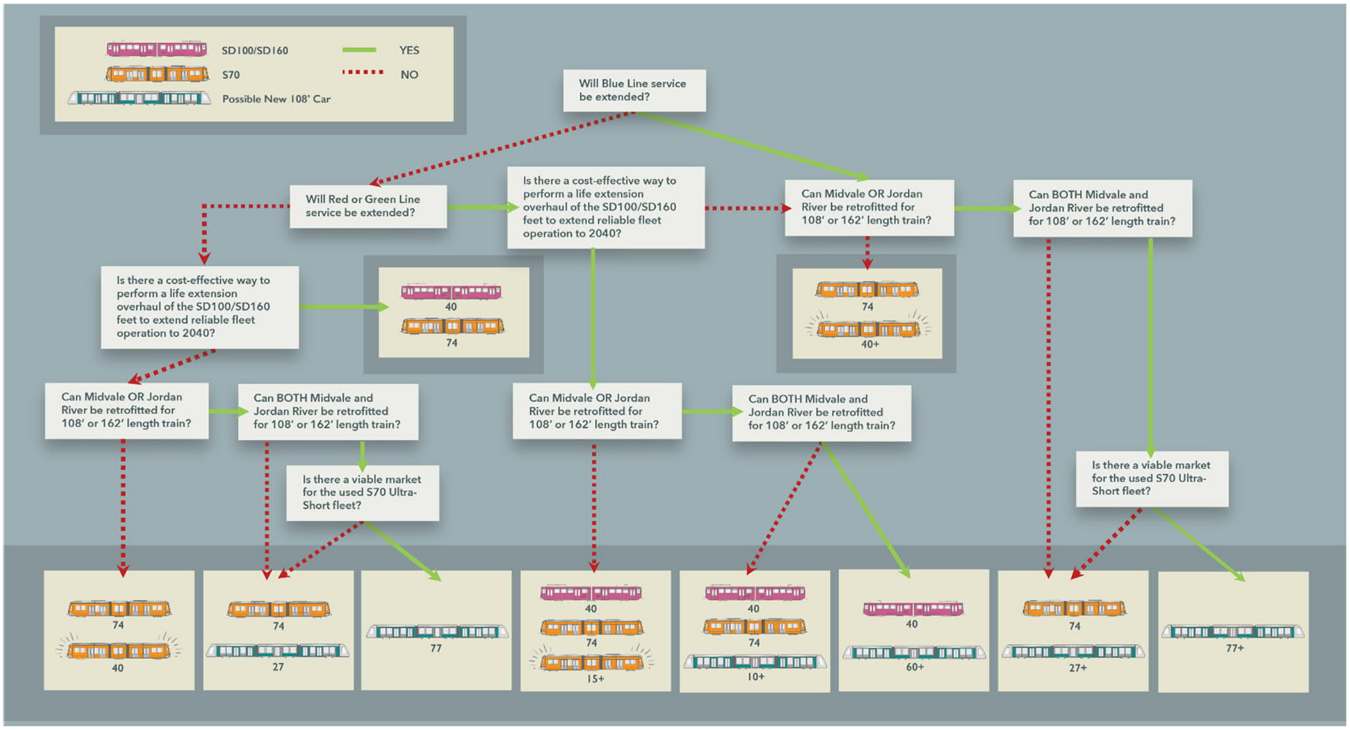

Figure 47 – Fleet Plan Decision Tree

In summary, Hatch LTK recommends the decision tree path that ends at the bottom box second from the left. This reflects retention of the existing S70 fleet and procurement of 27 longer cars (108 feet in length), replacing the capacity of the 40 shorter high floor cars to be retired. If, at the time of the procurement development, a robust secondary market for the S70 fleet is found, UTA should consider selling off the S70 fleet (except for the S70 streetcars needed for the S-

Line) and procuring an entirely new, standardized fleet. This is represented by the bottom box, third from left. This has additional implications with respect to Midvale modifications which should be the subject of a more detailed engineering study.

Should potential extension of one or more light rail lines (or network expansion such as the Orange Line deployment described in Scenarios 4 and 5) advance, UTA can address the need for expanded fleet by including provisions for options within the light rail vehicles RFP. This is a standard consideration in most agency vehicle procurements.

As discussed in the maintenance vehicle section of the Fleet Plan, UTA should consider reassignment of the S70 fleet from Jordan River to Midvale upon retirement of SD100/SD160 fleet. This is because Jordan River appears to be more flexible with respect to accommodating longer car lengths; the 108-foot or 162-foot cars would be assigned there.

UTA's reliance on a single wheel truing machine would need to be resolved as part of these recommendations. The existing wheel truing machine could be relocated to the Jordan River Service Center (where a pit designed for such a machine already exists and space constraints are less severe) or a second wheel truing machine could be procured for Jordan River. A third possibility is modifications to Midvale walls and structure which would need to be confirmed through a more focused engineering feasibility study.

Future of Light Rail Historic Ridership Analysis

This chapter analyzes UTA ridership on TRAX, reviewing weekday historic ridership data provided by UTA from 2000-2019 system wide for each new TRAX line as it was completed. The analysis also reviews station-level average weekday ridership from 2013-2019. While the analysis was completed in 2020, the analysis does not include 2020 data because of anomalous changes in ridership due to the COVID-19 pandemic.

TRAX ridership reached a collective peak in 2013 with the opening of several TRAX extensions adding on to the original North/South and University/Airport lines. Since 2013, average weekday ridership has been decreasing, although some TRAX lines appear more resilient than others, possibly due to the presence of populations more likely to use transit for a variety of trips near some stations. Several factors within Salt Lake County, including household access to automobiles, the relative affordability of owning and operating a vehicle, and overall income levels, may be contributing to a reduction in transit ridership. In short, an increasing number of people can afford to drive and choose to do so instead of using TRAX.

Daily Annual Ridership

UTA provided average weekday ridership by year from 1999-2019. The first UTA light rail line, now known as the Blue Line, opened in 1999 and saw its first full year of service in 2000, originally serving communities between Salt Lake City and Sandy. The Red Line opened in 2001, in time to serve visitors for the 2002 Olympic Winter Games, and the Green Line had its first full year of service in 2012. Figure 48 below shows cumulative average weekday ridership by line for the TRAX system, from 2000 until 2019.

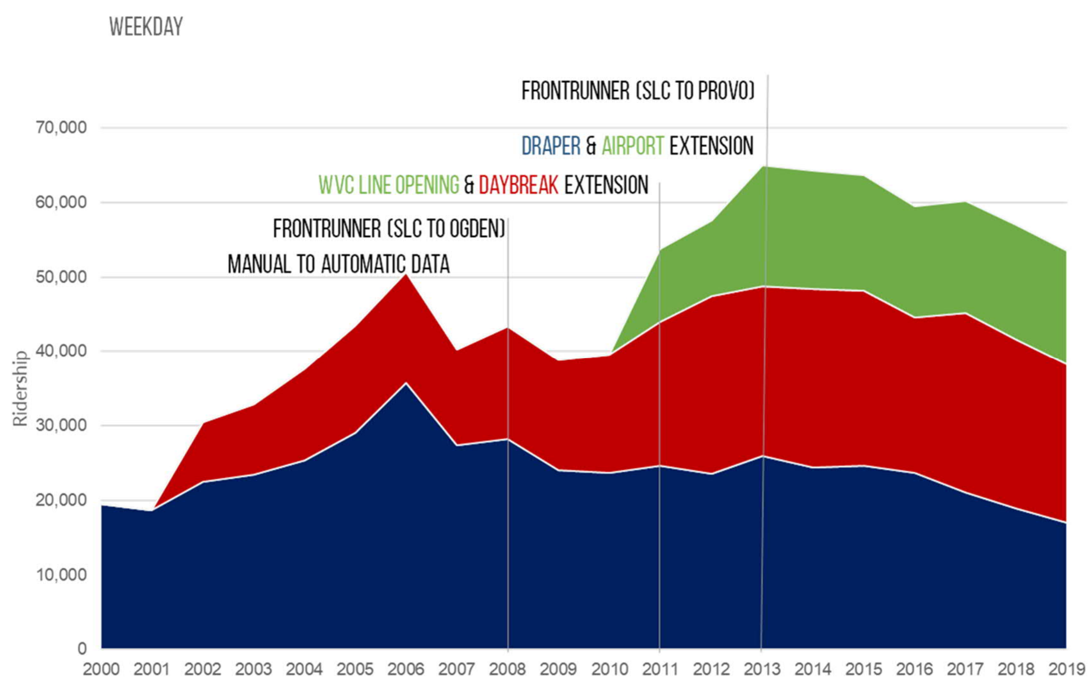

Figure 48 – UTA Average Weekday Ridership 2000 - 2019

Figure 48 contains several notable trends across the time axis. First, while there appears to be a sharp peak in ridership around 2006, this is likely due to a shift in data collection methods. UTA began using automated passenger count technology in 2007 rather than relying on manual methods of collecting passenger counts. The change in count methodology resulted in greater accuracy after 2006, and the 2006 peak should be considered an aberration of data rather than a true spike in ridership.

2008 was the peak of a six year upward trend in gas prices, which may have helped to make transit more competitive with driving a private vehicle, and likely contributed to a small spike in ridership that year. However, these trends did not hold as gas prices decreased. In 2008, UTA also opened FrontRunner commuter rail service between Salt Lake City and Ogden, which expanded high-capacity transit accessibility to many more communities along the Wasatch Front.

In 2011, UTA extended light rail service to the Daybreak master planned development in South Jordan, adding stations in several communities along the way and opened the Green Line extension to downtown West Valley City, which would subsequently interline with service to the airport starting in 2013. UTA also extended the Blue Line from Sandy to Draper in 2013, which may be responsible for the small spike in ridership seen on the Blue Line. That same year, UTA opened FrontRunner service between Salt Lake City and Provo. The Blue Line saw a steady decrease in ridership from 2013 forward, some of which could be explained by a shift from some transit riders from the Blue Line to FrontRunner, which offers faster trips between the Salt Lake Valley's southernmost communities and downtown Salt Lake City when compared to TRAX.

As shown in Figure 49 combined system ridership reached a peak in 2013 with the opening of the new lines, and began a trend of decline after 2013. The rates of decline were not consistent across all TRAX lines, however, as shown in the Figure 49.

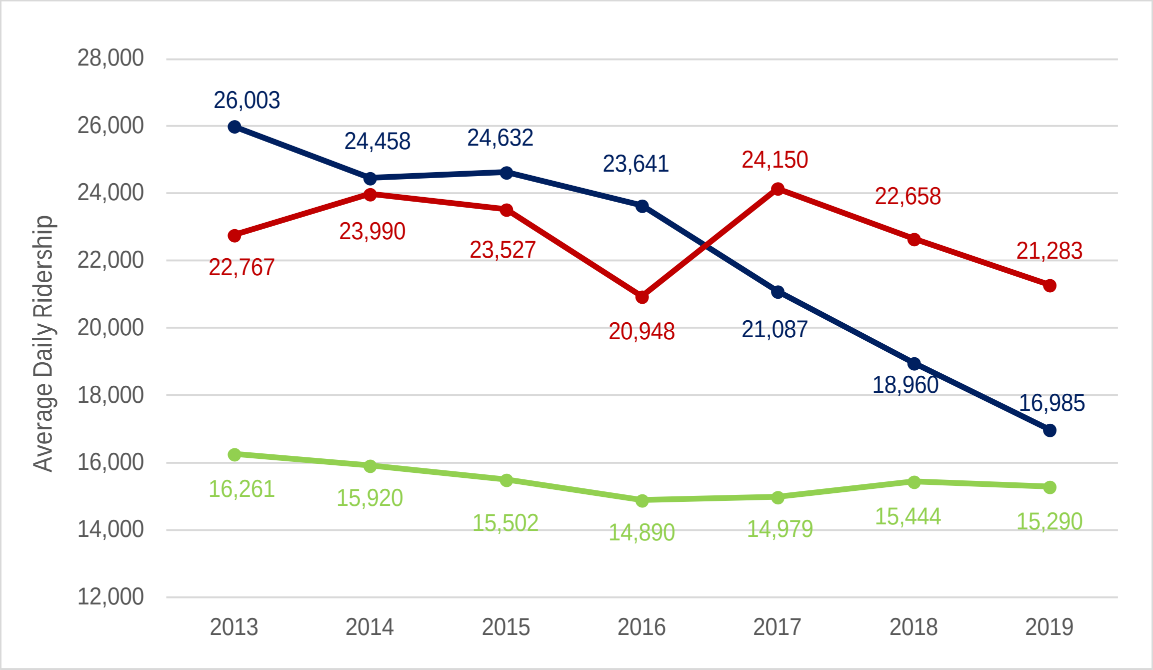

Figure 49 – TRAX Weekday Average Ridership by Line 2013 - 2019

As shown in Figure 49, the Green Line's ridership stayed relatively stable over time, as did ridership on the Red Line. Both the Green Line and the Red Line saw a decrease of between 1,000-1,500 riders per average weekday between 2013-2019. In comparison, ridership on the Blue Line decreased roughly by 9,000 over the same time period. UTA staff indicated that a shift in schedules in 2016 may have resulted in the Red Line becoming more attractive than the Blue Line at some heavily-traveled stations served by both lines, potentially causing the Red Line spike in ridership that year. Several extenuating circumstances likely contribute to the trend of declining ridership, however, as outlined below.

Potential Variables Influencing Transit Ridership

Many factors have the potential to influence individual travel behavior, including the choice of transportation modes used to get from one place to another. For the purposes of this analysis, the project team gathered historic data on the following variables that influence people's travel choices:

- Median household income, from the American Community Survey datasets of the U.S. Census Bureau for both Salt Lake County and the national average;
- The cost to own and operate a private vehicle, from the Bureau of Labor Statistics, available at a national level;
- Parking costs at major job centers and universities, gathered locally to the degree information was readily available;
- Fuel costs in dollars per gallon, for both the Rocky Mountain region and the nation, using data from the Energy Information Administration;
- Transit fares, including both cash and monthly fares charged by UTA for a range of pass type and services;
- Percentage of households with access to a private vehicle, from the American Community Survey datasets of the U.S. Census Bureau for both Salt Lake County and the national average;
- Cost of rent or mortgage, from the American Community Survey datasets of the U.S. Census Bureau for both Salt Lake County and the national average;
- The roadway congestion index, produced by the Texas Transportation Institute for metropolitan areas throughout the United States;
- Input from UTA operations staff, including concerns regarding possible passenger safety perceptions related to non-destination riders; and
- Results of UTA's customer service surveys such as the Net Promoter Survey and the GOALS survey.

Several factors emerged as the most likely influencers of regional travel behavior and the decline of transit ridership, as discussed in the following sections. Factors found not to be likely influencers (or for which statistically-significant data is not available) include parking costs, transit fares, cost of rent or mortgage, and results of UTA's customer service surveys.

Median Household Income

Median household income for Salt Lake County compared to the national average is shown in Figure 50.

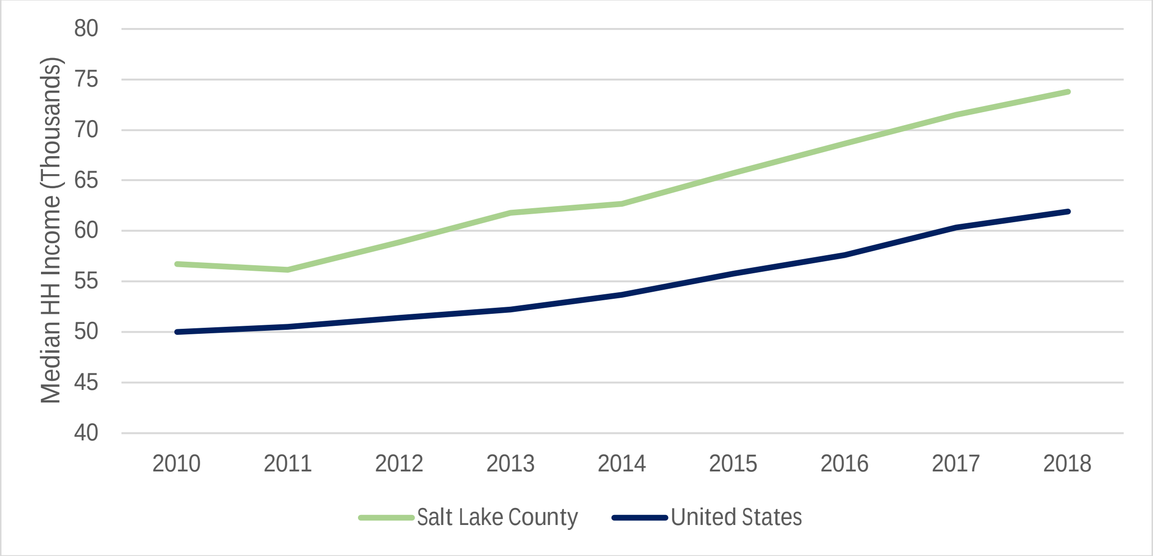

Figure 50 – Salt Lake County Median Household Income Compared with the National Average

Median household income in Salt Lake County increased annually during the time of ridership decline, from nearly $57,000 annually in 2010 to almost $74,000 in 2018 (the last year that data was available at the time of this analysis) – a notable increase of almost 30% in just eight years. In comparison, the national median household income was around $50,000 annually in 2010, growing to roughly $62,000 annually in 2018 and representing an increase of nearly 25%. The data indicates that Salt Lake County residents are somewhat wealthier on average than the rest of the country, and likely had greater access to disposable income that may have led to decreased use of transit for economic benefit or need.

Fuel Costs

Fuel costs for Salt Lake County compared to the national average are shown in Figure 51.

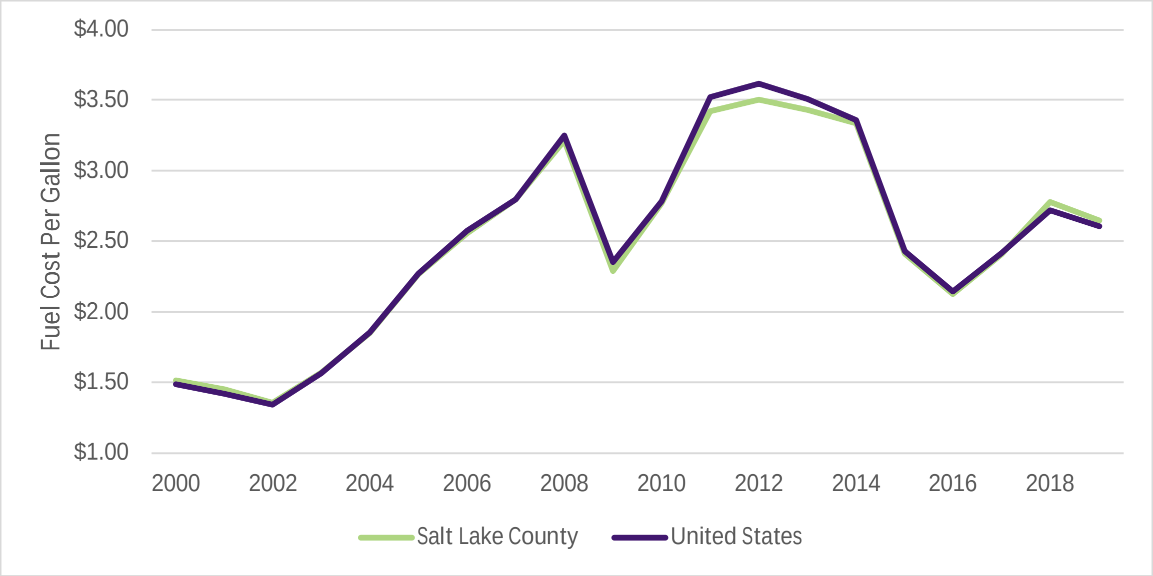

Figure 51 – Salt Lake County Fuel Costs Compared with the National Average

The average cost of a gallon of gas in Salt Lake County tracked fairly close with the rest of the country over time. The 2002-2008 timeframe saw a spike in fuel costs, which in turn contributed to a spike in transit ridership on UTA's system. Following a 2009 drop, fuel costs again increased. However, the associated higher cost of driving starting in 2010 did not seem to translate to a ridership spike on TRAX.

Currently, the price of a gallon of gas is hovering around $2.50, roughly the same as a one-way fare on TRAX or bus. The overall cost of owning, operating, and maintaining a vehicle is assuredly higher than the monthly cost of a transit pass; however, many travelers do not account for the hidden costs of car payments, maintenance, and insurance when making their daily choices of which travel model to use.

According to the AAA, "most drivers can tell you what they paid for their car and maybe even what it costs to keep the gas tank full…but the true annual costs of new vehicle ownership are trickier to track." AAA's latest (2019) cost of automobile ownership report found that the average annual cost of a new car increased 5% from the previous year to $9,282. The AAA annual survey found that average costs increased in every expense category it analyzed:

+ Fuel costs increased to 11.6 cents per mile, up about half a cent from last year, though representing less than a quarter of annual operating costs,
+ Maintenance, repair and tire costs increased to 8.94 cents per mile, up 0.73 cents,
+ Annual average insurance costs increased to $1,194 per year, a $5 increase, and
+ Licensing, registration and taxes rose to $753 per year, up $14.

Household Vehicle Access

The percent of households with access to a private vehicle is shown in Figure 52. The figure shows that the vast majority of households have access to at least one private vehicle.

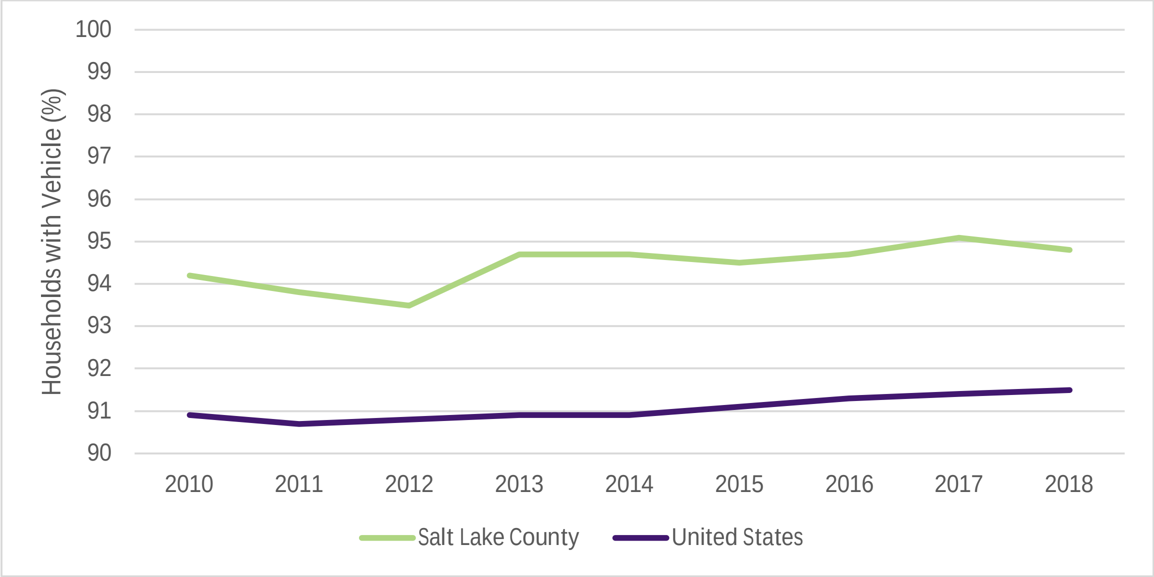

Figure 52 – Salt Lake County Households with Access to Private Vehicles Compared with the National Average

A very high percentage of Salt Lake County households – roughly 95% – have access to a private vehicle. This reflects an even higher percentage than national levels of vehicle ownership, with 91% of American households having access to their own vehicle. High rates of vehicle ownership generally means that relatively few households need to consider alternatives to driving for their transportation needs. It is also worth noting that few of Salt Lake County's neighborhoods contain the range and density of land uses that would enable a household to feasibly forgo ownership of a private vehicle, even those neighborhoods that are near TRAX stations.

Roadway Congestion

In addition, the Salt Lake urban area has been extremely successful in securing funding for and implementing roadway and freeway projects, which make driving a private vehicle more convenient and faster, and potentially making the use of transit more challenging. In addition to reducing trip times by auto, larger and busier roadways decrease walkability and make it more difficult to access transit. A sampling of these projects over the last decades includes the following projects which had major impacts on North/South highway capacity in the Salt Lake Valley:

+ I-15 Reconstruction, which added an HOV lane and a general purpose lane (construction ended in 2001)
+ Continuous Flow Intersections (CFI) on several Bangerter Highway intersections (such as 3500 South, 4100 South, 4700 South, and 13400 South);
+ Six new interchanges on Bangerter Highway (5400 South, 7000 South, 7800 South, 9000 South, 11400 South, and 600 West);
+ Mountain View Highway between Redwood Road and 5400 South (built in 2012) and between 5400 South and 4100 South in 2017; and
+ One southbound lane added to I-15 between 7800 South and Bangerter in 2018.

These examples are not exhaustive, but a short list of capacity projects that parallel the transit spines in Salt Lake County and which may have had the effect of dampening ridership as driving travel times are reduced or maintained despite increased traffic volumes.

While the preceding section has described patterns along the overall TRAX system since its opening, individual changes by line and how ridership has changed by station as the system ridership has declined may offer insights into strategies to increase ridership. These patterns are addressed in the following section.

Changes in Ridership by Line, 2014-2019

This section evaluates station-level ridership trends for the Blue, Red, and Green TRAX Lines from 2014 through 2019. While the analysis was completed in 2020, data from 2020 was excluded due to atypical ridership resulting from the COVID-19 pandemic. The analysis uses the annual August TRAX schedule change day datasets to compare across individual years, in order to maintain consistency and capture some seasonal patterns (such as universities and schools being in session), and avoid disruptions such as snow days as much as possible.

Blue Line Ridership

Figure 53 shows average weekday ridership by station on the Blue Line, beginning in 2014 after system realignments were already in place and the new Blue Line stations in Draper were opened. In the chart, green bands indicate stations where ridership increased, and purple lines indicate stations where ridership decreased; the darker the band, the greater the change. The width of the band represents the level of ridership; the wider the band, the greater the ridership.

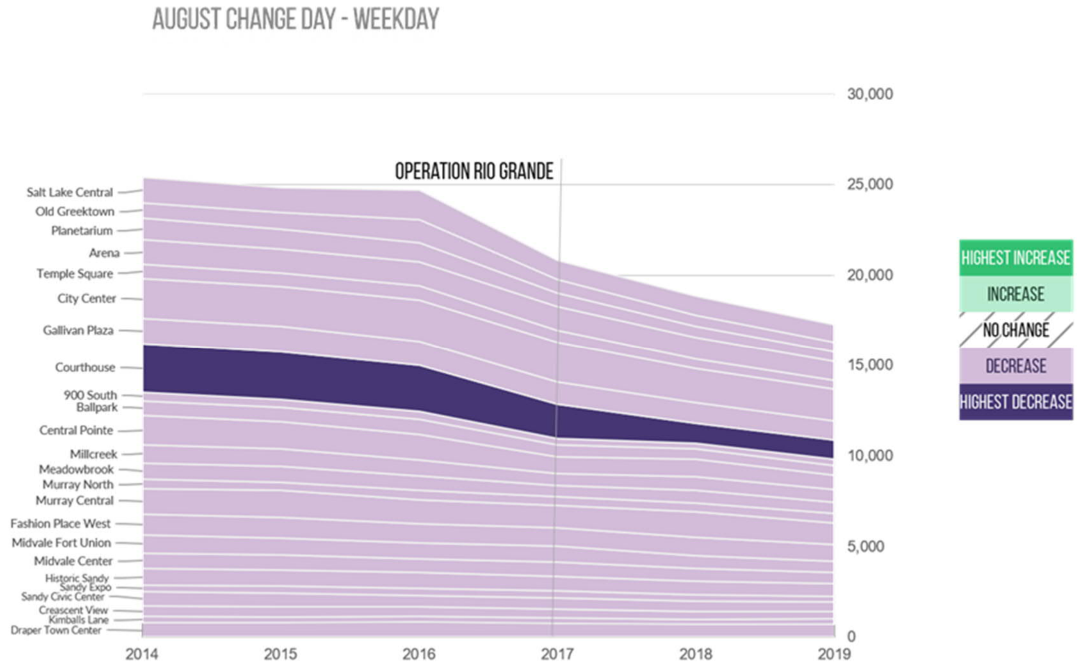

Figure 53 – Blue Line Average Weekday Ridership by Station

As Figure 53 shows, all stations on the Blue Line experienced a decrease in ridership after 2013. Courthouse Station in particular experienced a large drop in ridership, although some of this may be attributed to the change in line-by-line train sequencing that increased the likelihood of downtown travelers using the Green Line. The widest bands, representing the highest ridership levels on the Blue Line, are at the stations closest to downtown; and that the stations in the most southern and suburban communities contribute the lowest levels of ridership.

Red Line Ridership

Figure 54 shows average weekday ridership by station on the Red Line.

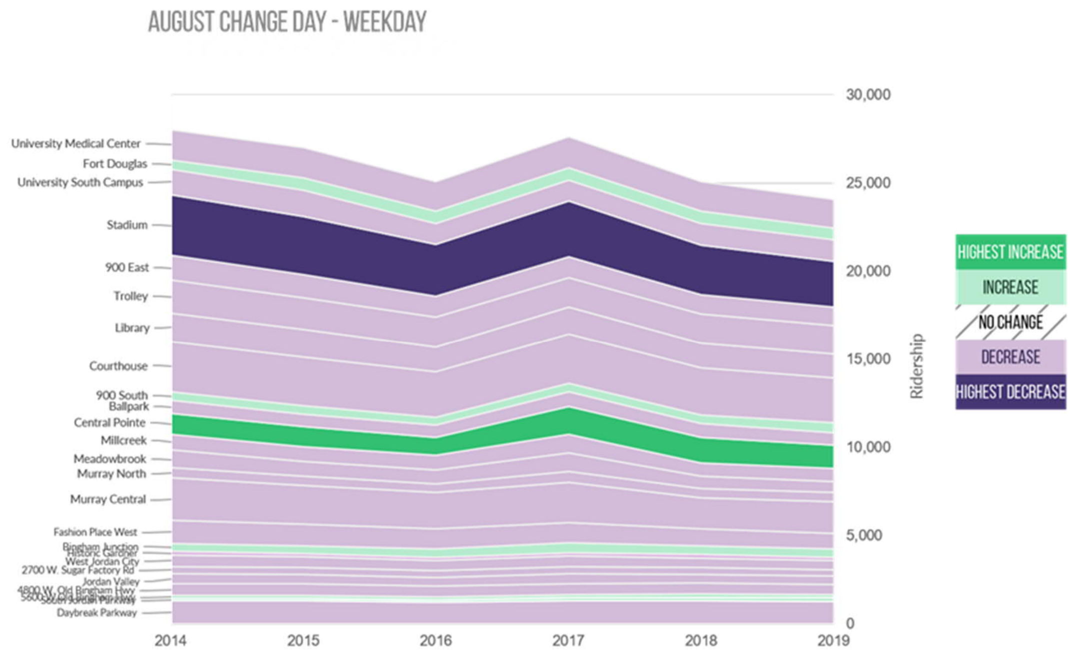

Figure 54 – Red Line Average Weekday Ridership by Station

The Red Line experienced increased ridership at some stations and decreased ridership at others. The largest increases occurred at Central Pointe station near 2100 South, although the reasons why are not apparent; this may have been a function of schedule changes rather than factors specific to the station itself. Stations at 900 South and Bingham Junction have been the focus of significant amounts of transit-oriented or transit-adjacent development, which may have contributed to an uptick in ridership at these stations, although considerable development at stations like Murray North and Meadowbrook does not appear to have the same effect. At many stations, ridership decreased during the same time period, with the Stadium station at the University of Utah experiencing the greatest decrease.

Green Line Ridership

Figure 55 shows average weekday ridership by station on the Green Line.

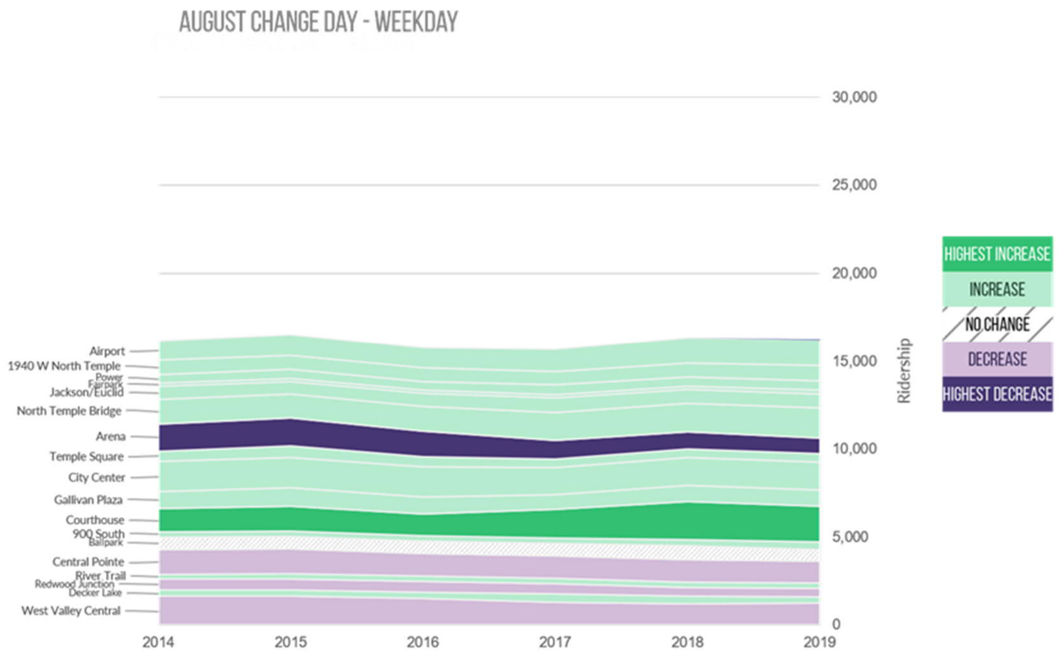

Figure 55 – Green Line Average Weekday Ridership by Station

Unlike stations on the Red and Blue Lines, most stations on the Green Line increased in ridership from 2014-2019, most consistently in the stations along North Temple between the Salt Lake City airport and downtown Salt Lake City. According to Wasatch Front Regional Council Equity Focus Areas Data, there is a relatively large population of low-income people who live in close proximity to the stations along North Temple. The Green Line service provides the best east-west transit service in this area, with connections to Downtown and the entire transit network. This combination of factors results in stronger contributions to transit ridership, helping the Green Line sustain its ridership levels while the Red and Blue Lines have declined. Notably, Courthouse Station experienced some of the highest increases on the Green Line in this time period, while Red and Blue Line ridership at this station decreased. Land uses around this station have not changed significantly in the 2014-2019 time period, and UTA staff suggested that the increase in ridership was a result of changes in arrival timing at this station, encouraging more transfers to the Green Line than the other TRAX lines.

Ridership Analysis Conclusions and Recommendations for Further Study

A variety of factors in recent years contributed to TRAX's declining average daily ridership, several of which were potentially significant and also outside UTA's control: increases in regional household income, growing household access to private vehicles, and the perception of affordability of owning and operating those vehicles. UTA can pursue several strategies, alongside its regional agency and community partners, to build ridership and support for the light rail system, as outlined below.

Focus on Key Demographic Groups

Analysis conducted for this project suggests that Green Line ridership may be more resilient due to the concentration of low-income populations along the corridor, especially along North Temple in Salt Lake City. This analysis relied on GIS data provided by Wasatch Front Regional Council regarding Equity Focus Areas, which identifies geographic areas with higher than average concentrations of people with a number of characteristics, including low income and lack household access to a vehicle. The presence of low-income populations along the Green Line in Salt Lake City is likely one of many factors at play that are influencing ridership.

As a next step, UTA may consider conducting follow-up surveys or studies of ridership trends of people who are low income to better understand the client base that is sustaining ridership and the factors influencing their travel choices. UTA could also partner with WFRC to update the locations of these Equity Focus Areas, potentially using forthcoming 2020 Census data or other sources, and use this information to consider how transit service could be modified or expanded to better serve the communities that need it most.

Support Affordable Housing Initiatives

An informal review of rental housing conducted for this project revealed that many of the housing developments built around TRAX stations are not affordable for a considerable segment of the population. The project team sampled entry-level monthly rental rates for large-scale multifamily developments near a range of TRAX stations, and generally found that the average monthly rent (not including utilities) for a one-bedroom, one-bathroom apartment near TRAX was slightly over $1,000. This varied somewhat throughout the region – typical monthly rents along the Green Line on the west side of Salt Lake City averaged around $950, while monthly rents along the Red Line in West Jordan or South Jordan started at around $1,150. The U.S. Department of Housing and Urban Development has a long-established affordability index indicating that households should not spend more than 30% of their income on housing costs; a high-level review of the data suggests that in Salt Lake County nearly a third of households would be spending more 30% of their income on rent to afford a one-bedroom, one-bathroom apartment on TRAX, putting transit-adjacent housing outside the range of affordability for that segment of Salt Lake County's population. Ostensibly, these households could save on other costs by forgoing owning or leasing their own vehicle, and relying on transit for their primary mode of transportation. However, relatively few TRAX stations in the region contain the full range of land uses and services within a feasible walking distance in order for people to conveniently live car-free. Moreover, housing costs are higher for people with children or other dependents who need larger apartments, further increasing the percentage of their income that must be dedicated to housing.

While the analysis conducted for this project was high-level, it suggests an important phenomenon: people most likely to use transit may not be able to afford to live at TRAX stations, and they may be getting crowded out by wealthier households who like the lifestyle offered at these TOD areas but are not choosing to utilize the transit system. More in-depth analysis is needed to confirm this is the case: UTA may wish to conduct an extensive survey of the available housing within a specific distance of each TRAX station, associated rental rates, typical vacancies, the range of products available, and other factors. UTA may also wish to evaluate the potential for new affordable housing at TRAX stations and opportunities to partner with development groups in order to build affordable housing near TRAX. Proactively identifying places for additional affordable housing, and partnering with communities and developers to provide it, may help add new transit riders to the system while also improving quality of life for Salt Lake County residents.

Explore Fare Policy Options

Issues of cost and convenience deter some potential riders from using the UTA system. With a current one-way fare of $2.50 outside of the Free Fare Zone, TRAX customers pay the same price for a gallon of gas as they do for a ticket for half of their round trip. Transit Cooperative Research Program Synthesis 101, *Implementation and Outcomes of Free-Fare Transit Systems,* 2012, cites UTA's October 1979 experiment with transit without fares as a temporary marketing promotion. The system, which then consisted solely of bus service, experienced a 13% increase in ridership during the month. The TCRP report notes more significant ridership gains at systems that implemented transit without fare payment system-wide for longer time periods or permanently.

Other studies have explored the potential relationship between removing fare payment and increased ridership and found that it may be substantial in changing travel behavior, and several transit agencies around the country have tested the concept (as has UTA during brief time periods, such as during times of poor air quality). UTA has additionally tested the concept of transit without fare payment on the UVX bus rapid transit route in Utah County, which is believed to have contributed to opening day ridership that was significantly higher than projected. UTA has been looking at methods to make using transit more affordable. Recent efforts include a pilot program to distribute discounted passes to public schools, nonprofits and other community organizations, so that they can provide them to their low-income clients. Another proposed program would allow low-income persons to apply for discounted fare cards. UTA may wish to explore options for expansion of reduced or no fares at all times. UTA may wish to partner with agencies such as UDOT on additional funding for low-fare or transit without fares incentives; the state transportation agency is likely well aware that transit will need to be an increasing part of the transportation solution as the region continues to grow, and the agencies may be able to work together to consider ways to shift more travel off roadways and onto transit.

Consider the Role of Parking

Parking policy in urban centers can deter transit use. In downtown Salt Lake City, visitors can often find affordable and accessible parking relatively easily, sometimes completely free of charge within a short walking distance of their destination. The convenience of cheap parking can discourage people from taking transit into the heart of the City, whether for work, recreational, entertainment, shopping, or other purposes. WFRC is currently leading a parking study which may provide additional guidance on revised downtown parking policies that better serve the region, including supporting transit ridership.

Provide Additional Focus on Non-Commute Trips

Transportation planning analysis is often focused on the morning and evening peak commute patterns and how to best serve people traveling to and from work. However, as shown in the *2017 National Household Travel Survey*, work commute represents less than 20% of total household trips. Travelers have a range of needs that could be met by transit, occurring at all times of day and into the evening. Activity centers and special events rely on late-night transit to serve entertainment venues, restaurants, nightlife, and other activities where parking may be limited or driving is not desired. Similarly, different parts of the population have different travel needs even during peak times, but outside the typical work/home trajectory: parents need to pick up kids from school and child care, run errands, attend sports practices, etc. Some of these trips might be served via transit if those needs are better understood. A number of recent studies, including TransitCenter's *Who's On Board 2016*, point to the strategy of making transit trips more appealing for more trip types for existing transit users as a more effective method of building and sustaining ridership than trying to lure new riders out of their cars for commute only trips. UTA may wish to study those needs further and respond by expanding the span of service between key destinations and proactively working with communities to ensure that a transit oriented "fifteen minute neighborhood" that serves a household's basic daily needs can be found around more TRAX stations. If more stations areas, particularly in the more suburban parts of the network, can be converted from parking lots that are difficult to access without an automobile to walkable centers containing a variety of work, shopping, and residential attractions, these locations may see increased ridership as destinations for a variety of purposes.

Phase 1 Conclusions

The work in Phase 1 has successfully identified a variety of operational and infrastructure improvements that offer the prospect of more attractive TRAX service and higher ridership. At the same time, the Phase 1 Ridership Analysis has indicated that pre-COVID declines in TRAX ridership are largely due to factors outside of UTA's control. Similar trends have occurred in recent years at most peer light rail networks as well. Table 56 summarizes the overall Study goals and objectives. Objectives realized in Phase 1 are shown in italics.

Table 56 - Study Goals & Objectives

Goal	Objectives
Develop plan to improve ridership outcomes	+ *Perform root cause analysis of ridership trends* + *Identify focus areas that are under UTA management* + *Use market data to identify potential new riders*
Define appropriate span and frequency of service for current and projected demand	+ *Analyze benefits of improved span and frequency* + Determine capital, operations and maintenance cost increases associated with various improvements + Consider benefit and cost of eliminating freight traffic from the main line
Recommend necessary fleet modifications and facility needs	+ *Consider necessary modifications to existing fleet, to include ADA accessible low-floor vehicles with each consist* + *Evaluate necessary fleet expansion and facility needs in concert with recommended improvements of service or expansions* + *Evaluate the facility and resource needs for extended overhaul program of existing and future light rail fleet* + *Evaluate the realistic life of the existing light rail fleet and create an estimated cost and strategy for replacement*
Recommend projects that improve speed, reliability and safety of existing system	+ Consider grade-separated crossings at priority locations + Evaluate benefits of removing shared left turns + *Consider signaling improvements* + Consider implications of impending positive train control

Table 56 - Study Goals & Objectives	
Goal	Objectives
Refine and define LRT expansion proposals or concepts	+ Perform a scenario analysis on the choices of proposed concepts with various alignments including baseline delivery timelines + *Consider all costs and needs associated with expanded system, including recommendations developed through the Point of the Mountain Alternatives Analysis if applicable* + Attach planning level ridership to system scenarios + Identify whether a revised light rail system should be proposed for the initial outreach during the next RTP cycle

TRAX Improvements and Operational Benefits

In Phase 1, many individual improvements were tested operationally using a “light” simulation model. This model was developed from the existing rail vehicles, simplified track alignment, train control, intersection control, and operations on the three light rail lines as well as the S Line. Based on guidance from study stakeholders, a series of future planning scenarios was modeled using the Future Baseline model as a starting point. These scenarios are designed to improve existing TRAX operational performance and to accommodate future growth by implementing service, operational, and capital improvements.

The scope of the Future Baseline model and individual improvement scenarios for the future are listed below. These individual improvement scenarios should not confused with the larger investment packages of improvements to be developed in Phase 2:

- Future Baseline:
  - Includes new 650 South Station and Relocated Airport Station
- Future Build Scenario 1 (Intersection Priority Improvements):
  - Includes new 650 South Station and Relocated Airport Station
  - Intersection Priority Improvements
- Future Build Scenario 2 (Trunk Line Curve Speed Improvements):
  - Includes new 650 South Station and Relocated Airport Station
  - Curve Speed Improvements
- Future Build Scenario 3 (Additional Intersection Priority Improvements):

- Includes new 650 South Station and Relocated Airport Station
- Intersection Priority Improvements from Scenario 1
- Additional Intersection Priority Improvements

+ Future Build Scenario 4 (Add Downtown Alignments with New Orange Line):
    - Includes new 650 South Station and Relocated Airport Station
    - Ballpark Spur/400 South/400 West Network Improvements with New Orange Line
+ Future Build Scenario 5 (Add Downtown Alignments and Research Park Extension with New Orange Line):
    - Includes new 650 South Station and Relocated Airport Station
    - Ballpark Spur/400 South/400 West Network Improvements with New Orange Line
    - University Research Park Branch with New Orange or Red Line
+ Future Build Scenario 6 (Existing Network with 12-Minute Headways on all 3 Lines):
    - Includes new 650 South Station and Relocated Airport Station
    - 12-Minute Headways on all 3 Future Baseline Lines (4-Minute Headway Combined)

Table 57 provides an overview of the results of the six individual Phase 1 simulation scenarios, comparing them to the Future Baseline scenario. All scenarios show improved system performance, in the form of higher on-time performance (OTP), compared to the Future Baseline. Scenarios 1, 2 and 3 all included reduced scheduled running times to take advantage of higher speeds or reduced intersection delays meaning that the improved OTP under more demanding scheduled running time conditions. Scenarios 4 and 5 reflect the most ambitious capital investments with higher associated fleet requirements and capital costs. Additional intersections traversed west of the Main St corridor and in the Granary District, as well as two services operating to the Airport and the University, resulted in higher per-distance stopped delay, a measure of congestion.

Scenario 6, which improves serves by offering all-day 12-minute branch headways instead of the current 15-minute frequency, has improved OTP and stopped delay versus the Future Baseline. In Phase 2, Scenario 6 could be combined with the curve speed improvements of Scenario 2 and/or the intersection improvements of Scenarios 1/3 for potential synergistic benefits.

The Scenario 4 capital cost of $195.7 million (in current dollars) was the result of a planning level unit cost analysis. Scenario 5 includes these same improvements as well as a new junction near the University and a new Research Park terminus. The Rough Order of Magnitude (ROM) cost of this is $20 million, to which 30% unallocated contingency is added. This brings the capital cost of Scenario 5 to $221.7 million. Scenario 1's ROM cost is based on 16 improved intersections at $100,000 per location while Scenario 3's ROM is based on the same unit cost for a total of 23 improved intersections.

The Scenario 2 ROM capital cost is based on 50 curve locations where realignment and adjustment of the Overhead Contact System (OCS or catenary) is assumed to be $100,000 per location. Much of this work can be accomplished in conjunction with programmed state of good repair/capital renewal work.

Table 57 – Summary of Individual Simulation Scenario Results

Future Build Scenario	Trunk Line Headway (Minutes)	Average Terminal-to-Terminal Scheduled Time Change (Minutes)	Simulated On-Time Performance (Percent)	Seconds of Stopped Delay per Mile Operated	Peak Fleet Requirement (Before Spares)*	Capital Cost (Including Fleet with Spares)	Change in Weekday Ridership
Future Baseline	5	N.A.	92.5	9.5	87	$0	TBD
Scenario 1 (Intersection Priority Improvements)	5	-0.5	93.8	8.5	87	$1.6	TBD
Scenario 2 (Curve Speed Improvements)	5	-1.0	96.1	9.0	87	$5.0	TBD
Scenario 3 (Additional Intersection Priority Improvements)	5	-1.0	96.1	7.0	87	$2.3	TBD
Scenario 4 (Add Downtown Alignments plus New Orange Line)	7.5/7.5	N.A. **	95.5	11.5	106	$195.7	TBD
Scenario 5 (Add Downtown Alignments and Research Park Ext. on Orange Line)	7.5/7.5	N.A. **	94.9	12.0	106	$221.7	TBD
Scenario 6 (Existing Network with 12-Minute Headways on all 3 Lines)	4	0	94.7	9.0	108	$100.5***	TBD

*All scenarios also include 3 S70 Streetcars assigned to the S-Line.

**Reflects a fundamentally different operating plan with new Orange Line, Blue Line revised to serve Airport, Green Line revised to serve Salt Lake Central.

***Includes only additional fleet capital cost; does not include traction power upgrades which require a separate load flow study to quantify.

Scenario 6's capital cost includes the procurement of 16 additional vehicles at a cost of almost $5 million each. A recent TRAX Traction Power Load Flow Study constrained all scenarios to the existing fleet but, nonetheless, identified some required traction power capital improvements. With Scenario 6 increasing the fleet from 114 cars to 130 cars, additional traction power capital improvements will almost certainly be required. A separate engineering study is needed to identify and quantify these specific improvements, the cost of which would need to be added to the $100.5 million shown in Table 57. Table 58 summarizes the relocated and new stations in all of the future scenarios.

Table 58 – Relocated and New Stations in Future Baseline and Future Build Scenarios

Future Build Scenario	Relocated Airport Station	650 South Station (new)	300 West Station (new)	800 South Station (new)	600 South Station (new)	Pioneer Park (new)	Courthouse on 400S (new)	Research Park Station (new)
Future Baseline	•	•						
Scenario 1 (Intersection Priority Improvements)	•	•						
Scenario 2 (Curve Speed Improvements)	•	•						
Scenario 3 (Additional Intersection Priority Improvements)	•	•						
Scenario 4 (Add Downtown Alignments plus New Orange Line)	•	•	•	•	•	•	•	
Scenario 5 (Add Downtown Alignments and Research Park Ext. on Orange Line)	•	•	•	•	•	•	•	•
Scenario 6 (Existing Network with 12-Minute Headways on all 3 Lines)	•	•						

Table 59 summarizes the changes to the Terminal Dispatch times for the future scenarios against the Baseline scenario (existing scheduled operations). Future Build Scenarios 4 through 6 have operating plans with new lines and terminal-terminal pairings; they are therefore not comparable to the Baseline schedule.

Table 59 – Change in Terminal Dispatch Time and Scheduled Headways									
	Schedule changes* (min)						Headway (min)		
Future Build Scenario	Blue NB	Blue SB	Red NB	Red SB	Green NB	Green SB	Trunk Line NS#	Trunk Line EW##	Branch Line
Future Baseline	No change	-1	No change	-1	No change	-2	5		15
Scenario 1 (Intersection Priority Improvements)	No change	-1	No change	-1	+1	-2	5		15
Scenario 2 (Curve Speed Improvements)	+2	-1	+1	-1	No change	-2	5		15
Scenario 3 (Additional Intersection Priority Improvements)	+1	-1	+1	-1	+1	-2	5		15
Scenario 4 (Add Downtown Alignments plus New Orange Line)							6-8	6-8	15
Scenario 5 (Add Downtown Alignments and Research Park Ext. on Orange Line)							6-8	6-8	15
Scenario 6 (Existing Network with 12-Minute Headways on all 3 Lines)							4		12

*Compared to Existing Baseline schedule.
"-" indicates an earlier departure time, "+" indicates a later departure time
Trunk Line NS# - Between Courthouse and Central Pointe Stations
Trunk Line EW## - Between Pioneer Park and Main Street on 400 S

The terminal to terminal travel times for the Future Baseline scenario require an increase of one minute in the Red and Blue Line schedules and two minutes for Green Line schedules above the Baseline schedule due to the additional station and longer distance for the relocated Airport Station. Future Build scenarios 2 and 3 improve travel times by one or two minutes depending on line and direction compared to the Future Baseline. Future Build Scenarios 1 and 6 require a similar schedule to the Future Baseline with only one minute savings in isolated directions or none at all. Future Build Scenarios 4 and 5 have operating plans that are not comparable to the Baseline schedule, due to adding a new line and modifying the terminal pairs for existing lines.

TRAX Span of Service

TRAX presently supports time-separated overnight freight service on the North/South Trunk Line used by Blue, Red and Green Line trains as well as on the Red Line from 650 West to 5600 West. The perpetual rights of freight carriers to use these lines between midnight and 5:00 a.m. mean that the TRAX span of service is limited, as all light rail vehicles must be off the line by midnight pursuant to federal regulations.

While the Red Line freight service is extremely active, freight activity on the North/South Line is more limited. Based on evaluation of North/South Line freight activity over three months prior to the COVID-19 pandemic, it may be possible to negotiate a reduce the freight operating window from 5 hours to 3 hours, thereby increased the light rail operating window.

Separately, UTA could pursue abandonment of freight service north of 2200 South which would eliminate any span of service constraints on Green Line operation (and potential future Orange Line operation). At present, there is only one in-service freight switch in this TRAX segment and the freight customer could use a public delivery freight siding south of Central Pointe Station. With such a change, UTA would have the flexibility to operate 24-hour service overnight on the Green Line while being able to access the Jordan River Service Center at all times.

Fleet Plan

As part of Phase 1 of the Future of Light Rail Study, Hatch LTK developed a Fleet Plan for UTA Light Rail. The purpose of the Fleet Plan is to ensure future sufficient, reliable and cost-effective light rail fleet. As part of cost-effectiveness considerations, the Fleet Plan considers fleet capital costs, maintenance costs and shop (Midvale and Jordan River Service Centers) implications.

Other considerations in developing the Fleet Plan are to ensure federal eligibility for capital funding of future line extensions and other service expansions. The Fleet Plan considers fleet alternatives that increase quality of service. These alternatives include longer vehicles that reduce maintenance complexity (because there are fewer operating controls to maintain) and encourage greater passenger separation, an important consideration in recovering from the COVID-19 pandemic.

All three light rail models that comprise today's UTA light rail fleet are 81 feet in length. With a maximum train length of four cars, many elements of the UTA light rail infrastructure – station platforms, yard tracks, terminal tracks, maintenance facilities – are designed around a 324-foot train length. It is important that any future UTA fleet be consistent with this train length. Global light rail vehicle trends in recent years have been towards longer light rail cars; this is not necessarily inconsistent with the UTA-standard 324-foot train length. As shown in Figure 39, this length can be satisfied with four 81-foot cars, three 108-foot cars or two 162-foot cars.

As light rail operators around the globe move to longer vehicles, UTA is likely to receive greater supplier interest and more cost-competitive bids with a vehicle specified to be in the 108-foot or 162-foot length. In addition to small but quantifiable capital cost benefits, there are maintenance cost savings and enhanced passenger comfort/safety benefits to a car length longer than the current UTA 81-foot standard.

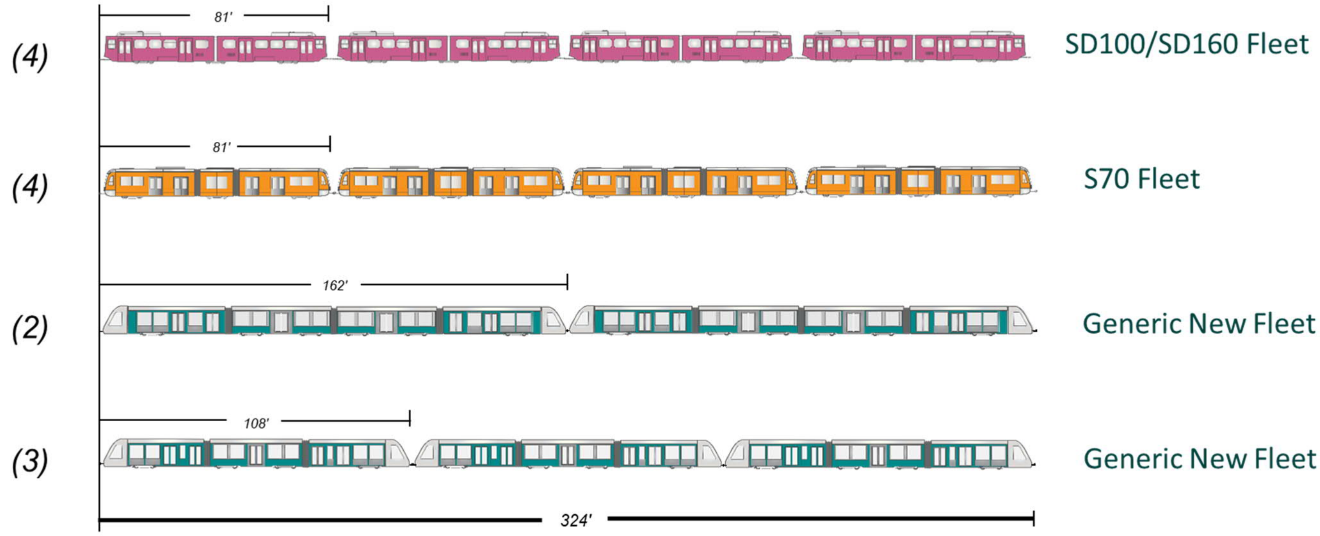

Figure 56 – Equivalent Train Consists – Maximum Length Train (324')

Today's UTA fleet consists of high floor models (SD100 and SD160) and 70% low floor models (S70). Accessibility for high floor models used on the Blue Line is achieved through the use of a "high block" boarding platform that provides access to the front portion of the train. The newer 70% low floor vehicles, used in all Red and Green Line trains, allow level or nearly-level boarding at each car in the train and provide greater accessibility by providing access to all cars in the train, eliminating congestion on the high block boarding platform as well as dependence on the Train Operator to manually deploy a bridging plate.

Potential replacement of the 81-foot high-floor fleet with a 108-foot or 162-foot light rail vehicle has implications for how light rail maintenance activities are performed at the Midvale and Jordan River Service Centers. The Fleet Plan suggests that, should UTA move forward with longer rail vehicles, that the existing S70 fleet be reassigned from Jordan River to Midvale upon retirement of SD100/SD160 fleet. The new longer cars would then be assigned to Jordan River, which appears to require significantly fewer modifications to support the new fleet.

UTA's reliance on a single wheel truing machine at a location that is designed for 81-foot cars would also require resolution. Options include relocating the existing wheel truing machines from Midvale to the Jordan River Track 10 location that was specifically designed for such a machine, modifying the Midvale wall and track constraints at the existing wheel truing machine location or procuring a second machine.

The overall UTA Fleet Plan decision tree, shown in Figure 47, addresses maintenance facility considerations with respect to maintaining 108-foor or 162-foot light rail vehicles. It also considers whether UTA might wish to sell its S70 fleet to another light rail property so as to be able to procure an all-new standardized fleet. Finally, it considers whether there is a cost-effective way to perform a life extension overhaul of the SD100/SD160 fleets to extend reliable operation to 2040, thereby deferring fleet replacement. Experience at other light rail properties shows that well-maintained light rail vehicles have a 30 to 35 year life span, meaning that SD100/SD160 reliable operation through 2040 is unlikely, no matter how thorough the UTA maintenance is.

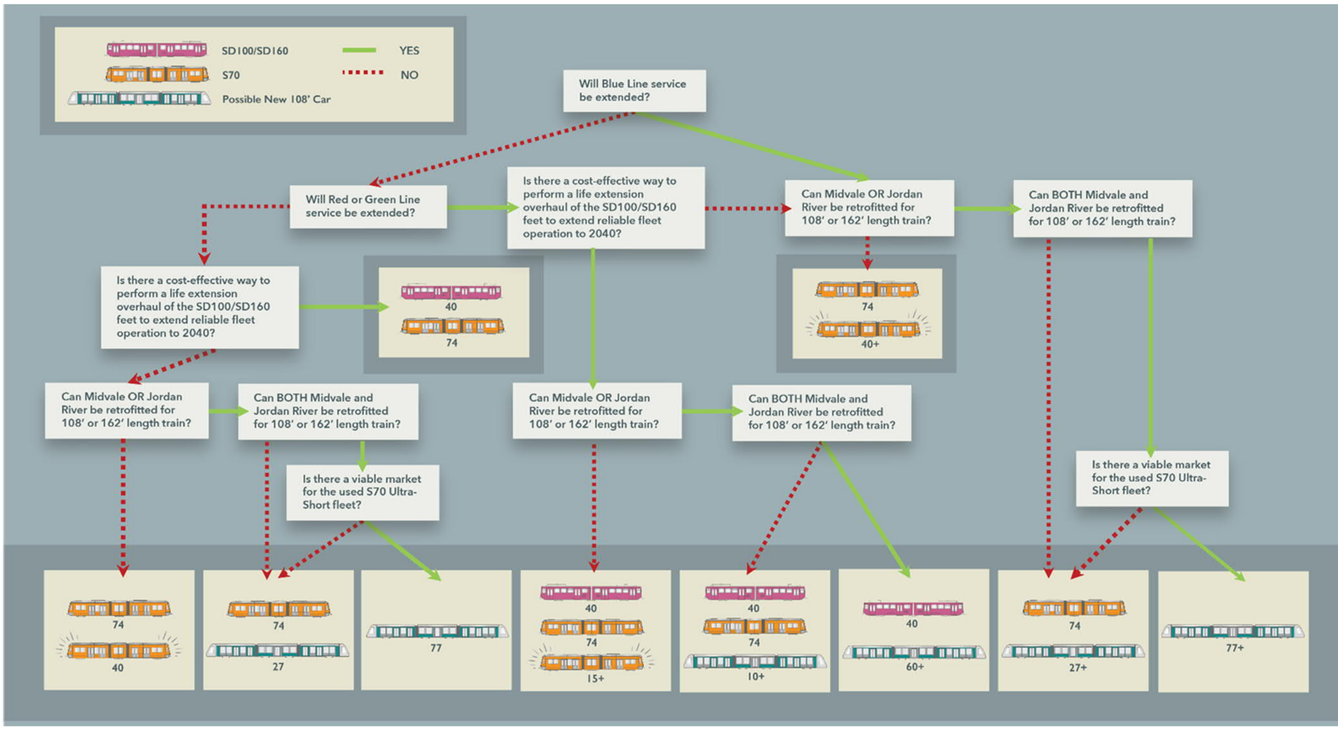

Figure 57 – Fleet Plan Decision Tree

The Fleet Plan chapter recommends the decision tree path that ends at the bottom box second from the left. This reflects retention of the existing S70 fleet and procurement of 27 longer cars (108 feet in length), replacing the capacity of the 40 shorter high floor cars to be retired. If, at the time of the procurement development, a robust secondary market for the S70 fleet is found, UTA should consider selling off the S70 fleet (except for the S70 streetcars needed for the S-Line) and procuring an entirely new, standardized fleet. This is represented by the bottom box, third from left. As discussed in the maintenance vehicle section of the chapter presenting the Fleet Plan, UTA should consider reassignment of the S70 fleet from Jordan River to Midvale upon retirement of SD100/SD160 fleet. This is because Jordan River appears to be more flexible with respect to accommodating longer car lengths; the 108-foot or 162-foot cars would be assigned there.

Ridership Analysis Results

The Phase 1 investigation found that a variety of factors in recent years contributed to TRAX's declining average daily ridership, several of which were potentially significant and also outside UTA's control: increases in regional household income, growing household access to private vehicles, and the perception of affordability of owning and operating those vehicles. UTA can pursue several strategies, alongside its regional agency and community partners, to build ridership and support for the light rail system, as outlined below.

Focus on Key Demographic Groups: Analysis conducted for this project suggests that Green Line ridership may be more resilient due to the concentration of low-income populations along the corridor, especially along North Temple in Salt Lake City. This analysis relied on GIS data provided by Wasatch Front Regional Council regarding Equity Focus Areas, which identifies geographic areas with higher than average concentrations of people with a number of characteristics, including low income and lack household access to a vehicle. The presence of low-income populations along the Green Line in Salt Lake City is likely one of many factors at play that are influencing ridership.

As a next step, UTA may consider conducting follow-up surveys or studies of ridership trends of people who are low income to better understand the client base that is sustaining ridership and the factors influencing their travel choices. UTA could also partner with WFRC to update the locations of these Equity Focus Areas, potentially using forthcoming 2020 Census data or other sources, and use this information to consider how transit service could be modified or expanded to better serve the communities that need it most.

Support Affordable Housing Initiatives: An informal review of rental housing conducted for this project revealed that many of the housing developments built around TRAX stations are not affordable for a considerable segment of the population. The project team sampled entry-level monthly rental rates for large-scale multifamily developments near a range of TRAX stations, and generally found that the average monthly rent (not including utilities) for a one-bedroom, one-bathroom apartment near TRAX was slightly over $1,000.

The U.S. Department of Housing and Urban Development has a long-established affordability index indicating that households should not spend more than 30% of their income on housing costs; a high-level review of the data suggests that in Salt Lake County nearly a third of households would be spending more 30% of their income on rent to afford a one-bedroom, one-bathroom apartment on TRAX, putting transit-adjacent housing outside the range of affordability for that segment of Salt Lake County's population. Ostensibly, these households could save on other costs by forgoing owning or leasing their own vehicle, and relying on transit for their primary mode of transportation. However, relatively few TRAX stations in the region contain the full range of land uses and services within a feasible walking distance in order for people to conveniently live car-free. Moreover, housing costs are higher for people with children or other dependents who need larger apartments, further increasing the percentage of their income that must be dedicated to housing.

While the analysis conducted for this project was high-level, it suggests an important phenomenon: people most likely to use transit may not be able to afford to live at TRAX stations, and they may be getting crowded out by wealthier households who like the lifestyle offered at these TOD areas but who are not regular TRAX riders. UTA may wish to conduct an extensive survey of the available housing within a specific distance of each TRAX station, associated rental rates, typical vacancies, the range of products available, and other factors. UTA may also wish to evaluate the potential for new affordable housing at TRAX stations and opportunities to partner with development groups in order to build affordable housing near TRAX. Proactively identifying places for additional affordable housing, and partnering with communities and developers to provide it, may help add new transit riders to the system while also improving quality of life for Salt Lake County residents.

Explore Fare Policy Options: Issues of cost and convenience deter some potential riders from using the UTA system. With a current one-way fare of $2.50 outside of the Free Fare Zone, TRAX customers pay the same price for a gallon of gas as they do for a ticket for half of their round trip. Transit studies have explored the potential relationship between removing fare payment and increased ridership and found that it may be substantial in changing travel behavior, and several transit agencies around the country have tested the concept. UTA has additionally tested the concept of transit without fare payment on the UVX bus rapid transit route in Utah County, which is believed to have contributed to opening day ridership that was significantly higher than projected. UTA has been looking at methods to make using transit more affordable. Recent efforts include a pilot program to distribute discounted passes to public schools, nonprofits and other community organizations, so that they can provide them to their low-income clients. Another proposed program would allow low-income persons to apply for discounted fare cards. UTA may wish to explore options for expansion of reduced or no fares at all times. UTA may wish to partner with agencies such as UDOT on additional funding for low-fare or transit without fares incentives; the state transportation agency is likely well aware that transit will need to be an increasing part of the transportation solution as the region continues to grow, and the agencies may be able to work together to consider ways to shift more travel off roadways and onto transit.

Consider the Role of Parking: Parking policy in urban centers can deter transit use. In downtown Salt Lake City, visitors can often find affordable and accessible parking relatively easily, sometimes completely free of charge within a short walking distance of their destination. The convenience of cheap parking can discourage people from taking transit into the heart of the City, whether for work, recreational, entertainment, shopping, or other purposes. WFRC is currently leading a parking study which may provide additional guidance on revised downtown parking policies that better serve the region, including supporting transit ridership.

Provide Additional Focus on Non-Commute Trips: Transportation planning analysis is often focused on the morning and evening peak commute patterns and how to best serve people traveling to and from work. However, as shown in the *2017 National Household Travel Survey*, work commute represents less than 20% of total household trips. Travelers have a range of needs that could be met by transit, occurring at all times of day and into the evening. Activity centers and special events rely on late-night transit to serve entertainment venues, restaurants, nightlife, and other activities where parking may be limited or driving is not desired. Similarly, different parts of the population have different travel needs even during peak times, but outside the typical work/home trajectory: parents need to pick up kids from school and child care, run errands, attend sports practices, etc. Some of these trips might be served via transit if those needs are better understood.

UTA may wish to study those needs further and respond by expanding the span of service between key destinations and proactively working with communities to ensure that a transit oriented “fifteen minute neighborhood” that serves a household’s basic daily needs can be found around more TRAX stations. If more stations areas, particularly in the more suburban parts of the network, can be converted from parking lots that are difficult to access without an automobile to walkable centers containing a variety of work, shopping, and residential attractions, these locations may see increased ridership – and potential development -- as destinations for a variety of purposes.

Appendices

Appendix A – Operations and Maintenance Cost Estimating Methodology

Introduction

This appendix provides an Operations and Maintenance (O&M) cost estimating methodology for use in conjunction with Phase 2 of the Future of Light Rail planning project. O&M costs of the various alternatives will play a large role in determining the feasibility of new and altered service patterns. Unit costs for use in developing O&M costs are presented in the methodology, as well as the basis for unit cost development and the recommended simplified method for computing O&M costs for alternatives considered during the project.

Methodology Scope

The UTA cost data that were reviewed to develop this methodology included labor, vehicle miles, and traction power data from 2019. The methodology as currently written is valid for study alternatives that would implement new LRT or streetcar lines or extensions and system improvement alternatives. However, the study may need to project cost estimates to future years in regard to inflation to develop O&M costs for projects in the future.

Basis of Cost Estimating Methodology

The basis and organization of the methodology uses standard industry cost units and information from UTA's recent O&M costs. Actual labor costs, vehicle data, and traction power costs from 2019 were reviewed to inform unit costs. The available cost information was projected to 2020, then the values were averaged and rounded to appropriate planning level of detail.

Cost Units

LRT O&M cost estimates are based on existing TRAX and streetcar service costs. Major cost drivers include operations labor costs (operators and supervisors), vehicle maintenance (electromechanics and service employees), and Maintenance-of-Way (MOW) including line and signal technicians and traction power costs.

Each of these units is assigned a specific value based on the UTA O&M data from 2019. The cost of each unit is then multiplied by the number of employees required for the service

Other costs and supplies are added to the operations costs, vehicle miles are added to the vehicle maintenance costs, and additional parts and maintenance are added to the MOW costs by project for an annual total cost estimate. These additional costs vary by project and take into consideration hours of service per day and trips per direction per day, which are then multiplied by the traction cost per mile in addition to the Light Rail Vehicle (LRV) cost per mile.

The hours of service per day and trips per direction per day is an estimate that can be calculated based on current service, using existing miles and schedule times, or a more sophisticated rail simulation model. The results of this service plan will include the total vehicle miles, operating hours, and required LRVs to run the service.

Additional Labor Costs

An amount of fringe is added to each labor cost to include employee benefits, training and development, and leave and extra board operators. For this methodology, 47.85% is assumed for fringe to bring the total labor cost to include fully allocated costs.

Traction Power Costs

Traction power costs are developed for this study based on the sum of each UTA substation electricity cost and then divided by the annual LRV mileage. The substation electricity cost and LRV mileage data used is from 2019. This methodology assumes a cost per mile of $0.87 for traction power.

Development of Cost Estimates

A standard spreadsheet will be developed that includes all of the categories and unit costs discussed in the Basis of Cost Estimating Methodology, before estimating begins. The spreadsheet will be used to ensure a standard approach and boost the efficiency in the estimate development.

Costs by Unit

The following tables show the costs assumed for each unit for this methodology. Table 60 shows the annual costs assumed for each employee position. Table 61 shows the LRV unit costs assumed, based on 2019 UTA data.

Table 60 – Labor Unit Cost Assumptions

Employee Position	Estimated Annual Salary	Fully Allocated Annual Cost (47.85% fringe)
Service Employees	$43,000	$63,576
Operators	$48,000	$70,968
Supervisors	$57,000	$84,275
Vehicle Electromechanics	$57,000	$84,275
Line and Signal Techs	$60,000	$88,710

Table 61 – LRV Unit Cost Assumptions

Item	Cost Per Mile
Traction Power Costs	$0.87
LRV Maintenance Cost Per Mile	$1.75

Example of Methodology

The Orange Line concept is presented as an example for using the O&M methodology to estimate the cost of a new service. The Orange Line is a proposed new service that would run between the Salt Lake City International Airport and the University of Utah Medical Center.

After the service plan is formed, which estimates the mileage, LRVs needed, and operating hours, this information is used to develop LRV maintenance and traction power cost estimates. Table 62 shows the weekday estimates and Table 63 shows the weekend and holiday estimates. Table 64 shows the total annual LRV maintenance and traction power cost estimates.

Table 62 – Weekday Orange Line LRV and Traction Power Cost Estimates					
Train and LRV Miles Per Day	**Hours of Service Per Day**	**Trips per direction per weekday**	**Total Trips per day (both directions)**	**One-way train miles per day**	**One-way LRV miles per day**
Airport to Medical	20	77*	154	1822	3644

Item	Cost Per Mile	Cost Per Weekday	Weekdays Per Year	Est. Annual TP Costs
Traction Power Costs	$0.87	$3,170	247	$782,982
LRV Maintenance Cost Per Mile	$1.75	$6,376	247	$1,574,963.39

*7 trips in each direction are to/from yard

Table 63 – Weekend and Holiday Orange Line LRV and Traction Power Cost Estimates					
Train and LRV Miles Per Day	**Hours of Service Per Day**	**Trips per direction per day (Sat/Sun)**	**Total Trips per day (both directions)**	**One-way train miles per day**	**One-way LRV miles per day**
Airport to Medical	20	56*	112	1325	2650

Item	Cost Per Mile	Cost Per Day (Sat/Sun)	Sat & Sun Per Year	Est. Annual TP Costs
Traction Power Costs	$0.87	$ 2,305	105	$242,070
LRV Maintenance Cost Per Mile	$1.75	$4,637	105	$486,922.80

*5 trips in each direction are to/from yard

Table 64 – Total Annual LRV and Traction Power Cost Estimates	
Traction Power Costs	**Est. Annual TP Costs**
Airport to Medical	$1,025,052

LRV Maintenance Costs	**Est Ann VM Costs**
Airport to Medical	$2,061,886

Table 65 shows the cost estimate by unit for operations, LRV maintenance, and MOW. This includes both labor and other parts and supplies. For the operations costs, the other costs and supplies includes equipment supplies, fuel, computers, etc. For the LRV maintenance costs, the LRV maintenance cost per mile per year includes parts for 16 additional LRVs (estimated at $92,000 per vehicle per year). The MOW additional parts and maintenance includes OCS parts, gates, inspections, replacement special trackwork components and fuel.

Table 65 – Orange Line Cost Estimate by Unit

Operations	**No. Additional**	**Est. Salary**	**Fully Alloc. Annual cost (47.85% fringe)**	**Annual Total Costs**
Operators	24	$48,000	$70,968	$1,703,232
Supervisors	4	$57,000	$84,275	$337,098
Other Costs/Supplies				$75,000
Total				**$2,115,330**
LRV Maintenance	**No. Additional**	**Est. Fully Allocated Costs**	**Fully Alloc. Annual cost (47.85% fringe)**	**Annual Total Costs**
Electromechanics	8	$57,000	$84,275	$674,196
Service Employees	6	$43,000	$63,576	$381,453
LRV Maintenance Cost Per Mile Per Year				$2,061,886
Total				**$3,117,535**
MOW	**No. Additional**	**Est. Annual Labor Costs**	**Fully Alloc. Annual cost (47.85% fringe)**	**Annual Total Costs**
Line and Signal Techs	3	$60,000	$88,710	$266,130.00
Traction Power Cost Per Year				$1,025,052
Additional Parts and Maintenance				$150,000
Total				**$1,441,182**

The total costs of operations, LRV maintenance, and MOW are then added for a total annual cost, as shown in Table 66.

Table 66 – Orange Line Cost Estimate Summary

	Scope of Service	**Operations**	**Vehicle Maintenance**	**MOW**	**Total Annual Cost**
From Medical Center to Airport	5am-11pm M-F; 6am-11pm Sa-Su	$2,115,330	$3,117,535	$1,441,182	$6,674,047

Table 67 – 2019 Direct and Total Allocated Light Rail Expense						
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**
Direct Light Rail Expense	$4,417,883	$4,246,307	$4,481,964	$4,030,578	$4,493,714	$3,499,317
Total Allocated Light Rail Expense	$6,578,689	$6,202,071	$6,866,962	$6,363,367	$6,732,932	$5,429,821

	Aug	**Sep**	**Oct**	**Nov**	**Dec**	**YTD**
Direct Light Rail Expense	$4,402,523	$4,652,967	$3,842,654	$4,054,307	$3,325,620	**$49,951,894**
Total Allocated Light Rail Expense	$6,358,453	$6,686,470	$6,230,409	$6,279,976	$5,757,210	**$76,209,725**

Referring to the annual totals in Table 67 provided by UTA Finance, this shows an overhead rate of 52.6%. In other words, the consultant team will utilize the UTA-provided pure light rail operating costs and multiply them by 1.526 in order to compute an "all in" operating cost with business unit and authority overhead costs reflected.

Conclusions and Limitations

The planning-level O&M cost estimates that will be developed in Phase 2 of the study using this methodology are conceptual in nature and are based on limited current data. These estimates are primarily for comparative purposes to determine the feasibility of the alternatives and establish long-range plan recommendations. As more detailed design and analysis occur during future phases of each project, the planning-level O&M cost estimates should be reviewed and refined.

Appendix B – Study Capital Cost Estimating Methodology

This appendix provides a brief planning-level capital cost estimating methodology used for the Future of Light Rail planning. As part of Phase 2 of the study, capital costs of the various alternatives will play a large role in determining their feasibility. Unit costs for use in developing capital costs are presented in the methodology, as well as the basis for unit cost development and the recommended simplified method for computing capital costs for alternatives considered during the project. The methodology addresses both infrastructure and fleet capital costs.

The planning-level capital cost estimates for the study are conceptual in nature and are based on limited engineering data. These estimates are primarily for comparative purposes to determine the feasibility of the alternatives and establish long-range plan recommendations. As more detailed design and analysis occur during future phases of each project, the planning-level capital cost estimates should be reviewed and refined.

Methodology Scope

The UTA historical project cost data that were reviewed to develop this methodology were largely limited to new LRT line construction. For this reason, the methodology as currently written is valid for study alternatives that would construct new LRT or streetcar lines or extensions. For the system improvement alternatives, the general procedure for developing the cost estimates can be used. However, the study will need to consult with UTA and consultant team systems engineers to develop order-of-magnitude cost estimates for such site-specific improvements.

Basis of Cost Estimating Methodology

The basis and organization of the estimating methodology is described below. For infrastructure unit costs, the methodology is organized using standard industry cost categories and information regarding UTA's historical project costs. Actual construction cost data from the Mid Jordan, West Valley, and Airport TRAX lines were reviewed to inform the unit costs presented in Table 68. The available cost information was escalated to 2020 from the year of each project completion, then the values were averaged and rounding to appropriate planning level of detail.

For UTA fleet unit costs, three different fleet cost estimating strategies were used, with the recommended fleet capital cost estimates reflecting a blend of the results of all three. These three strategies start with a database showing dozens of examples of the actual costs of purchasing similar types of fleets both domestic and international fleet purchase, covering experience within the industry over the past 20 years. The first approach is an initial examination of recent North American procurements of similar vehicle types, only adjusting to address escalation. The second approach builds up the cost estimates in more detail based on the direct comparison of manufacturing costs while the third approach provides further refinement to the more general second approach 2. The fleet unit costs developed under each of these three approaches are combined to provide a single capital cost per vehicle, using a straightforward averaging of the three cost estimates.

Cost Categories

The costs will be organized into categories consistent with the Federal Transit Authority (FTA) Standard Cost Categories (SCC). Sub-categories for major project quantities are described later in Section 0, Unit Costs. The sub-category unit costs will be used with conceptual-level quantities to generate a total estimate for each alternative. The major cost categories are:

+ SCC 10: Guideway and Track Elements
+ SCC 20: Stations, Stops, Terminals, Intermodal
+ SCC 30: Support Facilities: Yards, Shops, Administration Buildings
+ SCC 40: Sitework and Special Conditions
+ SCC 50: Systems
+ SCC 60: Right of Way, Land, Existing Improvements
+ SCC 70: Vehicles
+ SCC 80: Professional Services
+ SCC 90: Unallocated Contingency
+ SCC 100: Finance Charges

Capital costs for the first seven categories (SCC 10–70) will be calculated by using unit costs and estimated quantities for each identified sub-category. System-wide costs and allowances will be calculated based on route length. A per-track-foot unit cost developed from historical costs is proposed for such allowances. SCC 80–90 will be calculated as a percentage of construction costs, excluding vehicle procurement. SCC 100 would include finance charges incurred to complete the project. In the current methodology, finance charges are not included in the planning-level estimates.

Unit Costs

Unit costs for this methodology were calculated using historical SCC costs from previous UTA LRT and streetcar projects. No distinction is made between LRT and streetcar for SCC 10–60 because the infrastructure of the two systems is substantially the same.

Quantifiable Infrastructure Components (SCC 10–60)

Detailed quantity calculations will not be performed in the planning-level cost estimates. Therefore, unit costs were estimated for the major SCC sub-categories using UTA historical project SCC costs. The quantity units for these sub-category costs are *track-feet* or *route-miles* for linear elements such as guideway systems and *each* for discrete components such as stations or maintenance facilities. Before the cost estimates can be generated, the quantity of each sub-category considered in the methodology will need to be estimated for each alternative. The sub-categories that will be quantified for use in the cost estimates and their associated unit costs are listed in Table 68 below.

Some item unit costs are listed as to be determined (TBD). These are items whose cost will depend heavily on which alternatives are being considered or items that cannot be considered at this planning level of design. Costs for items marked TBD will be revisited when alternatives are selected for estimating, and the table will be revised at that time, if required. If items marked TBD cannot be considered, the unallocated contingency will be adjusted to ensure that it accounts for items that cannot be estimated.

Table 68 – Sub-categories and Unit Costs for Use in Planning-level Cost Estimates		
Sub-Category	**Unit**	**Unit Cost (2020 $)**
10 GUIDEWAY AND TRACK ELEMENTS		
10.01 – Guideway: At-grade Exclusive ROW	Route-miles	680,000
10.02 – Guideway: At-grade Semi-exclusive (Cross-traffic)	Route-miles	1,250,000
10.03 – Guideway: At-grade in Mixed Traffic	Route-miles	1,750,000
10.04 – Guideway: Aerial Structure	Route-feet	22,000
10.05 – Guideway: Build Up Fill	Route-miles	1,500,000
10.08 – Guideway: Retained Cut or Fill	Route-miles	1,100,000
10.09 – Track: Direct Fixation	Route-miles	4,000,000
10.10 – Track: Embedded	Route-miles	5,750,000
10.11 – Track: Ballasted	Route-miles	2,650,000
10.12 – Track: Special (Switches, Turnouts)	Each	35,000
10.13 – Track: Vibration and Noise Dampening	Route-miles	90,000
20 STATIONS, STOPS, TERMINALS, INTERMODAL		
20.01 – At-grade Station, Stop, Shelter, Platform	Each	1,150,000
20.06 – Automobile Parking Multi-story Structure	Each	1,500,000
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMINISTRATION BUILDINGS		
30.01 – Administration Building: Office, Sales, Storage	Each	TBD
30.03 – Heavy Maintenance Facility	Each	490,000
30.05 – Yard and Yard Track	Each	625,000
40 SITEWORK AND SPECIAL CONDITIONS		
40.01 – Demolition, Clearing, Earthwork	Route-miles	500,000
40.02 – Site Utilities, Utility Relocation	Route-miles	2,250,000
40.03 – Hazardous Materials	Route-miles	65,000
40.04 – Environmental Mitigation	Lump sum	TBD
40.05 – Site Structures Including Retaining Walls, Sound Walls	Route-miles	TBD
40.06 – Pedestrian/Bike Access and Accommodation	Lump sum	TBD
40.07 – Roadways, Park-and-Ride Lots	Each	TBD
40.08 – Temporary Facilities and Other Indirect Costs	Lump sum	8,500,000
50 SYSTEMS		
50.01 – Train Control and Signals	Route-miles	3,100,000
50.02 – Traffic Signals and Crossing Protection	Route-miles	600,000
50.03 – Traction Power Supply: Substation	Route-miles	1,850,000
50.04 – Traction Power Distribution: Catenary and Third Rail	Route-miles	2,500,000
50.05 – Communication	Route-miles	1,100,000
50.06 – Fare Collection System and Equipment	Each	200,000
50.07 – Central Control	Each	100,000

Table 68 – Sub-categories and Unit Costs for Use in Planning-level Cost Estimates		
Sub-Category	**Unit**	**Unit Cost (2020 $)**
60 RIGHT OF WAY, LAND, EXISTING IMPROVEMENTS		
60.01 – Purchase or Lease of Real Estate	Route-miles	TBD
60.02 – Relocation of Existing Households and Businesses	Each	TBD
70 VEHICLES		
`	Each	TBD – Refer to Chapter 3
70.01.02 – Streetcars	Each	TBD – Refer to Chapter 3
70.02 – Vehicle Spare Parts	Each	Included in above unit costs

Professional Services (SCC 80)

This category includes costs for engineering, administration, and construction management services. These costs will be estimated using a percentage of all total direct capital costs except vehicles and right of way (sum of SCC 10–50). Table 69 shows the percentages that are used in this methodology.

Table 69 – Percentages for Calculation of Professional Services Costs	
Professional Services Sub-category	**Percentage of Capital Costs SCC 10–50**
80.01 – Preliminary Engineering	3%
80.02 – Final Design	7%
80.03 – Project Management for Design and Construction	5%
80.04 – Construction Administration and Management	6%
80.05 – Insurance	3%
80.06 – Legal, Permits, Review Fees	2%
80.07 – Survey, Testing, Investigation, Inspection	2%
80.08 – Start-up Costs	2%
Total	**30%**

Contingency

Contingencies are used in an estimate to account for quantity uncertainty due to the current level of engineering. At the current planning level, contingencies are relatively high. The contingencies to be used for the estimates in this project are described below.

Allocated Contingencies

These contingencies vary by quantity. The allocated contingencies are applied line by line to each of the sub-categories in cost categories 10–70 identified in this methodology. The contingencies vary and were selected based on experience and engineering judgment regarding the potential variability of costs in each sub-category. Table 70 shows the allocated contingencies to be applied to costs in each category.

Table 70 – Allocated Contingency by Standard Cost Category

Cost Category	Allocated Contingency
SCC 10: Guideway and Track Elements	30%
SCC 20: Stations, Stops, Terminals, Intermodal	30%
SCC 30: Support Facilities: Yards, Shops, Administration Buildings	30%
SCC 40: Sitework and Special Conditions	30%
SCC 50: Systems	30%
SCC 60: Right of Way, Land, Existing Improvements	30%
SCC 70: Vehicles	10%

Unallocated Contingencies

The unallocated contingency is entered under SCC 90. It is a flat percentage applied to the overall estimate to account for project unknowns and unquantifiable items at the planning level of analysis. This methodology uses 30% as the unallocated contingency.

Escalation

To accurately plan and budget for projects with varying time horizons, capital cost estimates must be appropriately escalated. Escalation attempts to account for inflation and increase in the cost of construction, materials, and labor over time. Typically, an annual escalation factor is chosen for planning purposes. The factor is used to escalate to project estimates developed in the present to a future year of expenditure (YoE). In this cost estimate methodology, YoE is the year of the anticipated midpoint of project construction. The year of estimating is the current year (2020).

A standard annual escalation rate used in planning-level cost estimates in the transit industry is 3.5%; however, actual escalation can vary significantly when the planning horizon is more than 5 years. Different materials and labor increase in cost at different rates. Depending on the share of each material and labor in a given alternative, the escalation might be significantly more or less than 3.5% per year.

Development of Vehicles Unit Costs

To determine fleet unit costs, three different fleet cost estimating strategies will be used, with the recommended fleet capital cost estimates reflecting a blend of the results of all three. These three strategies start with a database showing dozens of examples of the actual costs of purchasing similar types of fleets both domestic and international fleet purchase, covering experience within the industry over the past 20 years.

Fleet Requirement

The fleet requirement by vehicle type and the projected overall size of the fleet are the two most important inputs to the fleet capital cost estimating process. Unlike many other classes of capital cost estimates, unit costs (e.g., cost per LRV) are highly dependent on the quantity of individual vehicles (streetcars, LRVs etc.) being purchased at any one time and the eventual overall size of the required fleet to be purchased.

The required size of an operation's fleet also includes a spare factor (or spare margin), defined as the percentage of the overall fleet not required to provide peak service delivery. For example, if a service plan required 45 train sets to handle peak period service, a spare factor of 10% would result in an overall fleet size of 50 – the 45 required to provide the peak period service and 5 extra to be used in case of breakdown, servicing, etc. Although there are variations within the industry with respect to how the spare margin is computed, UTA consistently defines the spare margin as a percentage of total fleet. The Future of Light Rail Study considers any standby or "protect" trains to be spares rather than part of the fleet required for peak service delivery. As with the methodology for computing the size of the spare factor, there are differences across the industry. North American light rail and streetcar spare factors, which range from 10 to 50%, depend on:

+ Reliability of the specific vehicle type, with more reliable vehicles requiring a lower spare factor,
+ Age of the specific vehicle type, with some newly-opened rail systems operating on a provisional basis with spare factors of less than 10% until initial heavy maintenance work is required,
+ Number of in-service vehicles of the specific vehicle type, with larger quantities requiring a lower spare factor

Data Sources

Hatch LTK employs a market-based methodology for estimating rail vehicle capital costs, relying on its proprietary vehicle pricing database. If appropriate data are not available for a specific fleet procurement, external databases including the American Public Transportation Association (APTA) equipment directory are used. Labor costs for vehicle engineering, project management and production cost elements of fleet capital costs are typically estimated using standard industry rates for fleet manufacturers.

Labor and Material Escalation

Escalation is added to the historical vehicle prices using an economic price adjustment formula that considers material, labor, fixed costs and exchange rate impacts using data from the U.S. Bureau of Labor Statistics (BLS) and historical currency exchange data from Olsen and Associates (OANDA). Material indices are shown below in Table 57 and Table 58. Table 71 displays escalation values for the last 22 years; the 1995 index value of 100 has increased to 147.55 in 2017, or a compounded annual increase of about 1.8 %. Currency (exchange rate) adjustments are required for all fleet acquisitions, though the percentage of the total fleet cost subject to adjustments will vary. Although some of the UTA's fleet acquisitions will be subject to federal "Buy America" requirements (because federal funding is part of the fleet acquisition), currency exchange adjustments are required for these compliant purchases because some vehicle components are purchased from non-U.S. markets. About 30% of "Buy America" compliant fleet costs are subject to current adjustments; higher percentages apply to fleet costs not subject to FTA "Buy America" requirements.

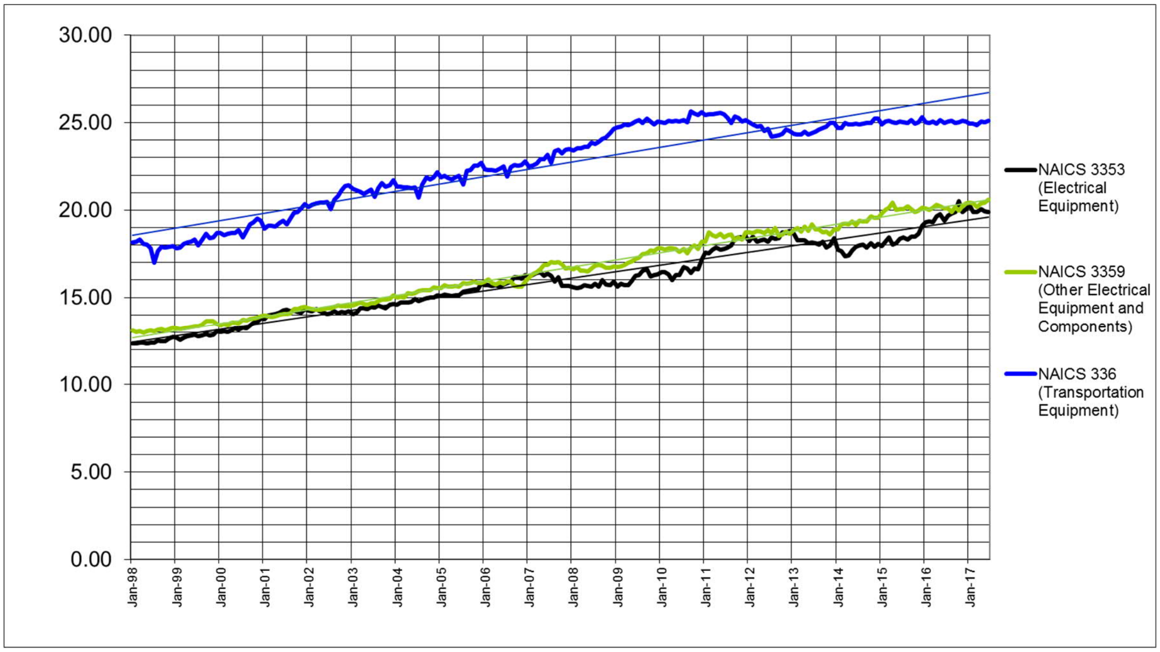

Figure 58– NAICS Indices for Electrical & Transportation Equipment

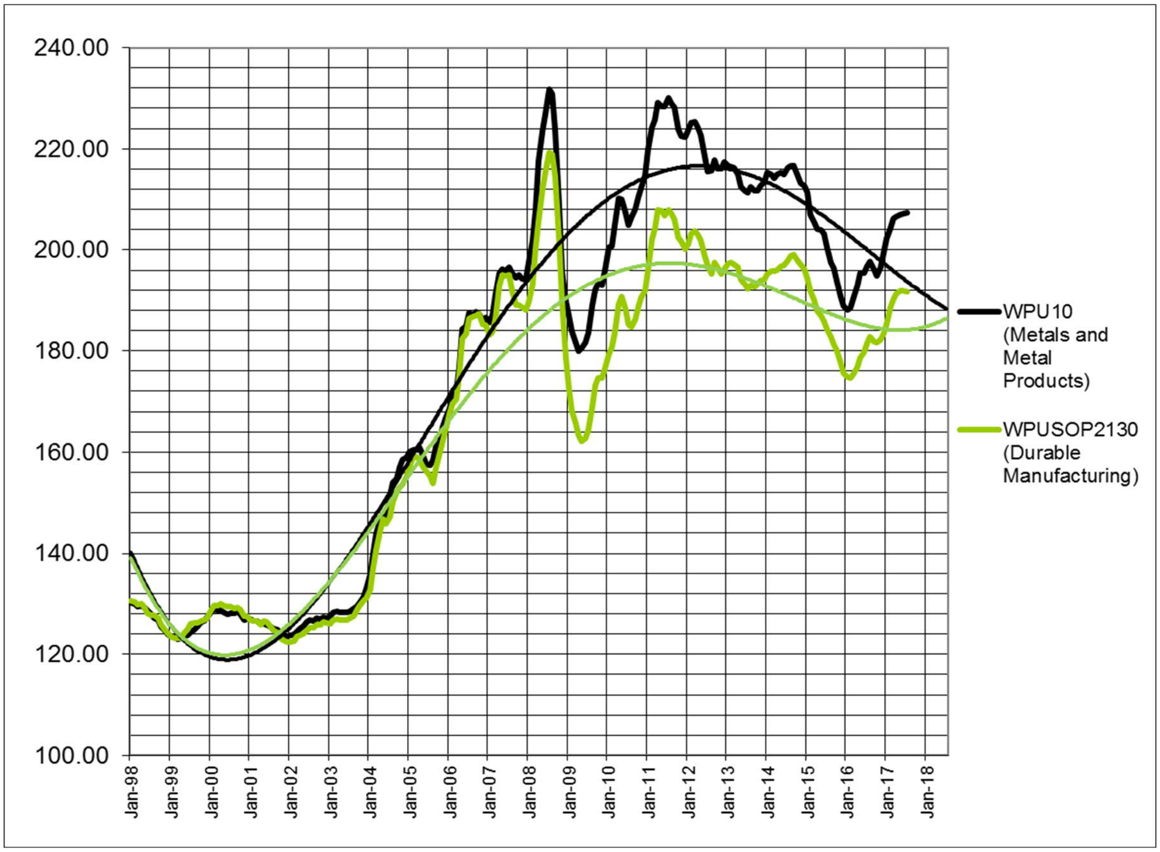

Figure 59 – WPU Indices for Metals & Manufacturing

Table 71 – Typical Vehicle Labor and Material Escalation 1995-2020						
	Labor			Material		
Index	**NAICS 3353**	**NAICS 3359**	**NAICS 336**	**WPU 10**	**WPUSOP2130**	
Percentage of Category	**41.5%**	**8.5%**	**50.0%**	**50.0%**	**50.0%**	
Overall Percentage	**16.6%**	**3.4%**	**20.0%**	**25.0%**	**25.0%**	**Summary:**
1995	11.02	11.86	17.21	134.50	135.60	73.20
1996	11.47	12.45	17.66	131.00	131.30	71.43
1997	12.10	12.90	17.99	131.80	132.80	72.20
1998	12.46	13.10	17.90	127.77	127.99	70.03
1999	12.80	13.39	18.24	124.63	125.09	68.66
2000	13.28	13.64	18.89	128.04	129.03	70.72
2001	14.14	14.13	19.48	125.39	125.13	69.35
2002	14.18	14.42	20.63	125.93	124.67	69.62
2003	14.40	14.76	21.22	129.23	127.88	71.42
2004	14.85	15.29	21.48	149.63	146.61	81.34
2005	15.30	15.74	22.08	160.80	158.31	87.27
2006	15.89	15.83	22.41	181.63	180.54	98.20
2007	16.11	16.72	23.03	193.47	189.80	103.67
2008	15.71	16.69	23.88	213.03	203.27	112.02
2009	16.11	17.26	24.98	186.81	168.93	97.19
2010	16.51	17.82	25.23	207.60	186.58	106.93
2011	17.99	18.51	25.34	225.94	204.18	116.21
2012	18.43	18.73	24.57	219.85	199.13	113.35
2013	18.20	18.87	24.56	213.50	194.58	110.59
2014	17.81	19.32	24.95	215.03	196.99	111.61
2015	18.38	20.07	25.05	200.26	184.88	105.03
2016	19.72	20.14	25.06	194.35	179.43	102.42
2017	20.22	20.54	25.36	207.80	191.68	109.00
2018	**20.73**	**21.40**	**26.31**	**223.60**	**206.30**	**116.90**
2019	**20.10**	**21.64**	**27.14**	**221.26**	**202.48**	**115.43**
2020	**20.56**	**21.23**	**27.96**	**218.58**	**195.45**	**113.23**

Source: U.S. Bureau of Labor Statistics (BLS)

Currency Escalation

When escalating historical car prices to the present, a foreign exchange (currency escalation) factor must be included. For the purpose of UTA fleet capital costs, it is assumed that the vehicles are subject to the Federal Transit Administration's (FTA) "Buy America" requirements and that foreign content, to which the foreign exchange factor applies, constitute 30% of overall fleet cost. The current FTA "Buy America" regulations require that all rolling stock purchased with Federal (FTA) funding have a minimum domestic content of 70%. Therefore, a maximum of 30% is international content and this "worst case" percentage is subject to currency escalation. Four different currencies are typically considered in this analysis (Euro, Canadian Dollar, Japanese Yen and Korean Won). These represent the home countries of the most likely bidders for LIRR fleet additions and replacements.

Suppliers based in China have recently started to bid on projects in North America. However, because of their recent entry into the market and also because the Chinese Yuan has tended to closely track the dollar, the Yuan is not typically considered in this analysis. Currency exchange rate impacts on the historical prices vary depending upon the year the contract was originally signed, and the currency involved. displays these currency escalation factors, with the German Mark used to establish a benchmark for the Euro prior to 1998.

Table 72 – Currency Escalation Factors 1995-2020								
	Euro Index Average for Year	Escalation to 2020	Canadian Dollar Index Average for Year	Escalation to 2020	Japanese Yen Index Average for Year	Escalation to 2020	Korean Won Index Average for Year	Escalation to 2020
1995 (Avg.)	0.53105	-69.48%	1.37258	-0.30%	94.07659	-14.55%	771.36667	-59.53%
1996 (Avg.)	0.61274	-46.89%	1.36381	-0.95%	108.82624	0.97%	804.83238	-52.89%
1997 (Avg.)	0.82637	-8.92%	1.38488	0.59%	121.04493	10.97%	953.99904	-28.99%
1998 (Avg.)	0.85388	-5.41%	1.48363	7.20%	130.88462	17.66%	1402.11164	12.24%
1999 (Avg.)	0.93917	4.17%	1.48586	7.34%	113.80969	5.31%	1190.12959	-3.40%
2000 (Avg.)	1.08500	17.05%	1.48526	7.31%	107.86045	0.09%	1131.15811	-8.79%
2001 (Avg.)	1.11691	19.42%	1.54904	11.12%	121.55551	11.34%	1291.49918	4.72%
2002 (Avg.)	1.06106	15.17%	1.57021	12.32%	125.21937	13.94%	1249.79397	1.54%
2003 (Avg.)	0.88540	-1.65%	1.40697	2.15%	115.97995	7.08%	1194.54247	-3.01%
2004 (Avg.)	0.80510	-11.79%	1.30151	-5.78%	108.17451	0.38%	1150.90628	-6.92%
2005 (Avg.)	0.80453	-11.87%	1.21173	-13.62%	110.12445	2.14%	1027.59332	-19.75%
2006 (Avg.)	0.79703	-12.92%	1.34610	-2.28%	116.33664	7.37%	969.90155	-26.87%
2007 (Avg.)	0.73082	-23.16%	1.07440	-28.14%	117.81453	8.53%	935.26976	-31.57%
2008 (Avg.)	0.66744	-34.85%	1.03482	-33.04%	105.30564	-2.34%	1046.94259	-17.54%
2009 (Avg.)	0.71920	-25.15%	1.14130	-20.63%	93.63000	-15.10%	1273.70000	3.39%
2010 (Avg.)	0.75510	-19.20%	1.03040	-33.61%	87.82000	-22.71%	1153.54000	-6.68%
2011 (Avg.)	0.71780	-25.39%	0.98830	-39.31%	79.73000	-35.16%	1104.95000	-11.37%
2012 (Avg.)	0.77810	-15.67%	0.99960	-37.73%	79.78000	-35.08%	1123.07000	-9.57%
2013 (Avg.)	0.75320	-19.50%	1.02980	-33.69%	97.58000	-10.44%	1090.42000	-12.85%
2014 (Avg.)	0.75350	-19.45%	1.16430	-18.25%	121.42000	11.25%	1050.63000	-17.12%
2015 (Avg.)	0.89770	-0.26%	1.25010	-10.13%	121.00000	10.94%	1113.78000	-10.48%
2016 (Avg.)	0.89060	-1.06%	1.29575	-6.25%	106.00600	-1.66%	1144.48000	-7.52%
2017 (Avg.)	0.92944	3.16%	1.33517	-3.11%	112.63918	4.33%	1099.38430	-11.93%
2018 (Avg.)	0.87014	-3.44%	1.31428	-4.75%	112.16429	3.92%	1123.38098	-9.54%
2019 (Avg.)	0.89306	-0.78%	1.32676	-3.77%	109.01196	1.14%	1166.02960	-5.53%
2020 (Avg.)	0.91126	1.23%	1.36600	-0.79%	108.34792	0.54%	1153.75344	-6.66%

Required Level of Detail

The vehicle capital cost estimates are to be developed at a level of detail appropriate for a long-range planning study. For the UTA Future of Light Rail Study, vehicle capital cost estimates include all-in vehicle cost (e.g., the escalated average of recent comparable procurements as detailed below as Approach 1) rather than the considerably more detailed "built-up" approach more appropriate when evaluating actual vehicle supplier proposals.

Vehicle Capital Cost Estimating Methodology

Three separate approaches are utilized to develop an integrated, market-based unit cost for additions and replacements to the UTA fleet. Approach 1 is an initial straightforward examination of recent North American procurements of similar vehicle types, only adjusting to address escalation. Approach 2 builds up the cost estimates in more detail based on the direct comparison of manufacturing costs while Approach 3 provides further refinement to the more general Approach 2. As described below, the capital cost estimates developed under each of these three approaches are combined to provide a single capital cost per vehicle, using a straightforward averaging of the three cost estimates.

The three vehicle cost estimating approaches which are discussed further below use as their basis all available domestic and, where applicable, international vehicle prices for similar types of vehicles. Depending on the specific vehicle type being considered, this list has from 10 to 50 individual vehicle contract results to draw upon, spanning the last 20 years. When historical data are available for similar types of LRVs, Approaches 1 and 2 are employed. For relatively unique vehicles such as the 162-foot LRVs not presently in service in the U.S. market, all three approaches are used with a greater emphasis placed on the more detailed price build-ups (Approaches 2 and 3).

Approach 1: Escalated Average of Recent Procurements:

This approach is based on the average per vehicle cost of recent vehicle procurements, adjusted for inflation only. Included within this analysis are different vehicles under review in the Future of Light Rail Study, all of which have a variety of technical attributes such as vehicle length, seating capacity, maximum design speed and passenger amenities. This results in an order-of-magnitude cost estimate for the vehicles.

Approach 2: Contract Cost Build-Up Based on Recent Procurements:

This approach is based on a cost build-up analysis using the average estimated base manufacturing cost of each vehicle type from the same data sources used in Approach 1. The base manufacturing cost is the estimated recurring labor and material costs required to produce each vehicle.

The base manufacturing cost is calculated by backing out from each of the recent procurements the following estimated program-related non-recurring costs:

+ profit,
+ general and administration (G&A),
+ engineering,
+ production-related "learning curve" costs.

Profit and G&A percentages are set at the same rate for all of the procurements in order to normalize that portion of the fleet capital cost estimates while engineering and learning curve costs vary as discussed below.

Engineering is considered principally a fixed cost related to the complexity of the vehicle. In certain cases, the engineering cost of the procurement is known from internal documents. All other engineering costs are estimated based on the size of the procurement and the complexity and uniqueness of the design.

The first production vehicles will require more hours to build and assemble than later vehicles that are part of the same contract. These “learning curve” cost impacts affect the first five to 20 (or more) vehicles depending on the builder, the complexity and other factors. The estimated base manufacturing costs from earlier procurements are averaged in order to provide the base manufacturing cost used in a contract cost build-up for the vehicles. After calculating the base manufacturing cost, all estimated program-related costs including engineering (detailed in), production set-up/tooling costs, vehicle supplier profit, G&A expenses and learning curve impacts are then added to yield an estimated contract cost per vehicle.

Approach 3: Contract Cost Build-Up Based on the Recent Procurement of a Near-Compatible Vehicle:

This approach is similar to Approach 2 in that a base manufacturing cost is calculated and then used as the basis for a contract cost (bid price) build-up. While Approach 2 uses a base manufacturing, cost averaged over several projects, Approach 3 uses the specific manufacturing cost from a vehicle that is expected to be close or near-compatible to the proposed vehicles. The labor and material costs for any known design differences are added during the cost build-up. When the technical details of the proposed vehicles have only been defined at a conceptual level, no costs for specific technical variations will be included.

Non-Recurring Engineering Costs

The planned delivery schedule of the vehicles is taken into consideration when developing the non-recurring engineering costs, which are based on an estimated project schedule and on the vehicle development’s complexity. For a specific vehicle that has a long delivery schedule due to engineering and manufacturing complexities, the project management, testing and engineering support costs will be greater. Manpower loading (labor hours) by job title for this schedule are developed. Complex projects with significant amounts of development and documentation will require heavier loading than simpler projects that are closer to “off-the-shelf” production. Standard industry labor rates are used for each job title, as shown in Table 73. The estimated engineering costs are applied to the estimated rolling stock unit prices developed using Approach 2 and Approach 3.

Title	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Averages	Production Average (Base 2019-2020)
Table 73 – Assumed Labor Rates by Title and Year of Production															
Shop Labor	$90.00	$92.70	$95.48	$98.35	$101.30	$104.33	$107.46	$110.69	$114.01	$117.43	$120.95	$124.58	$128.32	$97.03	$96.91
Project Manager	$175.00	$180.25	$185.66	$191.23	$196.96	$202.87	$208.96	$215.23	$221.68	$228.34	$235.19	$242.24	$249.51	$188.66	$188.44
Project Engineer	$160.00	$164.80	$169.74	$174.84	$180.08	$185.48	$191.05	$196.78	$202.68	$208.76	$215.03	$221.48	$228.12	$172.49	$172.29
Field Electronic Technician	$90.00	$92.70	$95.48	$98.35	$101.30	$104.33	$107.46	$110.69	$114.01	$117.43	$120.95	$124.58	$128.32	$97.03	$96.91
Software and System Engineer	$155.00	$159.65	$164.44	$169.37	$174.45	$179.69	$185.08	$190.63	$196.35	$202.24	$208.31	$214.56	$220.99	$167.10	$166.91
Engineering	$140.00	$144.20	$148.53	$152.98	$157.57	$162.30	$167.17	$172.18	$177.35	$182.67	$188.15	$193.79	$199.61	$150.93	$150.75

Development of Vehicle Contract Cost Estimate

The three approaches outlined above are used to create an interim estimated vehicle contract cost. To create a single integrated vehicle contract cost estimate, the estimated costs from each approach listed above are typically averaged together at equal weighting to develop the contract cost estimate for each vehicle type. Greater weighting to Approach 2 and especially to Approach 3 is applied when the vehicle design in question is considerably different than what has recently been produced by any vehicle supplier. Approach 3 is dropped entirely early in the vehicle capital cost estimating process if little to no technical details of the vehicle configuration are known. For the UTA Future of Light Rail estimates, most of the estimates focused on Approaches 1 and 2.

A risk factor is then applied based on the complexity of the design and anticipated market conditions, among other factors. This factor tends to be higher for estimates early in the procurement cycle. As such, budgetary type capital cost estimates tend to have more margin than estimates that are based off of detailed technical specifications that are provided close to the time of contract award. This provides protection against changes in quantity or relatively minor technical changes that often occur during the planning and specification process. For the UTA Study estimates, a range of plus 10% and minus 5% is applied. Typically when the technical specifications have not yet been defined and the fleet capital cost estimates are based only on functional requirements, the plus 10% risk factor is added due to the uncertainty in the design as well as the timing of the procurement. The lower end of the range is only used when the market is on a clear downward trend from a pricing high.

Training, Spare Parts and Other Ancillary Costs

In addition to estimating vehicle capital costs by the procedure outlined above, related ancillary costs are added to the estimated vehicle unit prices. These include:

- Bonding
- Training and Manuals
- Spare Parts, Special Tools and Test Equipment

Bonding prices are estimated at a percentage of the base vehicle capital cost estimate. The percentage is developed from a review of recent peer public agency procurements.

Training and manual costs are determined by estimating the hours needed for both groups of activities and then adding necessary material costs for the documentation and deliverables required.

Spare parts, special tools and test equipment prices are developed from Hatch LTK's component and equipment price database.

Table 74 shows the recommended Future of Light Rail vehicle unit costs, defined in terms of present 81-foot car lengths and in terms of potential 108-foot and 162-foot car lengths. The longer car lengths are based on adjustments to the 81-foot car unit costs in terms of propulsion system/trucks, doors, HVAC, carbody and Non-Recurring Engineering.

Table 74 – UTA Light Rail Vehicle Unit Capital Costs			
Price Comparisons	**81' Car**	**162' Car**	**108' Car**
Assumed Fleet Size	60	30	45
Base Price S70	$3,987,292	$3,987,292	$3,987,292
Propulsion/Trucks	$0	$1,641,636	$695,818
Doors	$0	$138,647	$69,323
HVAC	$0	$214,981	$107,491
Carbody/Others	$0	$656,181	$218,727
Non-Recurring Engineering	$0	$1,126,634	$300,436
Total Unit Cost	$3,987,292	$7,765,371	$5,379,087
Fleet	$239,237,507	$232,961,126	$242,058,895
Total/Ft	**$49,226**	**$47,934**	**$49,806**
	Difference	*-3%*	*1%*

Development of Planning-level Estimates

The steps for developing each cost estimate for the UTA Future of Light Rail Study are shown below. A standard spreadsheet was developed that includes all of the categories and unit costs discussed in the Basis of Cost Estimating Methodology and Development of Vehicles Unit Costs sections. The spreadsheet is used to ensure a standard approach and boost efficiency in the estimate development.

1. Estimate quantities in each sub-category in Table 68 using the planning-level alternative description.
2. Multiply quantities by unit costs developed previously.
3. Apply allocated contingency to each computed cost per Table 70.
4. Determine YoE and escalate costs and allocated contingency using 3.5% per year.
5. Sum costs to determine subtotal.
6. Determine professional services costs as a percentage of subtotal per Table 69.
7. Determine right of way, land, and existing improvements costs.
8. Determine vehicles costs, including appropriate provisions for spare margin and for spare parts/training.
9. Apply unallocated contingency to subtotal and professional services costs.
10. Develop grand total for planning-level capital cost estimate.

Appendix C – Light Simulation Intersection Priorities

This appendix details the light rail intersection priorities for existing (2019) operations. The data was compiled by Hatch LTK Team member Avenue Consultants using queries of the applicable traffic signal controllers. As such, it represents "in service" conditions. The data is organized by time of day and includes Avenue Consultants' estimation of light rail probability of stopping at a given intersection, as well as estimated stopped time if the train does stop at the intersection.

The appendix uses a number of traffic engineering terms, which are defined below.

- ***Free***: Free signal operation is typical used for signals where is not important to coordinate the arrival of vehicles between signals or where traffic volumes are lighter. When running free the signal does not have a set time that each of the phases turn green but instead serves vehicles on more of a first come first served basis. Free operation typically benefits TRAX since there is no need to keep the signal in sync with the signals around it and priority for the TRAX line can be given more easily.
- ***Coordinated***: Traffic signals that are operating with coordination are set so that vehicles traveling in the coordinated direction(s) will arrive as the light green. Coordination is used to predetermine when phases will turn green and will prioritize the phases associated with the main movements. While coordination does not necessary delay TRAX, the signals that run coordination are more likely to have a heavy vehicle demand making the impacts of transit priority more severe.
- ***Peer-to-Peer***: At 400 South and Main St the signal uses programmed logic to keep the signal in sync with both West Temple and State St. While the signal is set to Free, this logic mimics a coordinated traffic signal.
- ***Preemption***: Several traffic signals use preemption in place of priority. With preemption the operations of the signal will be interrupted to allow the train to pass through the signal without stopping. Preemption is often used at more isolated traffic signals or locations where the trains are traveling at higher speeds. This type of logic has a more significant impact on the vehicle traffic at a signal than Priority logic.
- ***Max Extend*** : The maximum possible extension of the signal phases serving the trains that the traffic signal currently allows the trains to proceed through the signal without stopping.
- ***Max Early Green***: The maximum possible time that the traffic signal currently allows the phase associated with the trains to start early.
- ***Potential for Additional Priority*** : The assessment of the feasibility of increasing priority for light rail trains at the intersection based on an initial review of traffic signal settings. Many of the traffic signals were rated low due to the following factors:

  - At pedestrian crossings, an early green can often not be given since it would require prematurely ending the pedestrian phase,
  - Many of the signals already allow the maximum amount of early green time available (without reducing splits below 15 seconds) and have a substantial extension time, and

  - Some intersections, such as 700 East/400 South may be limited due to heavy vehicle traffic which already exceeds the intersection capacity. While heavy vehicle traffic may not preclude additional priority, it will make it difficult to avoid major impacts to the performance of the traffic signal.

- ***Estimated % Green Arrival*** : An estimate of how often the train will be able to arrive at the traffic signal and pass though without stopping assuming a random arrival. The determination of this estimate was based on the green time available for the train phases at the traffic signal and the cycle length, which is the sum of the time given to all movements.

- ***Estimated Ave Wait Time(s)***: An estimate of the average duration of a train stop at a traffic signal before proceeding. Trains that are able to pass though the signal without stopping would have a wait time of 0 and are not included in this average.

Signal ID	Intersection	Agency	Priority	Weekday Signal Operation	Potential for Additional Priority Based on Initial Review	UTA Assessment of Priority	Notes
Green Line (Airport to North Temple & 400 W)							
1213	2400 W & North Temple	SLC	Enabled	Free	Medium		
1214	2200 W & North Temple	SLC	Enabled	Free	Low		
1215	1950 W & North Temple	SLC	Enabled	Coordinated	Low		
1234	1900 W & North Temple (Ped Crossing)	SLC	Enabled	Coordinated	Low		
7086	Redwood Rd & North Temple	UDOT	Disabled	Coordinated	High	High	
1235	1540 W & North Temple (Ped Crossing)	SLC	Enabled	Coordinated	Low		
1216	1460 W & North Temple	SLC	Enabled	Coordinated	Low		
1236	1300 W & North Temple	SLC	Enabled	Free	Low		
1206	1200 W & North Temple	SLC	Enabled	Free	Low		
1237	1100 W & North Temple (Ped Crossing)	SLC	Enabled	Free	Low		
1217	1000 W & North Temple	SLC	Enabled	Free	Low		
1218	900 W & North Temple	SLC	Enabled	Free	Low		
1238	850 W & North Temple (Ped Crossing)	SLC	Enabled	Free	Low		
1219	800 W & North Temple	SLC	Enabled	Free	Low		
1220	600 W & North Temple	SLC	Preempt Enabled	Free			
1205	400 W & North Temple	SLC	Enabled	Free	Low		
1203	400 W & 50 N	SLC	Preempt Enabled	Free			
1014	South Temple & 400 W	SLC	Enabled	Free	Low		
Blue Line (Salt Lake Central to North Temple & 400 W)							
1178	300 S & 600 W	SLC	Enabled	Free	Medium		
1177	200 S & 600 W	SLC	Enabled	Free	Low	High	90 deg. turn location where TRAX was originally served after every traffic phase.

Table 75 – General Intersection Information

Table 75 – General Intersection Information							
Signal ID	**Intersection**	**Agency**	**Priority**	**Weekday Signal Operation**	**Potential for Additional Priority Based on Initial Review**	**UTA Assessment of Priority**	**Notes**
1157	200 S & 500 W	SLC	Enabled	Free	Low		
1016	200 S & 400 W	SLC	Enabled	Free	Low		
1015	100 S & 400 W	SLC	Enabled	Free	Low		
1014	South Temple & 400 W	SLC	Enabled	Free	Low		
Blue and Green Lines (North Temple & 400 W to 400 S & Main St)							
7126	300 W & South Temple	UDOT	Enabled	Coordinated	Low	Medium	Change to UTA High Priority if Orange Line service is implemented
1023	South Temple & 200 W	SLC	Enabled	Free	Low		
1149	150 W & South Temple (Ped Crossing)	SLC	Enabled	Free	Low		
1030	West Temple & South Temple	SLC	Enabled	Free	Low		
1036	50 W & South Temple (Ped Crossing)	SLC	Enabled	Free	Low		
1038	Main St & South Temple	SLC	Enabled	Free	Low		
1039	50 S & Main St (Ped Crossing)	SLC	Enabled	Free	Low		
1040	100 S & Main St	SLC	Enabled	Free	Low		
1041	150 S & Main St (Ped Crossing)	SLC	Enabled	Free	Low		
1042	200 S & Main St	SLC	Enabled	Free	Low		
1043	250 S & Main St (Ped Crossing)	SLC	Enabled	Free	Low		
1044	300 S & Main St	SLC	Enabled	Free	Low		
1147	350 S & Main St (Ped Crossing)	SLC	Enabled	Free	Low		
7243	400 S & Main St	UDOT	Enabled	Peer-to-Peer	Low	High	May not be an issue of traffic signal controller but rather better connectivity between ATMS and Main Street Interlocking calls
Red Line (University Medical Center to 400 S & Main St)							
7044	Wasatch Dr & Mario Capecchi Dr	UDOT	Preempt Enabled	Free			

Table 75 – General Intersection Information							
Signal ID	**Intersection**	**Agency**	**Priority**	**Weekday Signal Operation**	**Potential for Additional Priority Based on Initial Review**	**UTA Assessment of Priority**	**Notes**
7043	South Campus Dr & Mario Capecchi Dr	UDOT	Enabled	Free	Low		
7042	South Campus Dr & 1800 E	UDOT	Enabled	Free	Low		
7041	South Campus Dr & 1725 E	UDOT	Enabled	Free	Low		
7040	South Campus Dr & 1550 E (Ped Crossing)	UDOT	Enabled	Free	Low		
7039	South Campus Dr & 1500 E	UDOT	Enabled	Free	Low		
7224	500 S & 1300 E	UDOT	Enabled	Coordinated (AM/PM) Free (Off-peak)	Medium		
7253	500 S & 1100 E	UDOT	Enabled	Free	Medium		
7250	400 S & 900 E	UDOT	Enabled	Coordinated	Low	High	
7249	400 S & 800 E	UDOT	Enabled	Coordinated	Low		
7180	400 S & 700 E	UDOT	Enabled	Coordinated	Low	High	
7248	400 S & 600 E	UDOT	Enabled	Coordinated	Low		
7247	400 S & 500 E	UDOT	Enabled	Coordinated	Low		
7246	400 S & 400 E	UDOT	Enabled	Coordinated	Low		
7245	400 S & 300 E	UDOT	Enabled	Coordinated	Low		
7244	400 S & 200 E	UDOT	Enabled	Coordinated	Low		
7142	400 S & State St	UDOT	Enabled	Coordinated	Low		
7243	400 S & Main St	UDOT	Enabled	Peer-to-Peer	Low		
Blue, Green and Red Lines (400 S to Central Pointe Station)							
1150	450 S & Main St (Ped Crossing)	SLC	Enabled	Free	Low		
7252	500 S & Main St	UDOT	Enabled	Coordinated	Medium		
1148	550 S & Main St	SLC	Enabled	Free	Low		
7255	600 S & Main St	UDOT	Enabled	Coordinated	Medium		
1045	700 S & Main St	SLC	Enabled	Free	Low	High	90 deg. turn location where TRAX was originally served after every traffic phase.

Table 75 – General Intersection Information							
Signal ID	**Intersection**	**Agency**	**Priority**	**Weekday Signal Operation**	**Potential for Additional Priority Based on Initial Review**	**UTA Assessment of Priority**	**Notes**
7134	700 S & West Temple	UDOT	Enabled	Coordinated	Low		
1027	700 S & 200 W	SLC	Enabled	Free	Low	High	90 deg. turn location where TRAX was originally served after every traffic phase.
1028	800 S & 200 W	SLC	Enabled	Free	Low		
1168	200 S & 850 W (Ped Crossing)	SLC	Enabled	Free	Low		
1146	900 S & Main St	SLC	Enabled	Free	Low		
Green Line (Central Pointe Station to West Valley Central Station)							
4525	2320 S & 1070 W	WVC	Enabled	Free	High		
4526	2455 S & 1070 W	WVC	Enabled	Free	High		
7080	Redwood Rd & Research Way	UDOT	Preempt Enabled	Coordinated			
4528	2770 S & 1935 W	WVC	Enabled	Free	High		
4529	2900 S & 1935 W	WVC	Enabled	Free	High		
4530	3025 S & 2210 W	WVC	Enabled	Free	High		
4522	3100 S & 2210 W	WVC	Enabled	Free	High		
4532	3100 S &2625 W	WVC	Enabled	Free			
4502	3100 S & 2700 W	WVC	Enabled	Free	High		
4533	3360 S & 2700 W	WVC	Enabled	Free	High		
7287	3500 S & 2700 W	UDOT	Enabled	Coordinated	High	High	
4534	Lehman Ave & 2700 W	WVC	Preempt Enabled	Coordinated			
Blue and Red Lines (Central Point Station to Fashion Place West)							
4852	5900 S & 300 W	Murray City	Preempt Enabled	Free			
4864	6100 S & 300 W	Murray City	Preempt Enabled	Free			
Red Line (Fashion Place West to Daybreak)							
4636	South Jordan Pkwy & Grandville Ave	South Jordan City	Preempt Enabled	Free			

Table 75 – General Intersection Information							
Signal ID	**Intersection**	**Agency**	**Priority**	**Weekday Signal Operation**	**Potential for Additional Priority Based on Initial Review**	**UTA Assessment of Priority**	**Notes**
4637	Lake Ave & Grandville Ave	South Jordan City	Preempt Enabled	Free			
4635	Black Twig Dr & Grandville Ave	South Jordan City	Preempt Enabled	Free			
4640	Rambutan Way & Grandville Ave	South Jordan City	Preempt Enabled	Free			
4641	Duckhorn Dr & Grandville Ave	South Jordan City	Preempt Enabled	Free			
Blue Line (Fashion Place West to Draper)							
4067	7720 S & 60 W (Queue Cutter)	Midvale City	Preempt Enabled	Free			
7000	9000 S & 150 E (Queue Cutter)	UDOT	Preempt Enabled	Coordinated			
4413	9400 S & 150 E (Queue Cutter)	Sandy City	Preempt Enabled	Coordinated			
4836	11400 S & 400 E (Queue Cutter)	Sandy City	Preempt Enabled	Coordinated			
7616	700 E & Kimballs Ln	UDOT	Preempt Enabled	Free			
4157	12300 S & 970 E	Draper City	Preempt Enabled	Free			

Table 76 – Intersection Morning Peak Settings							
Intersection	**Max Extend (seconds)**	**Max Early Green (seconds)**	**Cycle length**	**Estimated % Green Arrival**	**Estimated % Green Arrival**	**Estimated Ave Wait Time (s)**	**Estimated Ave Wait Time (s)**
Green Line (Airport to North Temple & 400 W)							
				To Airport	**To 400 W**	**To Airport**	**To 400 W**
2400 W & North Temple	0	0	90	25%	25%	34	34
2200 W & North Temple	30	25	110	65%	45%	13	28
1950 W & North Temple	59	53	108	80%	80%	5	5
1900 W & North Temple (Ped Crossing)	59	0	72	80%	80%	7	7
Redwood Rd & North Temple	0	0	108	27%	25%	40	41
1540 W & North Temple (Ped Crossing)	45	0	108	78%	80%	12	11
1460 W & North Temple	52	28	108	80%	80%	5	5
1300 W & North Temple	50	0	75	53%	53%	18	18
1200 W & North Temple	50	5	60	80%	80%	6	5
1100 W & North Temple (Ped Crossing)	50	0	70	80%	80%	7	7
1000 W & North Temple	50	15	90	76%	78%	7	6
900 W & North Temple	50	30	120	60%	71%	16	10
850 W & North Temple (Ped Crossing)	50	0	70	80%	80%	7	7
800 W & North Temple	50	5	80	80%	78%	7	8
600 W & North Temple	**Uses Preemption instead of Priority at this Signal**						
400 W & North Temple	60	50	120	80%	80%	5	5
400 W & 50 N	**Uses Preemption instead of Priority at this Signal**						
South Temple & 400 W	0	25	140	47%	47%	31	37
Blue Line (Salt Lake Central to North Temple & 400 W)							
				To SL Central	**To 400 W**	**To SL Central**	**To 400 W**
300 S & 600 W	10	0	50	70%	80%	5	5
200 S & 600 W	20	10	80	80%	80%	7	7

Table 76 – Intersection Morning Peak Settings							
Intersection	**Max Extend (seconds)**	**Max Early Green (seconds)**	**Cycle length**	**Estimated % Green Arrival**	**Estimated % Green Arrival**	**Estimated Ave Wait Time (s)**	**Estimated Ave Wait Time (s)**
200 S & 500 W	30	25	120	68%	68%	13	13
200 S & 400 W	10	30	110	58%	58%	16	16
100 S & 400 W	60	20	100	65%	65%	13	13
South Temple & 400 W	0	25	140	47%	47%	31	37
Blue and Green Lines (North Temple & 400 W to 400 S & Main St)							
				To 400 W	**To 400 S**	**To 400 W**	**To 400 S**
300 W & South Temple	51	37	120	49%	76%	21	7
South Temple & 200 W	50	15	80	73%	73%	7	7
150 W & South Temple (Ped Crossing)	45	0	71	80%	80%	7	7
West Temple & South Temple	15	20	85	56%	56%	14	14
50 W & South Temple (Ped Crossing)	50	0	62	80%	80%	6	6
Main St & South Temple	40	0	65	77%	77%	8	8
50 S & Main St (Ped Crossing)	60	10	60	80%	80%	5	6
100 S & Main St	50	10	70	80%	80%	5	5
150 S & Main St (Ped Crossing)	60	0	50	80%	80%	5	5
200 S & Main St	50	20	80	80%	80%	5	5
250 S & Main St (Ped Crossing)	50	0	60	80%	80%	6	6
300 S & Main St	30	10	60	79%	79%	5	5
350 S & Main St (Ped Crossing)	60	0	81	80%	80%	8	8
400 S & Main St	10	75	110	40%	40%	14	14
Red Line (University Medical Center to 400 S & Main St)							
				To Medical	**To Main St**	**To Medical**	**To Main St**
Wasatch Dr & Mario Capecchi Dr	**Uses Preemption instead of Priority at this Signal**						
South Campus Dr & Mario Capecchi Dr	0	35	155	48%	48%	32	36

Table 76 – Intersection Morning Peak Settings							
Intersection	Max Extend (seconds)	Max Early Green (seconds)	Cycle length	Estimated % Green Arrival	Estimated % Green Arrival	Estimated Ave Wait Time (s)	Estimated Ave Wait Time (s)
South Campus Dr & 1800 E	50	10	65	80%	80%	5	5
South Campus Dr & 1725 E	40	15	90	76%	76%	7	7
South Campus Dr & 1550 E (Ped Crossing)	50	0	82	80%	80%	8	8
South Campus Dr & 1500 E	30	0	115	65%	65%	20	20
500 S & 1300 E	25	38	150	41%	51%	35	31
500 S & 1100 E	35	15	75	80%	80%	6	5
400 S & 900 E	28	17	120	79%	55%	8	22
400 S & 800 E	25	27	120	73%	73%	9	9
400 S & 700 E	0	0	120	33%	33%	40	40
400 S & 600 E	25	20	120	76%	80%	10	7
400 S & 500 E	25	35	120	67%	67%	11	11
400 S & 400 E	25	25	120	75%	75%	9	9
400 S & 300 E	28	35	120	56%	61%	18	16
400 S & 200 E	20	27	120	50%	80%	23	7
400 S & State St	5	25	120	56%	56%	20	20
400 S & Main St	10	75	110	80%	80%	5	5
Blue, Green and Red Lines (400 S to Central Pointe Station)							
				To 400 S	**To Central Pointe**	**To 400 S**	**To Central Pointe**
450 S & Main St (Ped Crossing)	90	0	83	80%	80%	8	8
500 S & Main St	25	0	120	56%	31%	26	41
550 S & Main St	70	0	55	80%	80%	6	6
600 S & Main St	0	0	120	21%	46%	48	33
700 S & Main St	20	30	95	59%	59%	17	12
700 S & West Temple	20	38	120	37%	62%	28	14
700 S & 200 W	0	20	60	80%	80%	5	5
800 S & 200 W	30	0	52	67%	67%	9	9
200 S & 850 W (Ped Crossing)	25	0	60	79%	79%	6	6
900 S & Main St	40	10	50	80%	80%	5	5

Table 76 – Intersection Morning Peak Settings							
Intersection	**Max Extend (seconds)**	**Max Early Green (seconds)**	**Cycle length**	**Estimated % Green Arrival**	**Estimated % Green Arrival**	**Estimated Ave Wait Time (s)**	**Estimated Ave Wait Time (s)**
Green Line (Central Pointe Station to West Valley Central Station)							
				To WVC Central	**To Central Point**	**To WVC Central**	**To Central Point**
2320 S & 1070 W	0	5	50	53%	53%	11	11
2455 S & 1070 W	0	5	50	80%	80%	5	5
Redwood Rd & Research Way	**Uses Preemption instead of Priority at this Signal**						
2770 S & 1935 W	0	20	100	35%	35%	28	28
2900 S & 1935 W	0	5	70	45%	45%	18	18
3025 S & 2210 W	0	25	100	46%	46%	21	26
3100 S & 2210 W	0	0	100	20%	20%	40	40
3100 S &2625 W	**Uses Preemption instead of Priority at this Signal**						
3100 S & 2700 W	0	25	110	38%	38%	28	28
3360 S & 2700 W	0	5	60	69%	69%	8	8
3500 S & 2700 W	5	6	120	33%	34%	39	38
Lehman Ave & 2700 W	**Uses Preemption instead of Priority at this Signal**						
Blue and Red Lines (Central Point Station to Fashion Place West)							
5900 S & 300 W	**Uses Preemption instead of Priority at this Signal**						
6100 S & 300 W							
Red Line (Fashion Place West to Daybreak)							
South Jordan Pkwy & Grandville Ave	**Uses Preemption instead of Priority at this Signal**						
Lake Ave & Grandville Ave							
Black Twig Dr & Grandville Ave							
Rambutan Way & Grandville Ave							
Duckhorn Dr & Grandville Ave							
Blue Line (Fashion Place West to Draper)							

Table 76 – Intersection Morning Peak Settings							
Intersection	**Max Extend (seconds)**	**Max Early Green (seconds)**	**Cycle length**	**Estimated % Green Arrival**	**Estimated % Green Arrival**	**Estimated Ave Wait Time (s)**	**Estimated Ave Wait Time (s)**
7720 S & 60 W (Queue Cutter)	**Uses Preemption instead of Priority at this Signal**						
9000 S & 150 E (Queue Cutter)							
9400 S & 150 E (Queue Cutter)							
11400 S & 400 E (Queue Cutter)							
700 E & Kimballs Ln							
12300 S & 970 E							

Table 77 – Intersection Off-Peak Settings (Where Different Than Morning Settings)							
Intersection	**Max Extend (seconds)**	**Max Early Green (seconds)**	**Cycle length**	**Estimated % Green Arrival**	**Estimated % Green Arrival**	**Estimated Ave Wait Time (s)**	**Estimated Ave Wait Time (s)**
Green Line (Airport to North Temple & 400 W)							
				To Airport	**To 400 W**	**To Airport**	**To 400 W**
2400 W & North Temple	Runs "Free" with same settings all day						
2200 W & North Temple							
1950 W & North Temple	59	53	108	80%	80%	5	5
1900 W & North Temple (Ped Crossing)	59	0	72	80%	80%	7	7
Redwood Rd & North Temple	0	0	108	27%	24%	40	41
1540 W & North Temple (Ped Crossing)	45	0	108	78%	78%	12	12
1460 W & North Temple	52	43	108	80%	80%	5	5
1300 W & North Temple	Runs "Free" with same settings all day						
1200 W & North Temple							
1100 W & North Temple (Ped Crossing)							
1000 W & North Temple							
900 W & North Temple							
850 W & North Temple (Ped Crossing)							
800 W & North Temple							
600 W & North Temple							
400 W & North Temple	Runs "Free" with same settings all day						
400 W & 50 N							
South Temple & 400 W	Runs "Free" with same settings all day						
Blue Line (Salt Lake Central to North Temple & 400 W)							
				To SL Central	**To 400 W**	**To SL Central**	**To 400 W**
300 S & 600 W	Runs "Free" with same settings all day						
200 S & 600 W							
200 S & 500 W							
200 S & 400 W							

Table 77 – Intersection Off-Peak Settings (Where Different Than Morning Settings)							
Intersection	**Max Extend (seconds)**	**Max Early Green (seconds)**	**Cycle length**	**Estimated % Green Arrival**	**Estimated % Green Arrival**	**Estimated Ave Wait Time (s)**	**Estimated Ave Wait Time (s)**
100 S & 400 W							
South Temple & 400 W							
Blue and Green Lines (North Temple & 400 W to 400 S & Main St)							
				To 400 W	**To 400 S**	**To 400 W**	**To 400 S**
300 W & South Temple	49	33	108	56%	80%	15	5
South Temple & 200 W	**Runs "Free" with same settings all day**						
150 W & South Temple (Ped Crossing)							
West Temple & South Temple							
50 W & South Temple (Ped Crossing)							
Main St & South Temple							
50 S & Main St (Ped Crossing)							
100 S & Main St							
150 S & Main St (Ped Crossing)							
200 S & Main St							
250 S & Main St (Ped Crossing)							
300 S & Main St							
350 S & Main St (Ped Crossing)							
400 S & Main St	10	68	110	22%	22%	24	24
Red Line (University Medical Center to 400 S & Main St)							
				To Medical	**To Main St**	**To Medical**	**To Main St**
Wasatch Dr & Mario Capecchi Dr							
South Campus Dr & Mario Capecchi Dr	**Runs "Free" with same settings all day**						
South Campus Dr & 1800 E							
South Campus Dr & 1725 E							
South Campus Dr & 1550 E (Ped Crossing)							
South Campus Dr & 1500 E							

Table 77 – Intersection Off-Peak Settings (Where Different Than Morning Settings)							
Intersection	**Max Extend (seconds)**	**Max Early Green (seconds)**	**Cycle length**	**Estimated % Green Arrival**	**Estimated % Green Arrival**	**Estimated Ave Wait Time (s)**	**Estimated Ave Wait Time (s)**
500 S & 1300 E	15	20	155	53%	53%	32	32
500 S & 1100 E	Runs "Free" with same settings all day						
400 S & 900 E	14	28	108	80%	69%	5	10
400 S & 800 E	25	27	108	67%	67%	11	11
400 S & 700 E	0	0	108	35%	36%	35	35
400 S & 600 E	25	28	108	64%	80%	12	6
400 S & 500 E	25	33	108	72%	63%	9	12
400 S & 400 E	25	25	108	69%	69%	10	10
400 S & 300 E	25	30	108	54%	54%	17	17
400 S & 200 E	19	33	108	44%	80%	22	5
400 S & State St	0	0	108	54%	54%	19	19
400 S & Main St	10	68	110	80%	80%	5	5
Blue, Green and Red Lines (400 S to Central Pointe Station)							
				To 400 S	**To Central Pointe**	**To 400 S**	**To Central Pointe**
450 S & Main St (Ped Crossing)	Runs "Free" with same settings all day						
500 S & Main St	25	0	108	65%	39%	19	33
550 S & Main St	Runs "Free" with same settings all day						
600 S & Main St	25	0	108	51%	69%	27	17
700 S & Main St	Runs "Free" with same settings all day						
700 S & West Temple	20	31	108	41%	69%	24	10
700 S & 200 W	Runs "Free" with same settings all day						
800 S & 200 W							
200 S & 850 W (Ped Crossing)							
900 S & Main St							
Green Line (Central Pointe Station to West Valley Central Station)							
				To WVC Central	**To Central Point**	**To WVC Central**	**To Central Point**

Table 77 – Intersection Off-Peak Settings (Where Different Than Morning Settings)							
Intersection	**Max Extend (seconds)**	**Max Early Green (seconds)**	**Cycle length**	**Estimated % Green Arrival**	**Estimated % Green Arrival**	**Estimated Ave Wait Time (s)**	**Estimated Ave Wait Time (s)**
2320 S & 1070 W	Runs "Free" with same settings all day						
2455 S & 1070 W							
Redwood Rd & Research Way							
2770 S & 1935 W	Runs "Free" with same settings all day						
2900 S & 1935 W							
3025 S & 2210 W							
3100 S & 2210 W							
3100 S &2625 W							
3100 S & 2700 W	Runs "Free" with same settings all day						
3360 S & 2700 W							
3500 S & 2700 W	4	6	108	36%	31%	33	36
Lehman Ave & 2700 W							
Blue and Red Lines (Central Point Station to Fashion Place West)							
5900 S & 300 W							
6100 S & 300 W							
Red Line (Fashion Place West to Daybreak)							
South Jordan Pkwy & Grandville Ave							
Lake Ave & Grandville Ave							
Black Twig Dr & Grandville Ave							
Rambutan Way & Grandville Ave							
Duckhorn Dr & Grandville Ave							
Blue Line (Fashion Place West to Draper)							
7720 S & 60 W (Queue Cutter)							
9000 S & 150 E (Queue Cutter)							
9400 S & 150 E (Queue Cutter)							
11400 S & 400 E (Queue Cutter)							
700 E & Kimballs Ln							
12300 S & 970 E							

Table 78 – Intersection Evening Peak Settings (Where Different Than Morning Settings)							
Intersection	**Max Extend (seconds)**	**Max Early Green (seconds)**	**Cycle length**	**Estimated % Green Arrival**	**Estimated % Green Arrival**	**Estimated Ave Wait Time (s)**	**Estimated Ave Wait Time (s)**
Green Line (Airport to North Temple & 400 W)							
				To Airport	**To 400 W**	**To Airport**	**To 400 W**
2400 W & North Temple							
2200 W & North Temple							
1950 W & North Temple	44	50	120	80%	80%	5	5
1900 W & North Temple (Ped Crossing)	4	0	80	80%	80%	8	8
Redwood Rd & North Temple	0	0	120	24%	22%	46	47
1540 W & North Temple (Ped Crossing)	44	0	80	80%	80%	8	8
1460 W & North Temple	45	33	120	80%	80%	5	5
1300 W & North Temple							
1200 W & North Temple							
1100 W & North Temple (Ped Crossing)							
1000 W & North Temple							
900 W & North Temple							
850 W & North Temple (Ped Crossing)							
800 W & North Temple							
600 W & North Temple							
400 W & North Temple							
400 W & 50 N							
South Temple & 400 W							
Blue Line (Salt Lake Central to North Temple & 400 W)							
				To SL Central	**To 400 W**	**To SL Central**	**To 400 W**
300 S & 600 W							
200 S & 600 W							
200 S & 500 W							
200 S & 400 W							

Table 78 – Intersection Evening Peak Settings (Where Different Than Morning Settings)							
Intersection	**Max Extend (seconds)**	**Max Early Green (seconds)**	**Cycle length**	**Estimated % Green Arrival**	**Estimated % Green Arrival**	**Estimated Ave Wait Time (s)**	**Estimated Ave Wait Time (s)**
100 S & 400 W							
South Temple & 400 W							
Blue and Green Lines (North Temple & 400 W to 400 S & Main St)							
				To 400 W	**To 400 S**	**To 400 W**	**To 400 S**
300 W & South Temple	50	31	120	50%	76%	22	8
South Temple & 200 W							
150 W & South Temple (Ped Crossing)							
West Temple & South Temple							
50 W & South Temple (Ped Crossing)							
Main St & South Temple							
50 S & Main St (Ped Crossing)							
100 S & Main St							
150 S & Main St (Ped Crossing)							
200 S & Main St							
250 S & Main St (Ped Crossing)							
300 S & Main St							
350 S & Main St (Ped Crossing)							
400 S & Main St	10	65	110	22%	22%	24	24
Red Line (University Medical Center to 400 S & Main St)							
				To Medical	**To Main St**	**To Medical**	**To Main St**
Wasatch Dr & Mario Capecchi Dr							
South Campus Dr & Mario Capecchi Dr							
South Campus Dr & 1800 E							
South Campus Dr & 1725 E							
South Campus Dr & 1550 E (Ped Crossing)							
South Campus Dr & 1500 E							

Table 78 – Intersection Evening Peak Settings (Where Different Than Morning Settings)							
Intersection	Max Extend (seconds)	Max Early Green (seconds)	Cycle length	Estimated % Green Arrival	Estimated % Green Arrival	Estimated Ave Wait Time (s)	Estimated Ave Wait Time (s)
500 S & 1300 E	25	46	150	36%	60%	37	19
500 S & 1100 E							
400 S & 900 E	15	30	120	80%	61%	7	16
400 S & 800 E	25	26	120	74%	74%	9	9
400 S & 700 E	0	0	120	36%	33%	39	41
400 S & 600 E	25	25	120	70%	80%	12	7
400 S & 500 E	25	40	120	70%	62%	10	13
400 S & 400 E	25	27	120	73%	73%	10	10
400 S & 300 E	25	36	120	55%	60%	18	16
400 S & 200 E	20	25	120	52%	80%	23	7
400 S & State St	5	22	120	57%	57%	20	20
400 S & Main St	10	65	110	80%	80%	5	5
Blue, Green and Red Lines (400 S to Central Pointe Station)							
				To 400 S	To Central Pointe	To 400 S	To Central Pointe
450 S & Main St (Ped Crossing)							
500 S & Main St	0	0	120	60%	50%	24	30
550 S & Main St							
600 S & Main St	25	0	120	20%	70%	48	18
700 S & Main St							
700 S & West Temple	15	38	120	37%	80%	28	5
700 S & 200 W							
800 S & 200 W							
200 S & 850 W (Ped Crossing)							
900 S & Main St							
Green Line (Central Pointe Station to West Valley Central Station)							
				To WVC Central	To Central Point	To WVC Central	To Central Point

Table 78 – Intersection Evening Peak Settings (Where Different Than Morning Settings)							
Intersection	**Max Extend (seconds)**	**Max Early Green (seconds)**	**Cycle length**	**Estimated % Green Arrival**	**Estimated % Green Arrival**	**Estimated Ave Wait Time (s)**	**Estimated Ave Wait Time (s)**
2320 S & 1070 W							
2455 S & 1070 W							
Redwood Rd & Research Way							
2770 S & 1935 W							
2900 S & 1935 W							
3025 S & 2210 W							
3100 S & 2210 W							
3100 S &2625 W							
3100 S & 2700 W							
3360 S & 2700 W							
3500 S & 2700 W	5	6	120	33%	34%	39	38
Lehman Ave & 2700 W							
Blue and Red Lines (Central Point Station to Fashion Place West)							
5900 S & 300 W							
6100 S & 300 W							
Red Line (Fashion Place West to Daybreak)							
South Jordan Pkwy & Grandville Ave							
Lake Ave & Grandville Ave							
Black Twig Dr & Grandville Ave							
Rambutan Way & Grandville Ave							
Duckhorn Dr & Grandville Ave							
Blue Line (Fashion Place West to Draper)							
7720 S & 60 W (Queue Cutter)							
9000 S & 150 E (Queue Cutter)							
9400 S & 150 E (Queue Cutter)							
11400 S & 400 E (Queue Cutter)							
700 E & Kimballs Ln							
12300 S & 970 E							

Appendix D – Existing (pre-COVID) Baseline Operating Plan

Table 79 – Blue Line – Northbound

Train	Draper Town Center	Kimballs Lane	Crescent View	Sandy Civic Center	Sandy Expo	Historic Sandy	Midvale Center	Midvale Fort Union	Fashion Place West	Murray Central	Murray North	Meadowbrook	Millcreek	Central Pointe	Ballpark	900 South	Courthouse	Gallivan Plaza	City Center	Temple Square	Arena	Planetarium	Old Greektown	Salt Lake Central
16									4:57	5:00	5:03	5:05	5:05	5:07	5:12	5:14	5:18	5:20	5:22	5:24	5:26	5:28	5:30	5:32
17	4:56	4:58	4:59	5:02	5:04	5:05	5:08	5:10	5:12	5:15	5:18	5:20	5:22	5:25	5:27	5:29	5:33	5:35	5:37	5:39	5:41	5:43	5:45	5:47
10	5:11	5:13	5:14	5:17	5:19	5:20	5:23	5:25	5:27	5:30	5:33	5:35	5:37	5:40	5:42	5:44	5:48	5:50	5:52	5:54	5:56	5:58	6:00	6:02
11	5:26	5:28	5:29	5:32	5:34	5:35	5:38	5:40	5:42	5:45	5:48	5:50	5:52	5:55	5:57	5:59	6:03	6:05	6:07	6:09	6:11	6:13	6:15	6:17
12	5:41	5:43	5:44	5:47	5:49	5:50	5:53	5:55	5:57	6:00	6:03	6:05	6:07	6:10	6:12	6:14	6:18	6:20	6:22	6:24	6:26	6:28	6:30	6:32
13	5:56	5:58	5:59	6:02	6:04	6:05	6:08	6:10	6:12	6:15	6:18	6:20	6:22	6:25	6:27	6:29	6:33	6:35	6:37	6:39	6:41	6:43	6:45	6:47
14	6:11	6:13	6:14	6:17	6:19	6:20	6:23	6:25	6:27	6:30	6:33	6:35	6:37	6:40	6:42	6:44	6:48	6:50	6:52	6:54	6:56	6:58	7:00	7:02
15	6:26	6:28	6:29	6:32	6:34	6:35	6:38	6:40	6:42	6:45	6:48	6:50	6:52	6:55	6:57	6:59	7:03	7:05	7:07	7:09	7:11	7:13	7:15	7:17
16	6:41	6:43	6:44	6:47	6:49	6:50	6:53	6:55	6:57	7:00	7:03	7:05	7:07	7:10	7:12	7:14	7:18	7:20	7:22	7:24	7:26	7:28	7:30	7:32
17	6:56	6:58	6:59	7:02	7:04	7:05	7:08	7:10	7:12	7:15	7:18	7:20	7:22	7:25	7:27	7:29	7:33	7:35	7:37	7:39	7:41	7:43	7:45	7:47
10	7:11	7:13	7:14	7:17	7:19	7:20	7:23	7:25	7:27	7:30	7:33	7:35	7:37	7:40	7:42	7:44	7:48	7:50	7:52	7:54	7:56	7:58	8:00	8:02
11	7:26	7:28	7:29	7:32	7:34	7:35	7:38	7:40	7:42	7:45	7:48	7:50	7:52	7:55	7:57	7:59	8:03	8:05	8:07	8:09	8:11	8:13	8:15	8:17
12	7:41	7:43	7:44	7:47	7:49	7:50	7:53	7:55	7:57	8:00	8:03	8:05	8:07	8:10	8:12	8:14	8:18	8:20	8:22	8:24	8:26	8:28	8:30	8:32
13	7:56	7:58	7:59	8:02	8:04	8:05	8:08	8:10	8:12	8:15	8:18	8:20	8:22	8:25	8:27	8:29	8:33	8:35	8:37	8:39	8:41	8:43	8:45	8:47
14	8:11	8:13	8:14	8:17	8:19	8:20	8:23	8:25	8:27	8:30	8:33	8:35	8:37	8:40	8:42	8:44	8:48	8:50	8:52	8:54	8:56	8:58	9:00	9:02
15	8:26	8:28	8:29	8:32	8:34	8:35	8:38	8:40	8:42	8:45	8:48	8:50	8:52	8:55	8:57	8:59	9:03	9:05	9:07	9:09	9:11	9:13	9:15	9:17
16	8:41	8:43	8:44	8:47	8:49	8:50	8:53	8:55	8:57	9:00	9:03	9:05	9:07	9:10	9:12	9:14	9:18	9:20	9:22	9:24	9:26	9:28	9:30	9:32
17	8:56	8:58	8:59	9:02	9:04	9:05	9:08	9:10	9:12	9:15	9:18	9:20	9:22	9:25	9:27	9:29	9:33	9:35	9:37	9:39	9:41	9:43	9:45	9:47
10	9:11	9:13	9:14	9:17	9:19	9:20	9:23	9:25	9:27	9:30	9:33	9:35	9:37	9:40	9:42	9:44	9:48	9:50	9:52	9:54	9:56	9:58	10:00	10:02
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12	9:41	9:43	9:44	9:47	9:49	9:50	9:53	9:55	9:57	10:00	10:03	10:05	10:07	10:10	10:12	10:14	10:18	10:20	10:22	10:24	10:26	10:28	10:30	10:32
13	9:56	9:58	9:59	10:02	10:04	10:05	10:08	10:10	10:12	10:15	10:18	10:20	10:22	10:25	10:27	10:29	10:33	10:35	10:37	10:39	10:41	10:43	10:45	10:47
14	10:11	10:13	10:14	10:17	10:19	10:20	10:23	10:25	10:27	10:30	10:33	10:35	10:37	10:40	10:42	10:44	10:48	10:50	10:52	10:54	10:56	10:58	11:00	11:02
15	10:26	10:28	10:29	10:32	10:34	10:35	10:38	10:40	10:42	10:45	10:48	10:50	10:52	10:55	10:57	10:59	11:03	11:05	11:07	11:09	11:11	11:13	11:15	11:17
16	10:41	10:43	10:44	10:47	10:49	10:50	10:53	10:55	10:57	11:00	11:03	11:05	11:07	11:10	11:12	11:14	11:18	11:20	11:22	11:24	11:26	11:28	11:30	11:32
17	10:56	10:58	10:59	11:02	11:04	11:05	11:08	11:10	11:12	11:15	11:18	11:20	11:22	11:25	11:27	11:29	11:33	11:35	11:37	11:39	11:41	11:43	11:45	11:47
10	11:11	11:13	11:14	11:17	11:19	11:20	11:23	11:25	11:27	11:30	11:33	11:35	11:37	11:40	11:42	11:44	11:48	11:50	11:52	11:54	11:56	11:58	12:00	12:02

Table 79 – Blue Line – Northbound

Train	Draper Town Center	Kimballs Lane	Crescent View	Sandy Civic Center	Sandy Expo	Historic Sandy	Midvale Center	Midvale Fort Union	Fashion Place West	Murray Central	Murray North	Meadowbrook	Millcreek	Central Pointe	Ballpark	900 South	Courthouse	Gallivan Plaza	City Center	Temple Square	Arena	Planetarium	Old Greektown	Salt Lake Central
11	11:26	11:28	11:29	11:32	11:34	11:35	11:38	11:40	11:42	11:45	11:48	11:50	11:52	11:55	11:57	11:59	12:03	12:05	12:07	12:09	12:11	12:13	12:15	12:17
12	11:41	11:43	11:44	11:47	11:49	11:50	11:53	11:55	11:57	12:00	12:03	12:05	12:07	12:10	12:12	12:14	12:18	12:20	12:22	12:24	12:26	12:28	12:30	12:32
13	11:56	11:58	11:59	12:02	12:04	12:05	12:08	12:10	12:12	12:15	12:18	12:20	12:22	12:25	12:27	12:29	12:33	12:35	12:37	12:39	12:41	12:43	12:45	12:47
14	12:11	12:13	12:14	12:17	12:19	12:20	12:23	12:25	12:27	12:30	12:33	12:35	12:37	12:40	12:42	12:44	12:48	12:50	12:52	12:54	12:56	12:58	13:00	13:02
15	12:26	12:28	12:29	12:32	12:34	12:35	12:38	12:40	12:42	12:45	12:48	12:50	12:52	12:55	12:57	12:59	13:03	13:05	13:07	13:09	13:11	13:13	13:15	13:17
16	12:41	12:43	12:44	12:47	12:49	12:50	12:53	12:55	12:57	13:00	13:03	13:05	13:07	13:10	13:12	13:14	13:18	13:20	13:22	13:24	13:26	13:28	13:30	13:32
17	12:56	12:58	12:59	13:02	13:04	13:05	13:08	13:10	13:12	13:15	13:18	13:20	13:22	13:25	13:27	13:29	13:33	13:35	13:37	13:39	13:41	13:43	13:45	13:47
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11	13:26	13:28	13:29	13:32	13:34	13:35	13:38	13:40	13:42	13:45	13:48	13:50	13:52	13:55	13:57	13:59	14:03	14:05	14:07	14:09	14:11	14:13	14:15	14:17
12	13:41	13:43	13:44	13:47	13:49	13:50	13:53	13:55	13:57	14:00	14:03	14:05	14:07	14:10	14:12	14:14	14:18	14:20	14:22	14:24	14:26	14:28	14:30	14:32
13	13:56	13:58	13:59	14:02	14:04	14:05	14:08	14:10	14:12	14:15	14:18	14:20	14:22	14:25	14:27	14:29	14:33	14:35	14:37	14:39	14:41	14:43	14:45	14:47
14	14:11	14:13	14:14	14:17	14:19	14:20	14:23	14:25	14:27	14:30	14:33	14:35	14:37	14:40	14:42	14:44	14:48	14:50	14:52	14:54	14:56	14:58	15:00	15:02
15	14:26	14:28	14:29	14:32	14:34	14:35	14:38	14:40	14:42	14:45	14:48	14:50	14:52	14:55	14:57	14:59	15:03	15:05	15:07	15:09	15:11	15:13	15:15	15:17
16	14:41	14:43	14:44	14:47	14:49	14:50	14:53	14:55	14:57	15:00	15:03	15:05	15:07	15:10	15:12	15:14	15:18	15:20	15:22	15:24	15:26	15:28	15:30	15:32
17	14:56	14:58	14:59	15:02	15:04	15:05	15:08	15:10	15:12	15:15	15:18	15:20	15:22	15:25	15:27	15:29	15:33	15:35	15:37	15:39	15:41	15:43	15:45	15:47
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11	15:26	15:28	15:29	15:32	15:34	15:35	15:38	15:40	15:42	15:45	15:48	15:50	15:52	15:55	15:57	15:59	16:03	16:05	16:07	16:09	16:11	16:13	16:15	16:17
12	15:41	15:43	15:44	15:47	15:49	15:50	15:53	15:55	15:57	16:00	16:03	16:05	16:07	16:10	16:12	16:14	16:18	16:20	16:22	16:24	16:26	16:28	16:30	16:32
13	15:56	15:58	15:59	16:02	16:04	16:05	16:08	16:10	16:12	16:15	16:18	16:20	16:22	16:25	16:27	16:29	16:33	16:35	16:37	16:39	16:41	16:43	16:45	16:47
14	16:11	16:13	16:14	16:17	16:19	16:20	16:23	16:25	16:27	16:30	16:33	16:35	16:37	16:40	16:42	16:44	16:48	16:50	16:52	16:54	16:56	16:58	17:00	17:02
15	16:26	16:28	16:29	16:32	16:34	16:35	16:38	16:40	16:42	16:45	16:48	16:50	16:52	16:55	16:57	16:59	17:03	17:05	17:07	17:09	17:11	17:13	17:15	17:17
16	16:41	16:43	16:44	16:47	16:49	16:50	16:53	16:55	16:57	17:00	17:03	17:05	17:07	17:10	17:12	17:14	17:18	17:20	17:22	17:24	17:26	17:28	17:30	17:32
17	16:56	16:58	16:59	17:02	17:04	17:05	17:08	17:10	17:12	17:15	17:18	17:20	17:22	17:25	17:27	17:29	17:33	17:35	17:37	17:39	17:41	17:43	17:45	17:47
10	17:11	17:13	17:14	17:17	17:19	17:20	17:23	17:25	17:27	17:30	17:33	17:35	17:37	17:40	17:42	17:44	17:48	17:50	17:52	17:54	17:56	17:58	18:00	18:02
11	17:26	17:28	17:29	17:32	17:34	17:35	17:38	17:40	17:42	17:45	17:48	17:50	17:52	17:55	17:57	17:59	18:03	18:05	18:07	18:09	18:11	18:13	18:15	18:17
12	17:41	17:43	17:44	17:47	17:49	17:50	17:53	17:55	17:57	18:00	18:03	18:05	18:07	18:10	18:12	18:14	18:18	18:20	18:22	18:24	18:26	18:28	18:30	18:32
13	17:56	17:58	17:59	18:02	18:04	18:05	18:08	18:10	18:12	18:15	18:18	18:20	18:22	18:25	18:27	18:29	18:33	18:35	18:37	18:39	18:41	18:43	18:45	18:47
14	18:11	18:13	18:14	18:17	18:19	18:20	18:23	18:25	18:27	18:30	18:33	18:35	18:37	18:40	18:42	18:44	18:48	18:50	18:52	18:54	18:56	18:58	19:00	19:02
15	18:26	18:28	18:29	18:32	18:34	18:35	18:38	18:40	18:42	18:45	18:48	18:50	18:52	18:55	18:57	18:59	19:03	19:05	19:07	19:09	19:11	19:13	19:15	19:17

Table 79 – Blue Line – Northbound																								
Train	**Draper Town Center**	**Kimballs Lane**	**Crescent View**	**Sandy Civic Center**	**Sandy Expo**	**Historic Sandy**	**Midvale Center**	**Midvale Fort Union**	**Fashion Place West**	**Murray Central**	**Murray North**	**Meadowbrook**	**Millcreek**	**Central Pointe**	**Ballpark**	**900 South**	**Courthouse**	**Gallivan Plaza**	**City Center**	**Temple Square**	**Arena**	**Planetarium**	**Old Greektown**	**Salt Lake Central**
16	18:41	18:43	18:44	18:47	18:49	18:50	18:53	18:55	18:57	19:00	19:03	19:05	19:07	19:10	19:12	19:14	19:18	19:20	19:22	19:24	19:26	19:28	19:30	19:32
17	18:56	18:58	18:59	19:02	19:04	19:05	19:08	19:10	19:12	19:15	19:18	19:20	19:22	19:25	19:27	19:29	19:33	19:35	19:37	19:39	19:41	19:43	19:45	19:47
10	19:11	19:13	19:14	19:17	19:19	19:20	19:23	19:25	19:27	19:30	19:33	19:35	19:37	19:40	19:42	19:44	19:48	19:50	19:52	19:54	19:56	19:58	20:00	20:02
11	19:26	19:28	19:29	19:32	19:34	19:35	19:38	19:40	19:42	19:45	19:48	19:50	19:52	19:55	19:57	19:59	20:03	20:05	20:07	20:09	20:11	20:13	20:15	20:17
12	19:41	19:43	19:44	19:47	19:49	19:50	19:53	19:55	19:57	20:00	20:03	20:05	20:07	20:10	20:12	20:14	20:18	20:20	20:22	20:24	20:26	20:28	20:30	20:32
13	19:56	19:58	19:59	20:02	20:04	20:05	20:08	20:10	20:12	20:15	20:18	20:20	20:22	20:25	20:27	20:29	20:33	20:35	20:37	20:39	20:41	20:43	20:45	20:47
14	20:11	20:13	20:14	20:17	20:19	20:20	20:23	20:25	20:27	20:30	20:33	20:35	20:37	20:40	20:42	20:44	20:48	20:50	20:52	20:54	20:56	20:58	21:00	21:02
15	20:26	20:28	20:29	20:32	20:34	20:35	20:38	20:40	20:42	20:45	20:48	20:50	20:52	20:55	20:57	20:59	21:03	21:05	21:07	21:09	21:11	21:13	21:15	21:17
16	20:41	20:43	20:44	20:47	20:49	20:50	20:53	20:55	20:57	21:00	21:03	21:05	21:07	21:10	21:12	21:14	21:18	21:20	21:22	21:24	21:26	21:28	21:30	21:32
17	20:56	20:58	20:59	21:02	21:04	21:05	21:08	21:10	21:12	21:15	21:18	21:20	21:22	21:25	21:27	21:29	21:33	21:35	21:37	21:39	21:41	21:43	21:45	21:47
10	21:11	21:13	21:14	21:17	21:19	21:20	21:23	21:25	21:27	21:30	21:33	21:35	21:37	21:40	21:42	21:44	21:48	21:50	21:52	21:54	21:56	21:58	22:00	22:02
11	21:26	21:28	21:29	21:32	21:34	21:35	21:38	21:40	21:42	21:45	21:48	21:50	21:52	21:55	21:57	21:59	22:03	22:05	22:07	22:09	22:11	22:13	22:15	22:17
12	21:41	21:43	21:44	21:47	21:49	21:50	21:53	21:55	21:57	22:00	22:03	22:05	22:07	22:10	22:12	22:14	22:18	22:20	22:22	22:24	22:26	22:28	22:30	22:32
13	21:56	21:58	21:59	22:02	22:04	22:05	22:08	22:10	22:12	22:15	22:18	22:20	22:22	22:25	22:27	22:29	22:33	22:35	22:37	22:39	22:41	22:43	22:45	22:47
14	22:11	22:13	22:14	22:17	22:19	22:20	22:23	22:25	22:27	22:30	22:33	22:35	22:37	22:40	22:42	22:44	22:48	22:50	22:52	22:54	22:56	22:58	23:00	23:02
15	22:26	22:28	22:29	22:32	22:34	22:35	22:38	22:40	22:42	22:45	22:48	22:50	22:52	22:55	22:57	22:59	23:03	23:05	23:07	23:09	23:11	23:13	23:15	23:17
16	22:41	22:43	22:44	22:47	22:49	22:50	22:53	22:55	22:57															
17	22:56	22:58	22:59	23:02	23:04	23:05	23:08	23:10	23:12															
10	23:11	23:13	23:14	23:17	23:19	23:20	23:23	23:25	23:27															
11	23:26	23:28	23:29	23:32	23:34	23:35	23:38	23:40	23:42															
12	23:41	23:43	23:44	23:47	23:49	23:50	23:53	23:55	23:57															
13	23:56	23:58	23:59	0:02	0:04	0:05	0:08	0:10																
14	0:11	0:13	0:14	0:17	0:19	0:20	0:23	0:25																
15	0:26	0:28	0:29	0:32	0:34	0:35	0:38	0:40																

Table 80 – Blue Line - Southbound																								
Train	Salt Lake Central	Old Greektown	Planetarium	Arena	Temple Square	City Center	Gallivan Plaza	Courthouse	900 South	Ballpark	Central Pointe	Millcreek	Meadowbrook	Murray North	Murray Central	Fashion Place West	Midvale Fort Union	Midvale Center	Historic Sandy	Sandy Expo	Sandy Civic Center	Crescent View	Kimballs Lane	Draper Town Center
17																	4:35	4:37	4:40	4:41	4:43	4:45	4:47	4:50
10																	4:50	4:52	4:55	4:56	4:58	5:00	5:02	5:05
11																	5:05	5:07	5:10	5:11	5:13	5:15	5:17	5:20
12																	5:20	5:22	5:25	5:26	5:28	5:30	5:32	5:35
13																	5:35	5:37	5:40	5:41	5:43	5:45	5:47	5:50
14																	5:50	5:52	5:55	5:56	5:58	6:00	6:02	6:05
15																	6:05	6:07	6:10	6:11	6:13	6:15	6:17	6:20
16	5:43	5:45	5:47	5:49	5:51	5:53	5:55	5:57	6:01	6:03	6:06	6:09	6:11	6:13	6:15	6:18	6:20	6:22	6:25	6:26	6:28	6:30	6:32	6:35
17	5:58	6:00	6:02	6:04	6:06	6:08	6:10	6:12	6:16	6:18	6:21	6:24	6:26	6:28	6:30	6:33	6:35	6:37	6:40	6:41	6:43	6:45	6:47	6:50
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11	8:28	8:30	8:32	8:34	8:36	8:38	8:40	8:42	8:46	8:48	8:51	8:54	8:56	8:58	9:00	9:03	9:05	9:07	9:10	9:11	9:13	9:15	9:17	9:20
12	8:43	8:45	8:47	8:49	8:51	8:53	8:55	8:57	9:01	9:03	9:06	9:09	9:11	9:13	9:15	9:18	9:20	9:22	9:25	9:26	9:28	9:30	9:32	9:35
13	8:58	9:00	9:02	9:04	9:06	9:08	9:10	9:12	9:16	9:18	9:21	9:24	9:26	9:28	9:30	9:33	9:35	9:37	9:40	9:41	9:43	9:45	9:47	9:50
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15	9:28	9:30	9:32	9:34	9:36	9:38	9:40	9:42	9:46	9:48	9:51	9:54	9:56	9:58	10:00	10:03	10:05	10:07	10:10	10:11	10:13	10:15	10:17	10:20

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16	9:43	9:45	9:47	9:49	9:51	9:53	9:55	9:57	10:01	10:03	10:06	10:09	10:11	10:13	10:15	10:18	10:20	10:22	10:25	10:26	10:28	10:30	10:32	10:35
17	9:58	10:00	10:02	10:04	10:06	10:08	10:10	10:12	10:16	10:18	10:21	10:24	10:26	10:28	10:30	10:33	10:35	10:37	10:40	10:41	10:43	10:45	10:47	10:50
10	10:13	10:15	10:17	10:19	10:21	10:23	10:25	10:27	10:31	10:33	10:36	10:39	10:41	10:43	10:45	10:48	10:50	10:52	10:55	10:56	10:58	11:00	11:02	11:05
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17	11:58	12:00	12:02	12:04	12:06	12:08	12:10	12:12	12:16	12:18	12:21	12:24	12:26	12:28	12:30	12:33	12:35	12:37	12:40	12:41	12:43	12:45	12:47	12:50
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15	15:28	15:30	15:32	15:34	15:36	15:38	15:40	15:42	15:46	15:48	15:51	15:54	15:56	15:58	16:00	16:03	16:05	16:07	16:10	16:11	16:13	16:15	16:17	16:20
16	15:43	15:45	15:47	15:49	15:51	15:53	15:55	15:57	16:01	16:03	16:06	16:09	16:11	16:13	16:15	16:18	16:20	16:22	16:25	16:26	16:28	16:30	16:32	16:35

Table 80 – Blue Line - Southbound

Train	Salt Lake Central	Old Greektown	Planetarium	Arena	Temple Square	City Center	Gallivan Plaza	Courthouse	900 South	Ballpark	Central Pointe	Millcreek	Meadowbrook	Murray North	Murray Central	Fashion Place West	Midvale Fort Union	Midvale Center	Historic Sandy	Sandy Expo	Sandy Civic Center	Crescent View	Kimballs Lane	Draper Town Center
17	15:58	16:00	16:02	16:04	16:06	16:08	16:10	16:12	16:16	16:18	16:21	16:24	16:26	16:28	16:30	16:33	16:35	16:37	16:40	16:41	16:43	16:45	16:47	16:50
10	16:13	16:15	16:17	16:19	16:21	16:23	16:25	16:27	16:31	16:33	16:36	16:39	16:41	16:43	16:45	16:48	16:50	16:52	16:55	16:56	16:58	17:00	17:02	17:05
11	16:28	16:30	16:32	16:34	16:36	16:38	16:40	16:42	16:46	16:48	16:51	16:54	16:56	16:58	17:00	17:03	17:05	17:07	17:10	17:11	17:13	17:15	17:17	17:20
12	16:43	16:45	16:47	16:49	16:51	16:53	16:55	16:57	17:01	17:03	17:06	17:09	17:11	17:13	17:15	17:18	17:20	17:22	17:25	17:26	17:28	17:30	17:32	17:35
13	16:58	17:00	17:02	17:04	17:06	17:08	17:10	17:12	17:16	17:18	17:21	17:24	17:26	17:28	17:30	17:33	17:35	17:37	17:40	17:41	17:43	17:45	17:47	17:50
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11	18:28	18:30	18:32	18:34	18:36	18:38	18:40	18:42	18:46	18:48	18:51	18:54	18:56	18:58	19:00	19:03	19:05	19:07	19:10	19:11	19:13	19:15	19:17	19:20
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11	20:28	20:30	20:32	20:34	20:36	20:38	20:40	20:42	20:46	20:48	20:51	20:54	20:56	20:58	21:00	21:03	21:05	21:07	21:10	21:11	21:13	21:15	21:17	21:20
12	20:43	20:45	20:47	20:49	20:51	20:53	20:55	20:57	21:01	21:03	21:06	21:09	21:11	21:13	21:15	21:18	21:20	21:22	21:25	21:26	21:28	21:30	21:32	21:35
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15	21:28	21:30	21:32	21:34	21:36	21:38	21:40	21:42	21:46	21:48	21:51	21:54	21:56	21:58	22:00	22:03	22:05	22:07	22:10	22:11	22:13	22:15	22:17	22:20
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10	22:13	22:15	22:17	22:19	22:21	22:23	22:25	22:27	22:31	22:33	22:36	22:39	22:41	22:43	22:45	22:48	22:50	22:52	22:55	22:56	22:58	23:00	23:02	23:05
11	22:28	22:30	22:32	22:34	22:36	22:38	22:40	22:42	22:46	22:48	22:51	22:54	22:56	22:58	23:00	23:03	23:05	23:07	23:10	23:11	23:13	23:15	23:17	23:20
12	22:43	22:45	22:47	22:49	22:51	22:53	22:55	22:57	23:01	23:03	23:06	23:09	23:11	23:13	23:15	23:18	23:20	23:22	23:25	23:26	23:28	23:30	23:32	23:35
13	22:58	23:00	23:02	23:04	23:06	23:08	23:10	23:12	23:16	23:18	23:21	23:24	23:26	23:28	23:30	23:33	23:35	23:37	23:40	23:41	23:43	23:45	23:47	23:50
14	23:13	23:15	23:17	23:19	23:21	23:23	23:25	23:27	23:31	23:33	23:36	23:39	23:41	23:43	23:45	23:48	23:50	23:52	23:55	23:56	23:58	0:00	0:02	0:05
15	23:28	23:30	23:32	23:34	23:35	23:37	23:39	23:41	23:45	23:47	23:49	23:52	23:54	23:56	23:58	0:01	0:03	0:05	0:08	0:09	0:11	0:13	0:15	0:18

Table 81 – Red Line - Northbound

Train	Daybreak Parkway	South Jordan Parkway	5600 West Old Bingham	4800 West Old Bingham	Jordan Valley	2700 W Sugar Factory Rd	West Jordan City Center	Historic Gardner	Bingham Junction	MRSC Relief Stop	Fashion Place West	Murray Central	Murray North	Meadowbrook	Millcreek	Central Pointe	Ballpark	900 South	Courthouse	Library	Trolley	900 East	Stadium	South Campus	Fort Douglas	Medical Center
39																4:58	5:00	5:02	5:06	5:09	5:12	5:14	5:17	5:20	5:22	5:23
37																5:00	5:02	5:04	5:08	5:11	5:14	5:16	5:19	5:22	5:24	5:25
38																5:15	5:17	5:19	5:23	5:26	5:29	5:31	5:34	5:37	5:39	5:40
30	4:56	4:58	5:00	5:02	5:05	5:07	5:09	5:11	5:13	5:15	5:17	5:21	5:23	5:25	5:27	5:30	5:32	5:34	5:38	5:41	5:44	5:46	5:49	5:52	5:54	5:55
31	5:11	5:13	5:15	5:17	5:20	5:22	5:24	5:26	5:28	5:30	5:32	5:36	5:38	5:40	5:42	5:45	5:47	5:49	5:53	5:56	5:59	6:01	6:04	6:07	6:09	6:10
32	5:26	5:28	5:30	5:32	5:35	5:37	5:39	5:41	5:43	5:45	5:47	5:51	5:53	5:55	5:57	6:00	6:02	6:04	6:08	6:11	6:14	6:16	6:19	6:22	6:24	6:25
33	5:41	5:43	5:45	5:47	5:50	5:52	5:54	5:56	5:58	6:00	6:02	6:06	6:08	6:10	6:12	6:15	6:17	6:19	6:23	6:26	6:29	6:31	6:34	6:37	6:39	6:40
34	5:56	5:58	6:00	6:02	6:05	6:07	6:09	6:11	6:13	6:15	6:17	6:21	6:23	6:25	6:27	6:30	6:32	6:34	6:38	6:41	6:44	6:46	6:49	6:52	6:54	6:55
35	6:11	6:13	6:15	6:17	6:20	6:22	6:24	6:26	6:28	6:30	6:32	6:36	6:38	6:40	6:42	6:45	6:47	6:49	6:53	6:56	6:59	7:01	7:04	7:07	7:09	7:10
36	6:26	6:28	6:30	6:32	6:35	6:37	6:39	6:41	6:43	6:45	6:47	6:51	6:53	6:55	6:57	7:00	7:02	7:04	7:08	7:11	7:14	7:16	7:19	7:22	7:24	7:25
37	6:41	6:43	6:45	6:47	6:50	6:52	6:54	6:56	6:58	7:00	7:02	7:06	7:08	7:10	7:12	7:15	7:17	7:19	7:23	7:26	7:29	7:31	7:34	7:37	7:39	7:40
20											7:15	7:19	7:21	7:23	7:25	7:28	7:30	7:32	7:36	7:39	7:42	7:44	7:47	7:50	7:52	7:53
38	6:56	6:58	7:00	7:02	7:05	7:07	7:09	7:11	7:13	7:15	7:17	7:21	7:23	7:25	7:27	7:30	7:32	7:34	7:38	7:41	7:44	7:46	7:49	7:52	7:54	7:55
30	7:11	7:13	7:15	7:17	7:20	7:22	7:24	7:26	7:28	7:30	7:32	7:36	7:38	7:40	7:42	7:45	7:47	7:49	7:53	7:56	7:59	8:01	8:04	8:07	8:09	8:10
21											7:45	7:49	7:51	7:53	7:55	7:58	8:00	8:02	8:06	8:09	8:12	8:14	8:17	8:20	8:22	8:23
31	7:26	7:28	7:30	7:32	7:35	7:37	7:39	7:41	7:43	7:45	7:47	7:51	7:53	7:55	7:57	8:00	8:02	8:04	8:08	8:11	8:14	8:16	8:19	8:22	8:24	8:25
32	7:41	7:43	7:45	7:47	7:50	7:52	7:54	7:56	7:58	8:00	8:02	8:06	8:08	8:10	8:12	8:15	8:17	8:19	8:23	8:26	8:29	8:31	8:34	8:37	8:39	8:40
22											8:15	8:19	8:21	8:23	8:25	8:28	8:30	8:32	8:36	8:39	8:42	8:44	8:47	8:50	8:52	8:53
33	7:56	7:58	8:00	8:02	8:05	8:07	8:09	8:11	8:13	8:15	8:17	8:21	8:23	8:25	8:27	8:30	8:32	8:34	8:38	8:41	8:44	8:46	8:49	8:52	8:54	8:55
34	8:11	8:13	8:15	8:17	8:20	8:22	8:24	8:26	8:28	8:30	8:32	8:36	8:38	8:40	8:42	8:45	8:47	8:49	8:53	8:56	8:59	9:01	9:04	9:07	9:09	9:10
35	8:26	8:28	8:30	8:32	8:35	8:37	8:39	8:41	8:43	8:45	8:47	8:51	8:53	8:55	8:57	9:00	9:02	9:04	9:08	9:11	9:14	9:16	9:19	9:22	9:24	9:25
36	8:41	8:43	8:45	8:47	8:50	8:52	8:54	8:56	8:58	9:00	9:02	9:06	9:08	9:10	9:12	9:15	9:17	9:19	9:23	9:26	9:29	9:31	9:34	9:37	9:39	9:40
37	8:56	8:58	9:00	9:02	9:05	9:07	9:09	9:11	9:13	9:15	9:17	9:21	9:23	9:25	9:27	9:30	9:32	9:34	9:38	9:41	9:44	9:46	9:49	9:52	9:54	9:55
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34	10:26	10:28	10:30	10:32	10:35	10:37	10:39	10:41	10:43	10:45	10:47	10:51	10:53	10:55	10:57	11:00	11:02	11:04	11:08	11:11	11:14	11:16	11:19	11:22	11:24	11:25
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37	11:11	11:13	11:15	11:17	11:20	11:22	11:24	11:26	11:28	11:30	11:32	11:36	11:38	11:40	11:42	11:45	11:47	11:49	11:53	11:56	11:59	12:01	12:04	12:07	12:09	12:10
38	11:26	11:28	11:30	11:32	11:35	11:37	11:39	11:41	11:43	11:45	11:47	11:51	11:53	11:55	11:57	12:00	12:02	12:04	12:08	12:11	12:14	12:16	12:19	12:22	12:24	12:25
30	11:41	11:43	11:45	11:47	11:50	11:52	11:54	11:56	11:58	12:00	12:02	12:06	12:08	12:10	12:12	12:15	12:17	12:19	12:23	12:26	12:29	12:31	12:34	12:37	12:39	12:40
31	11:56	11:58	12:00	12:02	12:05	12:07	12:09	12:11	12:13	12:15	12:17	12:21	12:23	12:25	12:27	12:30	12:32	12:34	12:38	12:41	12:44	12:46	12:49	12:52	12:54	12:55
32	12:11	12:13	12:15	12:17	12:20	12:22	12:24	12:26	12:28	12:30	12:32	12:36	12:38	12:40	12:42	12:45	12:47	12:49	12:53	12:56	12:59	13:01	13:04	13:07	13:09	13:10
33	12:26	12:28	12:30	12:32	12:35	12:37	12:39	12:41	12:43	12:45	12:47	12:51	12:53	12:55	12:57	13:00	13:02	13:04	13:08	13:11	13:14	13:16	13:19	13:22	13:24	13:25

Table 81 – Red Line - Northbound

Train	Daybreak Parkway	South Jordan Parkway	5600 West Old Bingham	4800 West Old Bingham	Jordan Valley	2700 W Sugar Factory Rd	West Jordan City Center	Historic Gardner	Bingham Junction	MRSC Relief Stop	Fashion Place West	Murray Central	Murray North	Meadowbrook	Millcreek	Central Pointe	Ballpark	900 South	Courthouse	Library	Trolley	900 East	Stadium	South Campus	Fort Douglas	Medical Center
34	12:41	12:43	12:45	12:47	12:50	12:52	12:54	12:56	12:58	13:00	13:02	13:06	13:08	13:10	13:12	13:15	13:17	13:19	13:23	13:26	13:29	13:31	13:34	13:37	13:39	13:40
35	12:56	12:58	13:00	13:02	13:05	13:07	13:09	13:11	13:13	13:15	13:17	13:21	13:23	13:25	13:27	13:30	13:32	13:34	13:38	13:41	13:44	13:46	13:49	13:52	13:54	13:55
36	13:11	13:13	13:15	13:17	13:20	13:22	13:24	13:26	13:28	13:30	13:32	13:36	13:38	13:40	13:42	13:45	13:47	13:49	13:53	13:56	13:59	14:01	14:04	14:07	14:09	14:10
37	13:26	13:28	13:30	13:32	13:35	13:37	13:39	13:41	13:43	13:45	13:47	13:51	13:53	13:55	13:57	14:00	14:02	14:04	14:08	14:11	14:14	14:16	14:19	14:22	14:24	14:25
38	13:41	13:43	13:45	13:47	13:50	13:52	13:54	13:56	13:58	14:00	14:02	14:06	14:08	14:10	14:12	14:15	14:17	14:19	14:23	14:26	14:29	14:31	14:34	14:37	14:39	14:40
30	13:56	13:58	14:00	14:02	14:05	14:07	14:09	14:11	14:13	14:15	14:17	14:21	14:23	14:25	14:27	14:30	14:32	14:34	14:38	14:41	14:44	14:46	14:49	14:52	14:54	14:55
31	14:11	14:13	14:15	14:17	14:20	14:22	14:24	14:26	14:28	14:30	14:32	14:36	14:38	14:40	14:42	14:45	14:47	14:49	14:53	14:56	14:59	15:01	15:04	15:07	15:09	15:10
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33	14:41	14:43	14:45	14:47	14:50	14:52	14:54	14:56	14:58	15:00	15:02	15:06	15:08	15:10	15:12	15:15	15:17	15:19	15:23	15:26	15:29	15:31	15:34	15:37	15:39	15:40
34	14:56	14:58	15:00	15:02	15:05	15:07	15:09	15:11	15:13	15:15	15:17	15:21	15:23	15:25	15:27	15:30	15:32	15:34	15:38	15:41	15:44	15:46	15:49	15:52	15:54	15:55
35	15:11	15:13	15:15	15:17	15:20	15:22	15:24	15:26	15:28	15:30	15:32	15:36	15:38	15:40	15:42	15:45	15:47	15:49	15:53	15:56	15:59	16:01	16:04	16:07	16:09	16:10
36	15:26	15:28	15:30	15:32	15:35	15:37	15:39	15:41	15:43	15:45	15:47	15:51	15:53	15:55	15:57	16:00	16:02	16:04	16:08	16:11	16:14	16:16	16:19	16:22	16:24	16:25
37	15:41	15:43	15:45	15:47	15:50	15:52	15:54	15:56	15:58	16:00	16:02	16:06	16:08	16:10	16:12	16:15	16:17	16:19	16:23	16:26	16:29	16:31	16:34	16:37	16:39	16:40
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31	16:26	16:28	16:30	16:32	16:35	16:37	16:39	16:41	16:43	16:45	16:47	16:51	16:53	16:55	16:57	17:00	17:02	17:04	17:08	17:11	17:14	17:16	17:19	17:22	17:24	17:25
32	16:41	16:43	16:45	16:47	16:50	16:52	16:54	16:56	16:58	17:00	17:02	17:06	17:08	17:10	17:12	17:15	17:17	17:19	17:23	17:26	17:29	17:31	17:34	17:37	17:39	17:40
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34	17:11	17:13	17:15	17:17	17:20	17:22	17:24	17:26	17:28	17:30	17:32	17:36	17:38	17:40	17:42	17:45	17:47	17:49	17:53	17:56	17:59	18:01	18:04	18:07	18:09	18:10
35	17:26	17:28	17:30	17:32	17:35	17:37	17:39	17:41	17:43	17:45	17:47	17:51	17:53	17:55	17:57	18:00	18:02	18:04	18:08	18:11	18:14	18:16	18:19	18:22	18:24	18:25
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30	20:41	20:43	20:45	20:47	20:50	20:52	20:54	20:56	20:58	21:00	21:02	21:06	21:08	21:10	21:12	21:15	21:17	21:19	21:23	21:26	21:29	21:31	21:34	21:37	21:39	21:40
31	20:56	20:58	21:00	21:02	21:05	21:07	21:09	21:11	21:13	21:15	21:17	21:21	21:23	21:25	21:27	21:30	21:32	21:34	21:38	21:41	21:44	21:46	21:49	21:52	21:54	21:55
32	21:11	21:13	21:15	21:17	21:20	21:22	21:24	21:26	21:28	21:30	21:32	21:36	21:38	21:40	21:42	21:45	21:47	21:49	21:53	21:56	21:59	22:01	22:04	22:07	22:09	22:10
33	21:26	21:28	21:30	21:32	21:35	21:37	21:39	21:41	21:43	21:45	21:47	21:51	21:53	21:55	21:57	22:00	22:02	22:04	22:08	22:11	22:14	22:16	22:19	22:22	22:24	22:25
34	21:41	21:43	21:45	21:47	21:50	21:52	21:54	21:56	21:58	22:00	22:02	22:06	22:08	22:10	22:12	22:15	22:17	22:19	22:23	22:26	22:29	22:31	22:34	22:37	22:39	22:40

Table 81 – Red Line - Northbound

Train	Daybreak Parkway	South Jordan Parkway	5600 West Old Bingham	4800 West Old Bingham	Jordan Valley	2700 W Sugar Factory Rd	West Jordan City Center	Historic Gardner	Bingham Junction	MRSC Relief Stop	Fashion Place West	Murray Central	Murray North	Meadowbrook	Millcreek	Central Pointe	Ballpark	900 South	Courthouse	Library	Trolley	900 East	Stadium	South Campus	Fort Douglas	Medical Center
35	21:56	21:58	22:00	22:02	22:05	22:07	22:09	22:11	22:13	22:15	22:17	22:21	22:23	22:25	22:27	22:30	22:32	22:34	22:38	22:41	22:44	22:46	22:49	22:52	22:54	22:55
36	22:11	22:13	22:15	22:17	22:20	22:22	22:24	22:26	22:28	22:30	22:32	22:36	22:38	22:40	22:42	22:45	22:47	22:49	22:53	22:56	22:59	23:01	23:04	23:07	23:09	23:10
37	22:26	22:28	22:30	22:32	22:35	22:37	22:39	22:41	22:43	22:45	22:47	22:51	22:53	22:55	22:57	23:00	23:02	23:04	23:08	23:11	23:14	23:16	23:19	23:22	23:24	23:25
38	22:41	22:43	22:45	22:47	22:50	22:52	22:54	22:56	22:58	23:00	23:02	23:06	23:08	23:10	23:12	23:15										
30	22:56	22:58	23:00	23:02	23:05	23:07	23:09	23:11	23:13	23:15	23:17	23:21	23:23	23:25	23:27	23:30										
31	23:11	23:13	23:15	23:17	23:20	23:22	23:24	23:26	23:28	23:30	23:32	23:36	23:38	23:40	23:42	23:45										
32	23:26	23:28	23:30	23:32	23:35	23:37	23:39	23:41	23:43	23:45	23:47	23:51	23:53	23:55	23:57	0:00										

Table 82 – Red Line - Southbound

Train	Medical Center	Fort Douglas	South Campus	Stadium	900 East	Trolley	Library	Courthouse	900 South	Ballpark	Central Pointe	Millcreek	Meadowbrook	Murray North	Murray Central	Fashion Place West	MRSC Relief Stop	Bingham Junction	Historic Gardner	West Jordan City Center	2700 W Sugar Factory Rd	Jordan Valley	4800 West Old Bingham	5600 West Old Bingham	South Jordan Parkway	Daybreak Parkway
22											4:33	4:36	4:38	4:40	4:42	4:46										
33											5:00	5:03	5:05	5:07	5:09	5:13	5:15	5:17	5:19	5:20	5:23	5:25	5:28	5:30	5:32	5:34
34											5:15	5:18	5:20	5:22	5:24	5:28	5:30	5:32	5:34	5:35	5:38	5:40	5:43	5:45	5:47	5:49
35											5:30	5:33	5:35	5:37	5:39	5:43	5:45	5:47	5:49	5:50	5:53	5:55	5:58	6:00	6:02	6:04
20											5:38	5:41	5:43	5:45	5:47	5:51										
36											5:45	5:48	5:50	5:52	5:54	5:58	6:00	6:02	6:04	6:05	6:08	6:10	6:13	6:15	6:17	6:19
21											5:53	5:56	5:58	6:00	6:02	6:06										
37	5:34	5:35	5:37	5:40	5:43	5:45	5:48	5:52	5:56	5:58	6:00	6:03	6:05	6:07	6:09	6:13	6:15	6:17	6:19	6:20	6:23	6:25	6:28	6:30	6:32	6:34
38	5:49	5:50	5:52	5:55	5:58	6:00	6:03	6:07	6:11	6:13	6:15	6:18	6:20	6:22	6:24	6:28	6:30	6:32	6:34	6:35	6:38	6:40	6:43	6:45	6:47	6:49
30	6:04	6:05	6:07	6:10	6:13	6:15	6:18	6:22	6:26	6:28	6:30	6:33	6:35	6:37	6:39	6:43	6:45	6:47	6:49	6:50	6:53	6:55	6:58	7:00	7:02	7:04
31	6:19	6:20	6:22	6:25	6:28	6:30	6:33	6:37	6:41	6:43	6:45	6:48	6:50	6:52	6:54	6:58	7:00	7:02	7:04	7:05	7:08	7:10	7:13	7:15	7:17	7:19
32	6:34	6:35	6:37	6:40	6:43	6:45	6:48	6:52	6:56	6:58	7:00	7:03	7:05	7:07	7:09	7:13	7:15	7:17	7:19	7:20	7:23	7:25	7:28	7:30	7:32	7:34
33	6:49	6:50	6:52	6:55	6:58	7:00	7:03	7:07	7:11	7:13	7:15	7:18	7:20	7:22	7:24	7:28	7:30	7:32	7:34	7:35	7:38	7:40	7:43	7:45	7:47	7:49
34	7:04	7:05	7:07	7:10	7:13	7:15	7:18	7:22	7:26	7:28	7:30	7:33	7:35	7:37	7:39	7:43	7:45	7:47	7:49	7:50	7:53	7:55	7:58	8:00	8:02	8:04
35	7:19	7:20	7:22	7:25	7:28	7:30	7:33	7:37	7:41	7:43	7:45	7:48	7:50	7:52	7:54	7:58	8:00	8:02	8:04	8:05	8:08	8:10	8:13	8:15	8:17	8:19
36	7:34	7:35	7:37	7:40	7:43	7:45	7:48	7:52	7:56	7:58	8:00	8:03	8:05	8:07	8:09	8:13	8:15	8:17	8:19	8:20	8:23	8:25	8:28	8:30	8:32	8:34
37	7:49	7:50	7:52	7:55	7:58	8:00	8:03	8:07	8:11	8:13	8:15	8:18	8:20	8:22	8:24	8:28	8:30	8:32	8:34	8:35	8:38	8:40	8:43	8:45	8:47	8:49
38	8:04	8:05	8:07	8:10	8:13	8:15	8:18	8:22	8:26	8:28	8:30	8:33	8:35	8:37	8:39	8:43	8:45	8:47	8:49	8:50	8:53	8:55	8:58	9:00	9:02	9:04
20	8:11	8:12	8:14	8:17	8:20	8:22	8:25	8:29	8:33	8:35	8:37															
30	8:19	8:20	8:22	8:25	8:28	8:30	8:33	8:37	8:41	8:43	8:45	8:48	8:50	8:52	8:54	8:58	9:00	9:02	9:04	9:05	9:08	9:10	9:13	9:15	9:17	9:19
31	8:34	8:35	8:37	8:40	8:43	8:45	8:48	8:52	8:56	8:58	9:00	9:03	9:05	9:07	9:09	9:13	9:15	9:17	9:19	9:20	9:23	9:25	9:28	9:30	9:32	9:34
21	8:41	8:42	8:44	8:47	8:50	8:52	8:55	8:59	9:03	9:05	9:07															
32	8:49	8:50	8:52	8:55	8:58	9:00	9:03	9:07	9:11	9:13	9:15	9:18	9:20	9:22	9:24	9:28	9:30	9:32	9:34	9:35	9:38	9:40	9:43	9:45	9:47	9:49
33	9:04	9:05	9:07	9:10	9:13	9:15	9:18	9:22	9:26	9:28	9:30	9:33	9:35	9:37	9:39	9:43	9:45	9:47	9:49	9:50	9:53	9:55	9:58	10:00	10:02	10:04
22	9:10	9:11	9:13	9:16	9:19	9:21	9:24	9:28	9:32	9:34	9:36															
34	9:19	9:20	9:22	9:25	9:28	9:30	9:33	9:37	9:41	9:43	9:45	9:48	9:50	9:52	9:54	9:58	10:00	10:02	10:04	10:05	10:08	10:10	10:13	10:15	10:17	10:19
52	9:26	9:27	9:29	9:32	9:35	9:37	9:40	9:44	9:48	9:50	9:52															
35	9:34	9:35	9:37	9:40	9:43	9:45	9:48	9:52	9:56	9:58	10:00	10:03	10:05	10:07	10:09	10:13	10:15	10:17	10:19	10:20	10:23	10:25	10:28	10:30	10:32	10:34
36	9:49	9:50	9:52	9:55	9:58	10:00	10:03	10:07	10:11	10:13	10:15	10:18	10:20	10:22	10:24	10:28	10:30	10:32	10:34	10:35	10:38	10:40	10:43	10:45	10:47	10:49

Table 82 – Red Line - Southbound

Train	Medical Center	Fort Douglas	South Campus	Stadium	900 East	Trolley	Library	Courthouse	900 South	Ballpark	Central Pointe	Millcreek	Meadowbrook	Murray North	Murray Central	Fashion Place West	MRSC Relief Stop	Bingham Junction	Historic Gardner	West Jordan City Center	2700 W Sugar Factory Rd	Jordan Valley	4800 West Old Bingham	5600 West Old Bingham	South Jordan Parkway	Daybreak Parkway
37	10:04	10:05	10:07	10:10	10:13	10:15	10:18	10:22	10:26	10:28	10:30	10:33	10:35	10:37	10:39	10:43	10:45	10:47	10:49	10:50	10:53	10:55	10:58	11:00	11:02	11:04
38	10:19	10:20	10:22	10:25	10:28	10:30	10:33	10:37	10:41	10:43	10:45	10:48	10:50	10:52	10:54	10:58	11:00	11:02	11:04	11:05	11:08	11:10	11:13	11:15	11:17	11:19
30	10:34	10:35	10:37	10:40	10:43	10:45	10:48	10:52	10:56	10:58	11:00	11:03	11:05	11:07	11:09	11:13	11:15	11:17	11:19	11:20	11:23	11:25	11:28	11:30	11:32	11:34
31	10:49	10:50	10:52	10:55	10:58	11:00	11:03	11:07	11:11	11:13	11:15	11:18	11:20	11:22	11:24	11:28	11:30	11:32	11:34	11:35	11:38	11:40	11:43	11:45	11:47	11:49
32	11:04	11:05	11:07	11:10	11:13	11:15	11:18	11:22	11:26	11:28	11:30	11:33	11:35	11:37	11:39	11:43	11:45	11:47	11:49	11:50	11:53	11:55	11:58	12:00	12:02	12:04
33	11:19	11:20	11:22	11:25	11:28	11:30	11:33	11:37	11:41	11:43	11:45	11:48	11:50	11:52	11:54	11:58	12:00	12:02	12:04	12:05	12:08	12:10	12:13	12:15	12:17	12:19
34	11:34	11:35	11:37	11:40	11:43	11:45	11:48	11:52	11:56	11:58	12:00	12:03	12:05	12:07	12:09	12:13	12:15	12:17	12:19	12:20	12:23	12:25	12:28	12:30	12:32	12:34
35	11:49	11:50	11:52	11:55	11:58	12:00	12:03	12:07	12:11	12:13	12:15	12:18	12:20	12:22	12:24	12:28	12:30	12:32	12:34	12:35	12:38	12:40	12:43	12:45	12:47	12:49
36	12:04	12:05	12:07	12:10	12:13	12:15	12:18	12:22	12:26	12:28	12:30	12:33	12:35	12:37	12:39	12:43	12:45	12:47	12:49	12:50	12:53	12:55	12:58	13:00	13:02	13:04
37	12:19	12:20	12:22	12:25	12:28	12:30	12:33	12:37	12:41	12:43	12:45	12:48	12:50	12:52	12:54	12:58	13:00	13:02	13:04	13:05	13:08	13:10	13:13	13:15	13:17	13:19
38	12:34	12:35	12:37	12:40	12:43	12:45	12:48	12:52	12:56	12:58	13:00	13:03	13:05	13:07	13:09	13:13	13:15	13:17	13:19	13:20	13:23	13:25	13:28	13:30	13:32	13:34
30	12:49	12:50	12:52	12:55	12:58	13:00	13:03	13:07	13:11	13:13	13:15	13:18	13:20	13:22	13:24	13:28	13:30	13:32	13:34	13:35	13:38	13:40	13:43	13:45	13:47	13:49
31	13:04	13:05	13:07	13:10	13:13	13:15	13:18	13:22	13:26	13:28	13:30	13:33	13:35	13:37	13:39	13:43	13:45	13:47	13:49	13:50	13:53	13:55	13:58	14:00	14:02	14:04
32	13:19	13:20	13:22	13:25	13:28	13:30	13:33	13:37	13:41	13:43	13:45	13:48	13:50	13:52	13:54	13:58	14:00	14:02	14:04	14:05	14:08	14:10	14:13	14:15	14:17	14:19
33	13:34	13:35	13:37	13:40	13:43	13:45	13:48	13:52	13:56	13:58	14:00	14:03	14:05	14:07	14:09	14:13	14:15	14:17	14:19	14:20	14:23	14:25	14:28	14:30	14:32	14:34
34	13:49	13:50	13:52	13:55	13:58	14:00	14:03	14:07	14:11	14:13	14:15	14:18	14:20	14:22	14:24	14:28	14:30	14:32	14:34	14:35	14:38	14:40	14:43	14:45	14:47	14:49
35	14:04	14:05	14:07	14:10	14:13	14:15	14:18	14:22	14:26	14:28	14:30	14:33	14:35	14:37	14:39	14:43	14:45	14:47	14:49	14:50	14:53	14:55	14:58	15:00	15:02	15:04
36	14:19	14:20	14:22	14:25	14:28	14:30	14:33	14:37	14:41	14:43	14:45	14:48	14:50	14:52	14:54	14:58	15:00	15:02	15:04	15:05	15:08	15:10	15:13	15:15	15:17	15:19
37	14:34	14:35	14:37	14:40	14:43	14:45	14:48	14:52	14:56	14:58	15:00	15:03	15:05	15:07	15:09	15:13	15:15	15:17	15:19	15:20	15:23	15:25	15:28	15:30	15:32	15:34
38	14:49	14:50	14:52	14:55	14:58	15:00	15:03	15:07	15:11	15:13	15:15	15:18	15:20	15:22	15:24	15:28	15:30	15:32	15:34	15:35	15:38	15:40	15:43	15:45	15:47	15:49
30	15:04	15:05	15:07	15:10	15:13	15:15	15:18	15:22	15:26	15:28	15:30	15:33	15:35	15:37	15:39	15:43	15:45	15:47	15:49	15:50	15:53	15:55	15:58	16:00	16:02	16:04
31	15:19	15:20	15:22	15:25	15:28	15:30	15:33	15:37	15:41	15:43	15:45	15:48	15:50	15:52	15:54	15:58	16:00	16:02	16:04	16:05	16:08	16:10	16:13	16:15	16:17	16:19
32	15:34	15:35	15:37	15:40	15:43	15:45	15:48	15:52	15:56	15:58	16:00	16:03	16:05	16:07	16:09	16:13	16:15	16:17	16:19	16:20	16:23	16:25	16:28	16:30	16:32	16:34
33	15:49	15:50	15:52	15:55	15:58	16:00	16:03	16:07	16:11	16:13	16:15	16:18	16:20	16:22	16:24	16:28	16:30	16:32	16:34	16:35	16:38	16:40	16:43	16:45	16:47	16:49
34	16:04	16:05	16:07	16:10	16:13	16:15	16:18	16:22	16:26	16:28	16:30	16:33	16:35	16:37	16:39	16:43	16:45	16:47	16:49	16:50	16:53	16:55	16:58	17:00	17:02	17:04
35	16:19	16:20	16:22	16:25	16:28	16:30	16:33	16:37	16:41	16:43	16:45	16:48	16:50	16:52	16:54	16:58	17:00	17:02	17:04	17:05	17:08	17:10	17:13	17:15	17:17	17:19
36	16:34	16:35	16:37	16:40	16:43	16:45	16:48	16:52	16:56	16:58	17:00	17:03	17:05	17:07	17:09	17:13	17:15	17:17	17:19	17:20	17:23	17:25	17:28	17:30	17:32	17:34
37	16:49	16:50	16:52	16:55	16:58	17:00	17:03	17:07	17:11	17:13	17:15	17:18	17:20	17:22	17:24	17:28	17:30	17:32	17:34	17:35	17:38	17:40	17:43	17:45	17:47	17:49
38	17:04	17:05	17:07	17:10	17:13	17:15	17:18	17:22	17:26	17:28	17:30	17:33	17:35	17:37	17:39	17:43	17:45	17:47	17:49	17:50	17:53	17:55	17:58	18:00	18:02	18:04

Table 82 – Red Line - Southbound																										
Train	**Medical Center**	**Fort Douglas**	**South Campus**	**Stadium**	**900 East**	**Trolley**	**Library**	**Courthouse**	**900 South**	**Ballpark**	**Central Pointe**	**Millcreek**	**Meadowbrook**	**Murray North**	**Murray Central**	**Fashion Place West**	**MRSC Relief Stop**	**Bingham Junction**	**Historic Gardner**	**West Jordan City Center**	**2700 W Sugar Factory Rd**	**Jordan Valley**	**4800 West Old Bingham**	**5600 West Old Bingham**	**South Jordan Parkway**	**Daybreak Parkway**
30	17:19	17:20	17:22	17:25	17:28	17:30	17:33	17:37	17:41	17:43	17:45	17:48	17:50	17:52	17:54	17:58	18:00	18:02	18:04	18:05	18:08	18:10	18:13	18:15	18:17	18:19
31	17:34	17:35	17:37	17:40	17:43	17:45	17:48	17:52	17:56	17:58	18:00	18:03	18:05	18:07	18:09	18:13	18:15	18:17	18:19	18:20	18:23	18:25	18:28	18:30	18:32	18:34
32	17:49	17:50	17:52	17:55	17:58	18:00	18:03	18:07	18:11	18:13	18:15	18:18	18:20	18:22	18:24	18:28	18:30	18:32	18:34	18:35	18:38	18:40	18:43	18:45	18:47	18:49
33	18:04	18:05	18:07	18:10	18:13	18:15	18:18	18:22	18:26	18:28	18:30	18:33	18:35	18:37	18:39	18:43	18:45	18:47	18:49	18:50	18:53	18:55	18:58	19:00	19:02	19:04
34	18:19	18:20	18:22	18:25	18:28	18:30	18:33	18:37	18:41	18:43	18:45	18:48	18:50	18:52	18:54	18:58	19:00	19:02	19:04	19:05	19:08	19:10	19:13	19:15	19:17	19:19
35	18:34	18:35	18:37	18:40	18:43	18:45	18:48	18:52	18:56	18:58	19:00	19:03	19:05	19:07	19:09	19:13	19:15	19:17	19:19	19:20	19:23	19:25	19:28	19:30	19:32	19:34
36	18:49	18:50	18:52	18:55	18:58	19:00	19:03	19:07	19:11	19:13	19:15	19:18	19:20	19:22	19:24	19:28	19:30	19:32	19:34	19:35	19:38	19:40	19:43	19:45	19:47	19:49
37	19:04	19:05	19:07	19:10	19:13	19:15	19:18	19:22	19:26	19:28	19:30	19:33	19:35	19:37	19:39	19:43	19:45	19:47	19:49	19:50	19:53	19:55	19:58	20:00	20:02	20:04
38	19:19	19:20	19:22	19:25	19:28	19:30	19:33	19:37	19:41	19:43	19:45	19:48	19:50	19:52	19:54	19:58	20:00	20:02	20:04	20:05	20:08	20:10	20:13	20:15	20:17	20:19
30	19:34	19:35	19:37	19:40	19:43	19:45	19:48	19:52	19:56	19:58	20:00	20:03	20:05	20:07	20:09	20:13	20:15	20:17	20:19	20:20	20:23	20:25	20:28	20:30	20:32	20:34
31	19:49	19:50	19:52	19:55	19:58	20:00	20:03	20:07	20:11	20:13	20:15	20:18	20:20	20:22	20:24	20:28	20:30	20:32	20:34	20:35	20:38	20:40	20:43	20:45	20:47	20:49
32	20:04	20:05	20:07	20:10	20:13	20:15	20:18	20:22	20:26	20:28	20:30	20:33	20:35	20:37	20:39	20:43	20:45	20:47	20:49	20:50	20:53	20:55	20:58	21:00	21:02	21:04
33	20:19	20:20	20:22	20:25	20:28	20:30	20:33	20:37	20:41	20:43	20:45	20:48	20:50	20:52	20:54	20:58	21:00	21:02	21:04	21:05	21:08	21:10	21:13	21:15	21:17	21:19
34	20:34	20:35	20:37	20:40	20:43	20:45	20:48	20:52	20:56	20:58	21:00	21:03	21:05	21:07	21:09	21:13	21:15	21:17	21:19	21:20	21:23	21:25	21:28	21:30	21:32	21:34
35	20:49	20:50	20:52	20:55	20:58	21:00	21:03	21:07	21:11	21:13	21:15	21:18	21:20	21:22	21:24	21:28	21:30	21:32	21:34	21:35	21:38	21:40	21:43	21:45	21:47	21:49
36	21:04	21:05	21:07	21:10	21:13	21:15	21:18	21:22	21:26	21:28	21:30	21:33	21:35	21:37	21:39	21:43	21:45	21:47	21:49	21:50	21:53	21:55	21:58	22:00	22:02	22:04
37	21:19	21:20	21:22	21:25	21:28	21:30	21:33	21:37	21:41	21:43	21:45	21:48	21:50	21:52	21:54	21:58	22:00	22:02	22:04	22:05	22:08	22:10	22:13	22:15	22:17	22:19
38	21:34	21:35	21:37	21:40	21:43	21:45	21:48	21:52	21:56	21:58	22:00	22:03	22:05	22:07	22:09	22:13	22:15	22:17	22:19	22:20	22:23	22:25	22:28	22:30	22:32	22:34
30	21:49	21:50	21:52	21:55	21:58	22:00	22:03	22:07	22:11	22:13	22:15	22:18	22:20	22:22	22:24	22:28	22:30	22:32	22:34	22:35	22:38	22:40	22:43	22:45	22:47	22:49
31	22:04	22:05	22:07	22:10	22:13	22:15	22:18	22:22	22:26	22:28	22:30	22:33	22:35	22:37	22:39	22:43	22:45	22:47	22:49	22:50	22:53	22:55	22:58	23:00	23:02	23:04
32	22:19	22:20	22:22	22:25	22:28	22:30	22:33	22:37	22:41	22:43	22:45	22:48	22:50	22:52	22:54	22:58	23:00	23:02	23:04	23:05	23:08	23:10	23:13	23:15	23:17	23:19
33	22:34	22:35	22:37	22:40	22:43	22:45	22:48	22:52	22:56	22:58	23:00	23:03	23:05	23:07	23:09	23:13	23:15	23:17	23:19	23:20	23:23	23:25	23:28	23:30	23:32	23:34
34	22:49	22:50	22:52	22:55	22:58	23:00	23:03	23:07	23:11	23:13	23:15	23:18	23:20	23:22	23:24	23:28	23:30	23:32	23:34	23:35	23:38	23:40	23:43	23:45	23:47	23:49
35	23:04	23:05	23:07	23:10	23:13	23:15	23:18	23:22	23:26	23:28	23:30															
36	23:19	23:20	23:22	23:25	23:28	23:30	23:33	23:37	23:41	23:43	23:45															
37	23:34	23:35	23:37	23:40	23:43	23:45	23:48	23:52	23:56	23:58	0:00															

Table 83 – Green Line - Northbound																			
Train	West Valley Central	Decker Lake	Redwood Junction	River Trail	JRSC Relief Stop	Central Pointe	Ballpark	900 South	Courthouse	Gallivan Plaza	City Center	Temple Square	Arena	NTB/Guadalupe	Jackson/Euclid	Fairpark	Power	1940 W North Temple	Airport
46						4:53	4:55	4:57	5:01	5:03	5:05	5:07	5:09	5:12	5:14	5:16	5:17	5:20	5:26
47						5:05	5:07	5:09	5:13	5:15	5:17	5:19	5:21	5:24	5:26	5:28	5:29	5:32	5:38
40	5:05	5:09	5:12	5:15	5:16	5:20	5:22	5:24	5:28	5:30	5:32	5:34	5:36	5:39	5:41	5:43	5:44	5:47	5:53
41	5:20	5:24	5:27	5:30	5:31	5:35	5:37	5:39	5:43	5:45	5:47	5:49	5:51	5:54	5:56	5:58	5:59	6:02	6:08
42	5:35	5:39	5:42	5:45	5:46	5:50	5:52	5:54	5:58	6:00	6:02	6:04	6:06	6:09	6:11	6:13	6:14	6:17	6:23
43	5:50	5:54	5:57	6:00	6:01	6:05	6:07	6:09	6:13	6:15	6:17	6:19	6:21	6:24	6:26	6:28	6:29	6:32	6:38
44	6:05	6:09	6:12	6:15	6:16	6:20	6:22	6:24	6:28	6:30	6:32	6:34	6:36	6:39	6:41	6:43	6:44	6:47	6:53
45	6:20	6:24	6:27	6:30	6:31	6:35	6:37	6:39	6:43	6:45	6:47	6:49	6:51	6:54	6:56	6:58	6:59	7:02	7:08
46	6:35	6:39	6:42	6:45	6:46	6:50	6:52	6:54	6:58	7:00	7:02	7:04	7:06	7:09	7:11	7:13	7:14	7:17	7:23
47	6:50	6:54	6:57	7:00	7:01	7:05	7:07	7:09	7:13	7:15	7:17	7:19	7:21	7:24	7:26	7:28	7:29	7:32	7:38
40	7:05	7:09	7:12	7:15	7:16	7:20	7:22	7:24	7:28	7:30	7:32	7:34	7:36	7:39	7:41	7:43	7:44	7:47	7:53
41	7:20	7:24	7:27	7:30	7:31	7:35	7:37	7:39	7:43	7:45	7:47	7:49	7:51	7:54	7:56	7:58	7:59	8:02	8:08
42	7:35	7:39	7:42	7:45	7:46	7:50	7:52	7:54	7:58	8:00	8:02	8:04	8:06	8:09	8:11	8:13	8:14	8:17	8:23
43	7:50	7:54	7:57	8:00	8:01	8:05	8:07	8:09	8:13	8:15	8:17	8:19	8:21	8:24	8:26	8:28	8:29	8:32	8:38
44	8:05	8:09	8:12	8:15	8:16	8:20	8:22	8:24	8:28	8:30	8:32	8:34	8:36	8:39	8:41	8:43	8:44	8:47	8:53
45	8:20	8:24	8:27	8:30	8:31	8:35	8:37	8:39	8:43	8:45	8:47	8:49	8:51	8:54	8:56	8:58	8:59	9:02	9:08
46	8:35	8:39	8:42	8:45	8:46	8:50	8:52	8:54	8:58	9:00	9:02	9:04	9:06	9:09	9:11	9:13	9:14	9:17	9:23
47	8:50	8:54	8:57	9:00	9:01	9:05	9:07	9:09	9:13	9:15	9:17	9:19	9:21	9:24	9:26	9:28	9:29	9:32	9:38
40	9:05	9:09	9:12	9:15	9:16	9:20	9:22	9:24	9:28	9:30	9:32	9:34	9:36	9:39	9:41	9:43	9:44	9:47	9:53
20	9:08	9:12	9:15	9:18															
41	9:20	9:24	9:27	9:30	9:31	9:35	9:37	9:39	9:43	9:45	9:47	9:49	9:51	9:54	9:56	9:58	9:59	10:02	10:08
42	9:35	9:39	9:42	9:45	9:46	9:50	9:52	9:54	9:58	10:00	10:02	10:04	10:06	10:09	10:11	10:13	10:14	10:17	10:23
21	9:38	9:42	9:45	9:48															
43	9:50	9:54	9:57	10:00	10:01	10:05	10:07	10:09	10:13	10:15	10:17	10:19	10:21	10:24	10:26	10:28	10:29	10:32	10:38
44	10:05	10:09	10:12	10:15	10:16	10:20	10:22	10:24	10:28	10:30	10:32	10:34	10:36	10:39	10:41	10:43	10:44	10:47	10:53
22	10:06	10:11	10:14	10:17															

Table 83 – Green Line - Northbound																			
Train	**West Valley Central**	**Decker Lake**	**Redwood Junction**	**River Trail**	**JRSC Relief Stop**	**Central Pointe**	**Ballpark**	**900 South**	**Courthouse**	**Gallivan Plaza**	**City Center**	**Temple Square**	**Arena**	**NTB/Guadalupe**	**Jackson/Euclid**	**Fairpark**	**Power**	**1940 W North Temple**	**Airport**
45	10:20	10:24	10:27	10:30	10:31	10:35	10:37	10:39	10:43	10:45	10:47	10:49	10:51	10:54	10:56	10:58	10:59	11:02	11:08
52	10:23	10:27	10:30	10:33															
46	10:35	10:39	10:42	10:45	10:46	10:50	10:52	10:54	10:58	11:00	11:02	11:04	11:06	11:09	11:11	11:13	11:14	11:17	11:23
47	10:50	10:54	10:57	11:00	11:01	11:05	11:07	11:09	11:13	11:15	11:17	11:19	11:21	11:24	11:26	11:28	11:29	11:32	11:38
40	11:05	11:09	11:12	11:15	11:16	11:20	11:22	11:24	11:28	11:30	11:32	11:34	11:36	11:39	11:41	11:43	11:44	11:47	11:53
41	11:20	11:24	11:27	11:30	11:31	11:35	11:37	11:39	11:43	11:45	11:47	11:49	11:51	11:54	11:56	11:58	11:59	12:02	12:08
42	11:35	11:39	11:42	11:45	11:46	11:50	11:52	11:54	11:58	12:00	12:02	12:04	12:06	12:09	12:11	12:13	12:14	12:17	12:23
43	11:50	11:54	11:57	12:00	12:01	12:05	12:07	12:09	12:13	12:15	12:17	12:19	12:21	12:24	12:26	12:28	12:29	12:32	12:38
44	12:05	12:09	12:12	12:15	12:16	12:20	12:22	12:24	12:28	12:30	12:32	12:34	12:36	12:39	12:41	12:43	12:44	12:47	12:53
45	12:20	12:24	12:27	12:30	12:31	12:35	12:37	12:39	12:43	12:45	12:47	12:49	12:51	12:54	12:56	12:58	12:59	13:02	13:08
46	12:35	12:39	12:42	12:45	12:46	12:50	12:52	12:54	12:58	13:00	13:02	13:04	13:06	13:09	13:11	13:13	13:14	13:17	13:23
47	12:50	12:54	12:57	13:00	13:01	13:05	13:07	13:09	13:13	13:15	13:17	13:19	13:21	13:24	13:26	13:28	13:29	13:32	13:38
40	13:05	13:09	13:12	13:15	13:16	13:20	13:22	13:24	13:28	13:30	13:32	13:34	13:36	13:39	13:41	13:43	13:44	13:47	13:53
41	13:20	13:24	13:27	13:30	13:31	13:35	13:37	13:39	13:43	13:45	13:47	13:49	13:51	13:54	13:56	13:58	13:59	14:02	14:08
42	13:35	13:39	13:42	13:45	13:46	13:50	13:52	13:54	13:58	14:00	14:02	14:04	14:06	14:09	14:11	14:13	14:14	14:17	14:23
43	13:50	13:54	13:57	14:00	14:01	14:05	14:07	14:09	14:13	14:15	14:17	14:19	14:21	14:24	14:26	14:28	14:29	14:32	14:38
44	14:05	14:09	14:12	14:15	14:16	14:20	14:22	14:24	14:28	14:30	14:32	14:34	14:36	14:39	14:41	14:43	14:44	14:47	14:53
45	14:20	14:24	14:27	14:30	14:31	14:35	14:37	14:39	14:43	14:45	14:47	14:49	14:51	14:54	14:56	14:58	14:59	15:02	15:08
46	14:35	14:39	14:42	14:45	14:46	14:50	14:52	14:54	14:58	15:00	15:02	15:04	15:06	15:09	15:11	15:13	15:14	15:17	15:23
47	14:50	14:54	14:57	15:00	15:01	15:05	15:07	15:09	15:13	15:15	15:17	15:19	15:21	15:24	15:26	15:28	15:29	15:32	15:38
40	15:05	15:09	15:12	15:15	15:16	15:20	15:22	15:24	15:28	15:30	15:32	15:34	15:36	15:39	15:41	15:43	15:44	15:47	15:53
41	15:20	15:24	15:27	15:30	15:31	15:35	15:37	15:39	15:43	15:45	15:47	15:49	15:51	15:54	15:56	15:58	15:59	16:02	16:08
42	15:35	15:39	15:42	15:45	15:46	15:50	15:52	15:54	15:58	16:00	16:02	16:04	16:06	16:09	16:11	16:13	16:14	16:17	16:23
43	15:50	15:54	15:57	16:00	16:01	16:05	16:07	16:09	16:13	16:15	16:17	16:19	16:21	16:24	16:26	16:28	16:29	16:32	16:38
44	16:05	16:09	16:12	16:15	16:16	16:20	16:22	16:24	16:28	16:30	16:32	16:34	16:36	16:39	16:41	16:43	16:44	16:47	16:53
45	16:20	16:24	16:27	16:30	16:31	16:35	16:37	16:39	16:43	16:45	16:47	16:49	16:51	16:54	16:56	16:58	16:59	17:02	17:08

Train	West Valley Central	Decker Lake	Redwood Junction	River Trail	JRSC Relief Stop	Central Pointe	Ballpark	900 South	Courthouse	Gallivan Plaza	City Center	Temple Square	Arena	NTB/Guadalupe	Jackson/Euclid	Fairpark	Power	1940 W North Temple	Airport
Table 83 – Green Line - Northbound																			
46	16:35	16:39	16:42	16:45	16:46	16:50	16:52	16:54	16:58	17:00	17:02	17:04	17:06	17:09	17:11	17:13	17:14	17:17	17:23
47	16:50	16:54	16:57	17:00	17:01	17:05	17:07	17:09	17:13	17:15	17:17	17:19	17:21	17:24	17:26	17:28	17:29	17:32	17:38
40	17:05	17:09	17:12	17:15	17:16	17:20	17:22	17:24	17:28	17:30	17:32	17:34	17:36	17:39	17:41	17:43	17:44	17:47	17:53
41	17:20	17:24	17:27	17:30	17:31	17:35	17:37	17:39	17:43	17:45	17:47	17:49	17:51	17:54	17:56	17:58	17:59	18:02	18:08
42	17:35	17:39	17:42	17:45	17:46	17:50	17:52	17:54	17:58	18:00	18:02	18:04	18:06	18:09	18:11	18:13	18:14	18:17	18:23
43	17:50	17:54	17:57	18:00	18:01	18:05	18:07	18:09	18:13	18:15	18:17	18:19	18:21	18:24	18:26	18:28	18:29	18:32	18:38
44	18:05	18:09	18:12	18:15	18:16	18:20	18:22	18:24	18:28	18:30	18:32	18:34	18:36	18:39	18:41	18:43	18:44	18:47	18:53
45	18:20	18:24	18:27	18:30	18:31	18:35	18:37	18:39	18:43	18:45	18:47	18:49	18:51	18:54	18:56	18:58	18:59	19:02	19:08
46	18:35	18:39	18:42	18:45	18:46	18:50	18:52	18:54	18:58	19:00	19:02	19:04	19:06	19:09	19:11	19:13	19:14	19:17	19:23
47	18:50	18:54	18:57	19:00	19:01	19:05	19:07	19:09	19:13	19:15	19:17	19:19	19:21	19:24	19:26	19:28	19:29	19:32	19:38
40	19:05	19:09	19:12	19:15	19:16	19:20	19:22	19:24	19:28	19:30	19:32	19:34	19:36	19:39	19:41	19:43	19:44	19:47	19:53
41	19:20	19:24	19:27	19:30	19:31	19:35	19:37	19:39	19:43	19:45	19:47	19:49	19:51	19:54	19:56	19:58	19:59	20:02	20:08
42	19:35	19:39	19:42	19:45	19:46	19:50	19:52	19:54	19:58	20:00	20:02	20:04	20:06	20:09	20:11	20:13	20:14	20:17	20:23
43	19:50	19:54	19:57	20:00	20:01	20:05	20:07	20:09	20:13	20:15	20:17	20:19	20:21	20:24	20:26	20:28	20:29	20:32	20:38
44	20:05	20:09	20:12	20:15	20:16	20:20	20:22	20:24	20:28	20:30	20:32	20:34	20:36	20:39	20:41	20:43	20:44	20:47	20:53
45	20:20	20:24	20:27	20:30	20:31	20:35	20:37	20:39	20:43	20:45	20:47	20:49	20:51	20:54	20:56	20:58	20:59	21:02	21:08
46	20:35	20:39	20:42	20:45	20:46	20:50	20:52	20:54	20:58	21:00	21:02	21:04	21:06	21:09	21:11	21:13	21:14	21:17	21:23
47	20:50	20:54	20:57	21:00	21:01	21:05	21:07	21:09	21:13	21:15	21:17	21:19	21:21	21:24	21:26	21:28	21:29	21:32	21:38
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41	21:20	21:24	21:27	21:30	21:31	21:35	21:37	21:39	21:43	21:45	21:47	21:49	21:51	21:54	21:56	21:58	21:59	22:02	22:08
42	21:35	21:39	21:42	21:45	21:46	21:50	21:52	21:54	21:58	22:00	22:02	22:04	22:06	22:09	22:11	22:13	22:14	22:17	22:23
43	21:50	21:54	21:57	22:00	22:01	22:05	22:07	22:09	22:13	22:15	22:17	22:19	22:21	22:24	22:26	22:28	22:29	22:32	22:38
44	22:05	22:09	22:12	22:15	22:16	22:20	22:22	22:24	22:28	22:30	22:32	22:34	22:36	22:39	22:41	22:43	22:44	22:47	22:53
45	22:20	22:24	22:27	22:30	22:31	22:35	22:37	22:39	22:43	22:45	22:47	22:49	22:51	22:54	22:56	22:58	22:59	23:02	23:08
46	22:35	22:39	22:42	22:45	22:46	22:50	22:52	22:54	22:58	23:00	23:02	23:04	23:06	23:09	23:11	23:13	23:14	23:17	23:23
47	22:50	22:54	22:57	23:00															

Table 83 – Green Line - Northbound																			
Train	**West Valley Central**	**Decker Lake**	**Redwood Junction**	**River Trail**	**JRSC Relief Stop**	**Central Pointe**	**Ballpark**	**900 South**	**Courthouse**	**Gallivan Plaza**	**City Center**	**Temple Square**	**Arena**	**NTB/Guadalupe**	**Jackson/Euclid**	**Fairpark**	**Power**	**1940 W North Temple**	**Airport**
40	23:05	23:09	23:12	23:15															
41	23:20	23:24	23:27	23:30															
42	23:35	23:39	23:42	23:45															
43	23:50	23:54	23:57	0:00															
44	0:05	0:09	0:12	0:15															
45	0:20	0:24	0:27	0:30															

Table 84 – Green Line - Southbound																			
Train	Airport	1940 W North Temple	Power	Fairpark	Jackson/Euclid	NTB/Guadalupe	Arena	Temple Square	City Center	Gallivan Plaza	Courthouse	900 South	Ballpark	Central Pointe	JRSC Relief Stop	River Trail	Redwood Junction	Decker Lake	West Valley Central
40																4:50	4:53	4:56	5:00
41																5:05	5:08	5:11	5:15
42																5:20	5:23	5:26	5:30
43																5:35	5:38	5:41	5:45
44																5:50	5:53	5:56	6:00
45																6:05	6:08	6:11	6:15
46	5:38	5:43	5:46	5:47	5:49	5:52	5:54	5:56	5:58	6:00	6:02	6:06	6:08	6:10	6:12	6:14	6:17	6:20	6:24
47	5:53	5:58	6:01	6:02	6:04	6:07	6:09	6:11	6:13	6:15	6:17	6:21	6:23	6:25	6:27	6:29	6:32	6:35	6:39
40	6:08	6:13	6:16	6:17	6:19	6:22	6:24	6:26	6:28	6:30	6:32	6:36	6:38	6:40	6:42	6:44	6:47	6:50	6:54
41	6:23	6:28	6:31	6:32	6:34	6:37	6:39	6:41	6:43	6:45	6:47	6:51	6:53	6:55	6:57	6:59	7:02	7:05	7:09
42	6:38	6:43	6:46	6:47	6:49	6:52	6:54	6:56	6:58	7:00	7:02	7:06	7:08	7:10	7:12	7:14	7:17	7:20	7:24
43	6:53	6:58	7:01	7:02	7:04	7:07	7:09	7:11	7:13	7:15	7:17	7:21	7:23	7:25	7:27	7:29	7:32	7:35	7:39
44	7:08	7:13	7:16	7:17	7:19	7:22	7:24	7:26	7:28	7:30	7:32	7:36	7:38	7:40	7:42	7:44	7:47	7:50	7:54
45	7:23	7:28	7:31	7:32	7:34	7:37	7:39	7:41	7:43	7:45	7:47	7:51	7:53	7:55	7:57	7:59	8:02	8:05	8:09
46	7:38	7:43	7:46	7:47	7:49	7:52	7:54	7:56	7:58	8:00	8:02	8:06	8:08	8:10	8:12	8:14	8:17	8:20	8:24
47	7:53	7:58	8:01	8:02	8:04	8:07	8:09	8:11	8:13	8:15	8:17	8:21	8:23	8:25	8:27	8:29	8:32	8:35	8:39
20											8:29	8:33	8:35	8:37	8:39	8:41	8:44	8:47	8:51
40	8:08	8:13	8:16	8:17	8:19	8:22	8:24	8:26	8:28	8:30	8:32	8:36	8:38	8:40	8:42	8:44	8:47	8:50	8:54
41	8:23	8:28	8:31	8:32	8:34	8:37	8:39	8:41	8:43	8:45	8:47	8:51	8:53	8:55	8:57	8:59	9:02	9:05	9:09
21											8:59	9:03	9:05	9:07	9:09	9:11	9:14	9:17	9:21
42	8:38	8:43	8:46	8:47	8:49	8:52	8:54	8:56	8:58	9:00	9:02	9:06	9:08	9:10	9:12	9:14	9:17	9:20	9:24
43	8:53	8:58	9:01	9:02	9:04	9:07	9:09	9:11	9:13	9:15	9:17	9:21	9:23	9:25	9:27	9:29	9:32	9:35	9:39
22											9:28	9:32	9:34	9:36	9:38	9:40	9:43	9:46	9:50
44	9:08	9:13	9:16	9:17	9:19	9:22	9:24	9:26	9:28	9:30	9:32	9:36	9:38	9:40	9:42	9:44	9:47	9:50	9:54
52											9:44	9:48	9:50	9:52	9:54	9:56	9:59	10:02	10:06
45	9:23	9:28	9:31	9:32	9:34	9:37	9:39	9:41	9:43	9:45	9:47	9:51	9:53	9:55	9:57	9:59	10:02	10:05	10:09

Table 84 – Green Line - Southbound																			
Train	**Airport**	**1940 W North Temple**	**Power**	**Fairpark**	**Jackson/Euclid**	**NTB/Guadalupe**	**Arena**	**Temple Square**	**City Center**	**Gallivan Plaza**	**Courthouse**	**900 South**	**Ballpark**	**Central Pointe**	**JRSC Relief Stop**	**River Trail**	**Redwood Junction**	**Decker Lake**	**West Valley Central**
46	9:38	9:43	9:46	9:47	9:49	9:52	9:54	9:56	9:58	10:00	10:02	10:06	10:08	10:10	10:12	10:14	10:17	10:20	10:24
47	9:53	9:58	10:01	10:02	10:04	10:07	10:09	10:11	10:13	10:15	10:17	10:21	10:23	10:25	10:27	10:29	10:32	10:35	10:39
40	10:08	10:13	10:16	10:17	10:19	10:22	10:24	10:26	10:28	10:30	10:32	10:36	10:38	10:40	10:42	10:44	10:47	10:50	10:54
41	10:23	10:28	10:31	10:32	10:34	10:37	10:39	10:41	10:43	10:45	10:47	10:51	10:53	10:55	10:57	10:59	11:02	11:05	11:09
42	10:38	10:43	10:46	10:47	10:49	10:52	10:54	10:56	10:58	11:00	11:02	11:06	11:08	11:10	11:12	11:14	11:17	11:20	11:24
43	10:53	10:58	11:01	11:02	11:04	11:07	11:09	11:11	11:13	11:15	11:17	11:21	11:23	11:25	11:27	11:29	11:32	11:35	11:39
44	11:08	11:13	11:16	11:17	11:19	11:22	11:24	11:26	11:28	11:30	11:32	11:36	11:38	11:40	11:42	11:44	11:47	11:50	11:54
45	11:23	11:28	11:31	11:32	11:34	11:37	11:39	11:41	11:43	11:45	11:47	11:51	11:53	11:55	11:57	11:59	12:02	12:05	12:09
46	11:38	11:43	11:46	11:47	11:49	11:52	11:54	11:56	11:58	12:00	12:02	12:06	12:08	12:10	12:12	12:14	12:17	12:20	12:24
47	11:53	11:58	12:01	12:02	12:04	12:07	12:09	12:11	12:13	12:15	12:17	12:21	12:23	12:25	12:27	12:29	12:32	12:35	12:39
40	12:08	12:13	12:16	12:17	12:19	12:22	12:24	12:26	12:28	12:30	12:32	12:36	12:38	12:40	12:42	12:44	12:47	12:50	12:54
41	12:23	12:28	12:31	12:32	12:34	12:37	12:39	12:41	12:43	12:45	12:47	12:51	12:53	12:55	12:57	12:59	13:02	13:05	13:09
42	12:38	12:43	12:46	12:47	12:49	12:52	12:54	12:56	12:58	13:00	13:02	13:06	13:08	13:10	13:12	13:14	13:17	13:20	13:24
43	12:53	12:58	13:01	13:02	13:04	13:07	13:09	13:11	13:13	13:15	13:17	13:21	13:23	13:25	13:27	13:29	13:32	13:35	13:39
44	13:08	13:13	13:16	13:17	13:19	13:22	13:24	13:26	13:28	13:30	13:32	13:36	13:38	13:40	13:42	13:44	13:47	13:50	13:54
45	13:23	13:28	13:31	13:32	13:34	13:37	13:39	13:41	13:43	13:45	13:47	13:51	13:53	13:55	13:57	13:59	14:02	14:05	14:09
46	13:38	13:43	13:46	13:47	13:49	13:52	13:54	13:56	13:58	14:00	14:02	14:06	14:08	14:10	14:12	14:14	14:17	14:20	14:24
47	13:53	13:58	14:01	14:02	14:04	14:07	14:09	14:11	14:13	14:15	14:17	14:21	14:23	14:25	14:27	14:29	14:32	14:35	14:39
40	14:08	14:13	14:16	14:17	14:19	14:22	14:24	14:26	14:28	14:30	14:32	14:36	14:38	14:40	14:42	14:44	14:47	14:50	14:54
41	14:23	14:28	14:31	14:32	14:34	14:37	14:39	14:41	14:43	14:45	14:47	14:51	14:53	14:55	14:57	14:59	15:02	15:05	15:09
42	14:38	14:43	14:46	14:47	14:49	14:52	14:54	14:56	14:58	15:00	15:02	15:06	15:08	15:10	15:12	15:14	15:17	15:20	15:24
43	14:53	14:58	15:01	15:02	15:04	15:07	15:09	15:11	15:13	15:15	15:17	15:21	15:23	15:25	15:27	15:29	15:32	15:35	15:39
44	15:08	15:13	15:16	15:17	15:19	15:22	15:24	15:26	15:28	15:30	15:32	15:36	15:38	15:40	15:42	15:44	15:47	15:50	15:54
45	15:23	15:28	15:31	15:32	15:34	15:37	15:39	15:41	15:43	15:45	15:47	15:51	15:53	15:55	15:57	15:59	16:02	16:05	16:09
46	15:38	15:43	15:46	15:47	15:49	15:52	15:54	15:56	15:58	16:00	16:02	16:06	16:08	16:10	16:12	16:14	16:17	16:20	16:24
47	15:53	15:58	16:01	16:02	16:04	16:07	16:09	16:11	16:13	16:15	16:17	16:21	16:23	16:25	16:27	16:29	16:32	16:35	16:39

Table 84 – Green Line - Southbound																			
Train	**Airport**	**1940 W North Temple**	**Power**	**Fairpark**	**Jackson/Euclid**	**NTB/Guadalupe**	**Arena**	**Temple Square**	**City Center**	**Gallivan Plaza**	**Courthouse**	**900 South**	**Ballpark**	**Central Pointe**	**JRSC Relief Stop**	**River Trail**	**Redwood Junction**	**Decker Lake**	**West Valley Central**
40	16:08	16:13	16:16	16:17	16:19	16:22	16:24	16:26	16:28	16:30	16:32	16:36	16:38	16:40	16:42	16:44	16:47	16:50	16:54
41	16:23	16:28	16:31	16:32	16:34	16:37	16:39	16:41	16:43	16:45	16:47	16:51	16:53	16:55	16:57	16:59	17:02	17:05	17:09
42	16:38	16:43	16:46	16:47	16:49	16:52	16:54	16:56	16:58	17:00	17:02	17:06	17:08	17:10	17:12	17:14	17:17	17:20	17:24
43	16:53	16:58	17:01	17:02	17:04	17:07	17:09	17:11	17:13	17:15	17:17	17:21	17:23	17:25	17:27	17:29	17:32	17:35	17:39
44	17:08	17:13	17:16	17:17	17:19	17:22	17:24	17:26	17:28	17:30	17:32	17:36	17:38	17:40	17:42	17:44	17:47	17:50	17:54
45	17:23	17:28	17:31	17:32	17:34	17:37	17:39	17:41	17:43	17:45	17:47	17:51	17:53	17:55	17:57	17:59	18:02	18:05	18:09
46	17:38	17:43	17:46	17:47	17:49	17:52	17:54	17:56	17:58	18:00	18:02	18:06	18:08	18:10	18:12	18:14	18:17	18:20	18:24
47	17:53	17:58	18:01	18:02	18:04	18:07	18:09	18:11	18:13	18:15	18:17	18:21	18:23	18:25	18:27	18:29	18:32	18:35	18:39
40	18:08	18:13	18:16	18:17	18:19	18:22	18:24	18:26	18:28	18:30	18:32	18:36	18:38	18:40	18:42	18:44	18:47	18:50	18:54
41	18:23	18:28	18:31	18:32	18:34	18:37	18:39	18:41	18:43	18:45	18:47	18:51	18:53	18:55	18:57	18:59	19:02	19:05	19:09
42	18:38	18:43	18:46	18:47	18:49	18:52	18:54	18:56	18:58	19:00	19:02	19:06	19:08	19:10	19:12	19:14	19:17	19:20	19:24
43	18:53	18:58	19:01	19:02	19:04	19:07	19:09	19:11	19:13	19:15	19:17	19:21	19:23	19:25	19:27	19:29	19:32	19:35	19:39
44	19:08	19:13	19:16	19:17	19:19	19:22	19:24	19:26	19:28	19:30	19:32	19:36	19:38	19:40	19:42	19:44	19:47	19:50	19:54
45	19:23	19:28	19:31	19:32	19:34	19:37	19:39	19:41	19:43	19:45	19:47	19:51	19:53	19:55	19:57	19:59	20:02	20:05	20:09
46	19:38	19:43	19:46	19:47	19:49	19:52	19:54	19:56	19:58	20:00	20:02	20:06	20:08	20:10	20:12	20:14	20:17	20:20	20:24
47	19:53	19:58	20:01	20:02	20:04	20:07	20:09	20:11	20:13	20:15	20:17	20:21	20:23	20:25	20:27	20:29	20:32	20:35	20:39
40	20:08	20:13	20:16	20:17	20:19	20:22	20:24	20:26	20:28	20:30	20:32	20:36	20:38	20:40	20:42	20:44	20:47	20:50	20:54
41	20:23	20:28	20:31	20:32	20:34	20:37	20:39	20:41	20:43	20:45	20:47	20:51	20:53	20:55	20:57	20:59	21:02	21:05	21:09
42	20:38	20:43	20:46	20:47	20:49	20:52	20:54	20:56	20:58	21:00	21:02	21:06	21:08	21:10	21:12	21:14	21:17	21:20	21:24
43	20:53	20:58	21:01	21:02	21:04	21:07	21:09	21:11	21:13	21:15	21:17	21:21	21:23	21:25	21:27	21:29	21:32	21:35	21:39
44	21:08	21:13	21:16	21:17	21:19	21:22	21:24	21:26	21:28	21:30	21:32	21:36	21:38	21:40	21:42	21:44	21:47	21:50	21:54
45	21:23	21:28	21:31	21:32	21:34	21:37	21:39	21:41	21:43	21:45	21:47	21:51	21:53	21:55	21:57	21:59	22:02	22:05	22:09
46	21:38	21:43	21:46	21:47	21:49	21:52	21:54	21:56	21:58	22:00	22:02	22:06	22:08	22:10	22:12	22:14	22:17	22:20	22:24
47	21:53	21:58	22:01	22:02	22:04	22:07	22:09	22:11	22:13	22:15	22:17	22:21	22:23	22:25	22:27	22:29	22:32	22:35	22:39
40	22:08	22:13	22:16	22:17	22:19	22:22	22:24	22:26	22:28	22:30	22:32	22:36	22:38	22:40	22:42	22:44	22:47	22:50	22:54
41	22:23	22:28	22:31	22:32	22:34	22:37	22:39	22:41	22:43	22:45	22:47	22:51	22:53	22:55	22:57	22:59	23:02	23:05	23:09

Table 84 – Green Line - Southbound

Train	Airport	1940 W North Temple	Power	Fairpark	Jackson/Euclid	NTB/Guadalupe	Arena	Temple Square	City Center	Gallivan Plaza	Courthouse	900 South	Ballpark	Central Pointe	JRSC Relief Stop	River Trail	Redwood Junction	Decker Lake	West Valley Central
42	22:38	22:43	22:46	22:47	22:49	22:52	22:54	22:56	22:58	23:00	23:02	23:06	23:08	23:10	23:12	23:14	23:17	23:20	23:24
43	22:53	22:58	23:01	23:02	23:04	23:07	23:09	23:11	23:13	23:15	23:17	23:21	23:23	23:25	23:27	23:29	23:32	23:35	23:39
44	23:08	23:13	23:16	23:17	23:19	23:22	23:24	23:26	23:28	23:30	23:32	23:36	23:38	23:40	23:42	23:44	23:47	23:50	23:54
45	23:23	23:28	23:31	23:32	23:34	23:37	23:39	23:41	23:43	23:45	23:47	23:51	23:53	23:55	23:57	23:59	0:02	0:05	0:09
46	23:25	23:30	23:33	23:34	23:36	23:39	23:41	23:43	23:45	23:47	23:49	23:53	23:55	23:57					

Table 85 – S-Line

Eastbound								Westbound							
Train	Central Pointe	South Salt Lake City	300 East	500 East	700 East	Sugarmont	Fairmont	Train	Fairmont	Sugarmont	700 East	500 East	300 East	South Salt Lake City	Central Pointe
70	5:02	5:04	5:06	5:07	5:09	5:11	5:12	70	5:17	5:18	5:20	5:21	5:22	5:24	5:26
71	5:17	5:19	5:21	5:22	5:24	5:26	5:27	71	5:32	5:33	5:35	5:36	5:37	5:39	5:41
70	5:32	5:34	5:36	5:37	5:39	5:41	5:42	70	5:47	5:48	5:50	5:51	5:52	5:54	5:56
71	5:47	5:49	5:51	5:52	5:54	5:56	5:57	71	6:02	6:03	6:05	6:06	6:07	6:09	6:11
70	6:02	6:04	6:06	6:07	6:09	6:11	6:12	70	6:17	6:18	6:20	6:21	6:22	6:24	6:26
71	6:17	6:19	6:21	6:22	6:24	6:26	6:27	71	6:32	6:33	6:35	6:36	6:37	6:39	6:41
70	6:32	6:34	6:36	6:37	6:39	6:41	6:42	70	6:47	6:48	6:50	6:51	6:52	6:54	6:56
71	6:47	6:49	6:51	6:52	6:54	6:56	6:57	71	7:02	7:03	7:05	7:06	7:07	7:09	7:11
70	7:02	7:04	7:06	7:07	7:09	7:11	7:12	70	7:17	7:18	7:20	7:21	7:22	7:24	7:26

Table 85 – S-Line															
Eastbound								Westbound							
Train	Central Pointe	South Salt Lake City	300 East	500 East	700 East	Sugarmont	Fairmont	Train	Fairmont	Sugarmont	700 East	500 East	300 East	South Salt Lake City	Central Pointe
71	7:17	7:19	7:21	7:22	7:24	7:26	7:27	71	7:32	7:33	7:35	7:36	7:37	7:39	7:41
70	7:32	7:34	7:36	7:37	7:39	7:41	7:42	70	7:47	7:48	7:50	7:51	7:52	7:54	7:56
71	7:47	7:49	7:51	7:52	7:54	7:56	7:57	71	8:02	8:03	8:05	8:06	8:07	8:09	8:11
70	8:02	8:04	8:06	8:07	8:09	8:11	8:12	70	8:17	8:18	8:20	8:21	8:22	8:24	8:26
71	8:17	8:19	8:21	8:22	8:24	8:26	8:27	71	8:32	8:33	8:35	8:36	8:37	8:39	8:41
70	8:32	8:34	8:36	8:37	8:39	8:41	8:42	70	8:47	8:48	8:50	8:51	8:52	8:54	8:56
71	8:47	8:49	8:51	8:52	8:54	8:56	8:57	71	9:02	9:03	9:05	9:06	9:07	9:09	9:11
70	9:02	9:04	9:06	9:07	9:09	9:11	9:12	70	9:17	9:18	9:20	9:21	9:22	9:24	9:26
71	9:17	9:19	9:21	9:22	9:24	9:26	9:27	71	9:32	9:33	9:35	9:36	9:37	9:39	9:41
70	9:32	9:34	9:36	9:37	9:39	9:41	9:42	70	9:47	9:48	9:50	9:51	9:52	9:54	9:56
71	9:47	9:49	9:51	9:52	9:54	9:56	9:57	71	10:02	10:03	10:05	10:06	10:07	10:09	10:11
70	10:02	10:04	10:06	10:07	10:09	10:11	10:12	70	10:17	10:18	10:20	10:21	10:22	10:24	10:26
71	10:17	10:19	10:21	10:22	10:24	10:26	10:27	71	10:32	10:33	10:35	10:36	10:37	10:39	10:41
70	10:32	10:34	10:36	10:37	10:39	10:41	10:42	70	10:47	10:48	10:50	10:51	10:52	10:54	10:56
71	10:47	10:49	10:51	10:52	10:54	10:56	10:57	71	11:02	11:03	11:05	11:06	11:07	11:09	11:11
70	11:02	11:04	11:06	11:07	11:09	11:11	11:12	70	11:17	11:18	11:20	11:21	11:22	11:24	11:26
71	11:17	11:19	11:21	11:22	11:24	11:26	11:27	71	11:32	11:33	11:35	11:36	11:37	11:39	11:41
70	11:32	11:34	11:36	11:37	11:39	11:41	11:42	70	11:47	11:48	11:50	11:51	11:52	11:54	11:56
71	11:47	11:49	11:51	11:52	11:54	11:56	11:57	71	12:02	12:03	12:05	12:06	12:07	12:09	12:11
70	12:02	12:04	12:06	12:07	12:09	12:11	12:12	70	12:17	12:18	12:20	12:21	12:22	12:24	12:26
71	12:17	12:19	12:21	12:22	12:24	12:26	12:27	71	12:32	12:33	12:35	12:36	12:37	12:39	12:41
70	12:32	12:34	12:36	12:37	12:39	12:41	12:42	70	12:47	12:48	12:50	12:51	12:52	12:54	12:56
71	12:47	12:49	12:51	12:52	12:54	12:56	12:57	71	13:02	13:03	13:05	13:06	13:07	13:09	13:11
70	13:02	13:04	13:06	13:07	13:09	13:11	13:12	70	13:17	13:18	13:20	13:21	13:22	13:24	13:26
71	13:17	13:19	13:21	13:22	13:24	13:26	13:27	71	13:32	13:33	13:35	13:36	13:37	13:39	13:41
70	13:32	13:34	13:36	13:37	13:39	13:41	13:42	70	13:47	13:48	13:50	13:51	13:52	13:54	13:56

Table 85 – S-Line

Eastbound

Train	Central Pointe	South Salt Lake City	300 East	500 East	700 East	Sugarmont	Fairmont
71	13:47	13:49	13:51	13:52	13:54	13:56	13:57
70	14:02	14:04	14:06	14:07	14:09	14:11	14:12
71	14:17	14:19	14:21	14:22	14:24	14:26	14:27
70	14:32	14:34	14:36	14:37	14:39	14:41	14:42
71	14:47	14:49	14:51	14:52	14:54	14:56	14:57
70	15:02	15:04	15:06	15:07	15:09	15:11	15:12
71	15:17	15:19	15:21	15:22	15:24	15:26	15:27
70	15:32	15:34	15:36	15:37	15:39	15:41	15:42
71	15:47	15:49	15:51	15:52	15:54	15:56	15:57
70	16:02	16:04	16:06	16:07	16:09	16:11	16:12
71	16:17	16:19	16:21	16:22	16:24	16:26	16:27
70	16:32	16:34	16:36	16:37	16:39	16:41	16:42
71	16:47	16:49	16:51	16:52	16:54	16:56	16:57
70	17:02	17:04	17:06	17:07	17:09	17:11	17:12
71	17:17	17:19	17:21	17:22	17:24	17:26	17:27
70	17:32	17:34	17:36	17:37	17:39	17:41	17:42
71	17:47	17:49	17:51	17:52	17:54	17:56	17:57
70	18:02	18:04	18:06	18:07	18:09	18:11	18:12
71	18:17	18:19	18:21	18:22	18:24	18:26	18:27
70	18:32	18:34	18:36	18:37	18:39	18:41	18:42
71	18:47	18:49	18:51	18:52	18:54	18:56	18:57
70	19:02	19:04	19:06	19:07	19:09	19:11	19:12
71	19:17	19:19	19:21	19:22	19:24	19:26	19:27
70	19:32	19:34	19:36	19:37	19:39	19:41	19:42
71	19:47	19:49	19:51	19:52	19:54	19:56	19:57
70	20:02	20:04	20:06	20:07	20:09	20:11	20:12

Westbound

Train	Fairmont	Sugarmont	700 East	500 East	300 East	South Salt Lake City	Central Pointe
71	14:02	14:03	14:05	14:06	14:07	14:09	14:11
70	14:17	14:18	14:20	14:21	14:22	14:24	14:26
71	14:32	14:33	14:35	14:36	14:37	14:39	14:41
70	14:47	14:48	14:50	14:51	14:52	14:54	14:56
71	15:02	15:03	15:05	15:06	15:07	15:09	15:11
70	15:17	15:18	15:20	15:21	15:22	15:24	15:26
71	15:32	15:33	15:35	15:36	15:37	15:39	15:41
70	15:47	15:48	15:50	15:51	15:52	15:54	15:56
71	16:02	16:03	16:05	16:06	16:07	16:09	16:11
70	16:17	16:18	16:20	16:21	16:22	16:24	16:26
71	16:32	16:33	16:35	16:36	16:37	16:39	16:41
70	16:47	16:48	16:50	16:51	16:52	16:54	16:56
71	17:02	17:03	17:05	17:06	17:07	17:09	17:11
70	17:17	17:18	17:20	17:21	17:22	17:24	17:26
71	17:32	17:33	17:35	17:36	17:37	17:39	17:41
70	17:47	17:48	17:50	17:51	17:52	17:54	17:56
71	18:02	18:03	18:05	18:06	18:07	18:09	18:11
70	18:17	18:18	18:20	18:21	18:22	18:24	18:26
71	18:32	18:33	18:35	18:36	18:37	18:39	18:41
70	18:47	18:48	18:50	18:51	18:52	18:54	18:56
71	19:02	19:03	19:05	19:06	19:07	19:09	19:11
70	19:17	19:18	19:20	19:21	19:22	19:24	19:26
71	19:32	19:33	19:35	19:36	19:37	19:39	19:41
70	19:47	19:48	19:50	19:51	19:52	19:54	19:56
71	20:02	20:03	20:05	20:06	20:07	20:09	20:11
70	20:17	20:18	20:20	20:21	20:22	20:24	20:26

Table 85 – S-Line															
Eastbound								Westbound							
Train	Central Pointe	South Salt Lake City	300 East	500 East	700 East	Sugarmont	Fairmont	Train	Fairmont	Sugarmont	700 East	500 East	300 East	South Salt Lake City	Central Pointe
71	20:17	20:19	20:21	20:22	20:24	20:26	20:27	**71**	20:32	20:33	20:35	20:36	20:37	20:39	20:41
70	20:32	20:34	20:36	20:37	20:39	20:41	20:42	**70**	20:47	20:48	20:50	20:51	20:52	20:54	20:56
71	20:47	20:49	20:51	20:52	20:54	20:56	20:57	**71**	21:02	21:03	21:05	21:06	21:07	21:09	21:11
70	21:02	21:04	21:06	21:07	21:09	21:11	21:12	**70**	21:17	21:18	21:20	21:21	21:22	21:24	21:26
71	21:17	21:19	21:21	21:22	21:24	21:26	21:27	**71**	21:32	21:33	21:35	21:36	21:37	21:39	21:41
70	21:32	21:34	21:36	21:37	21:39	21:41	21:42	**70**	21:47	21:48	21:50	21:51	21:52	21:54	21:56
71	21:47	21:49	21:51	21:52	21:54	21:56	21:57	**71**	22:02	22:03	22:05	22:06	22:07	22:09	22:11
70	22:02	22:04	22:06	22:07	22:09	22:11	22:12	**70**	22:17	22:18	22:20	22:21	22:22	22:24	22:26
71	22:17	22:19	22:21	22:22	22:24	22:26	22:27	**71**	22:32	22:33	22:35	22:36	22:37	22:39	22:41
70	22:32	22:34	22:36	22:37	22:39	22:41	22:42	**70**	22:47	22:48	22:50	22:51	22:52	22:54	22:56
71	22:47	22:49	22:51	22:52	22:54	22:56	22:57	**71**	23:02	23:03	23:05	23:06	23:07	23:09	23:11
70	23:02	23:04	23:06	23:07	23:09	23:11	23:12	**70**	23:17	23:18	23:20	23:21	23:22	23:24	23:26
71	23:17	23:19	23:21	23:22	23:24	23:26	23:27	**71**	23:32	23:33	23:35	23:36	23:37	23:39	23:41
70	23:32	23:34	23:36	23:37	23:39	23:41	23:42	**70**	23:47	23:48	23:50	23:51	23:52	23:54	23:56

Appendix E – Granary District Ballpark Spur Extension and Orange Line Concept Design

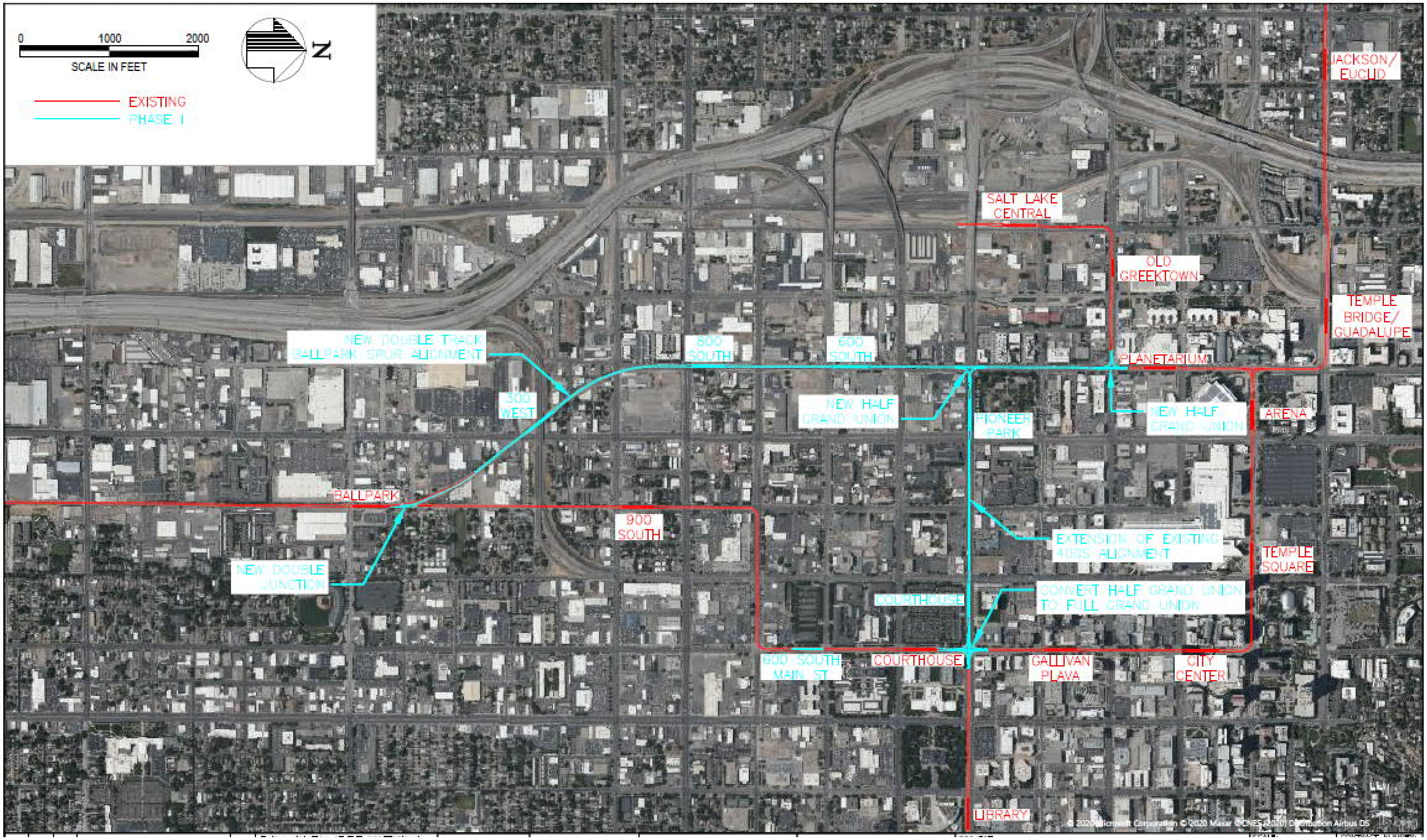

Figure 60 – Granary District Ballpark Spur Extension and Orange Line Concept Design Overview

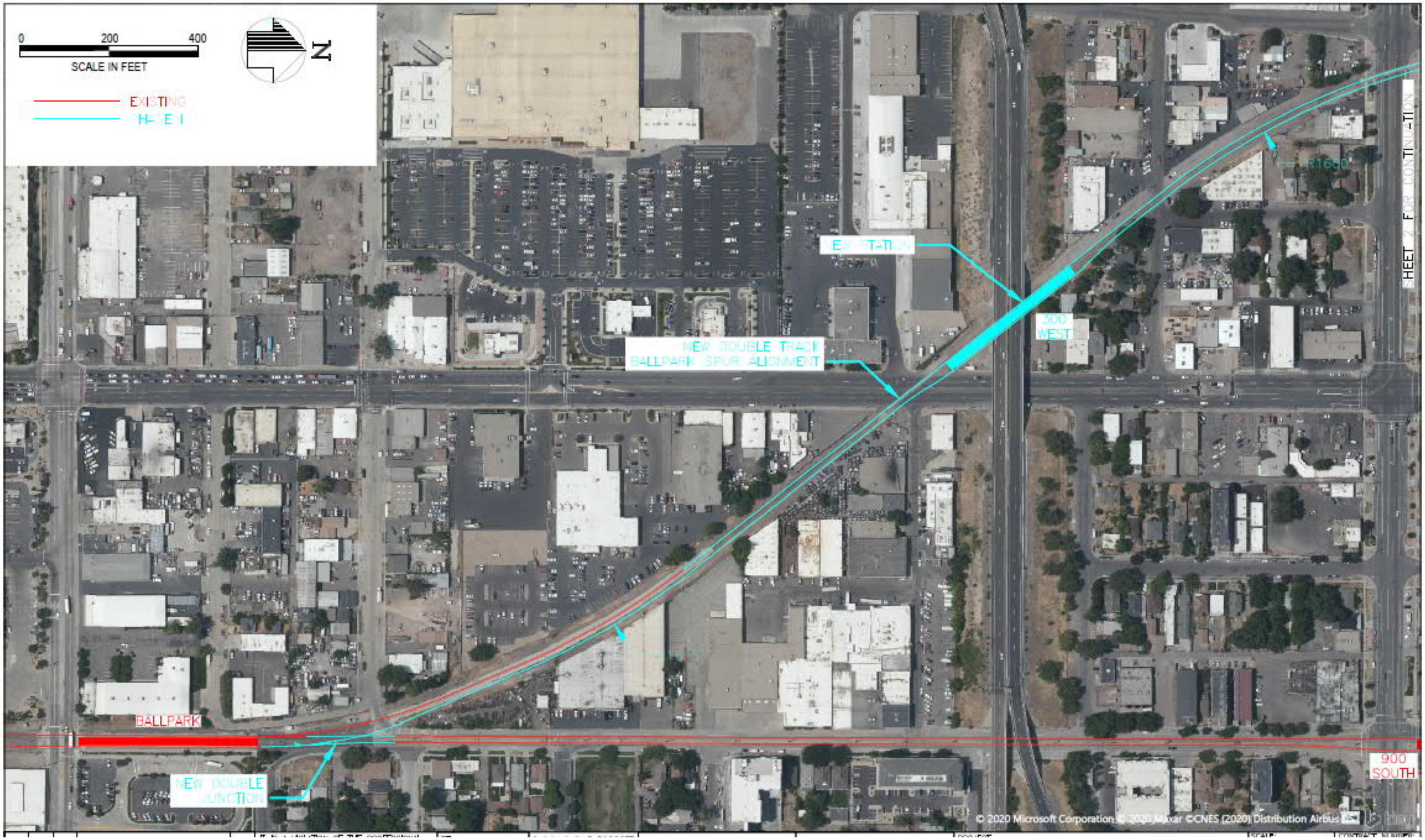

Figure 61 – Granary District Ballpark Spur Extension and Orange Line Concept Design at Ballpark

Figure 62 – Granary District Ballpark Spur Extension and Orange Line Concept Design at 700 South

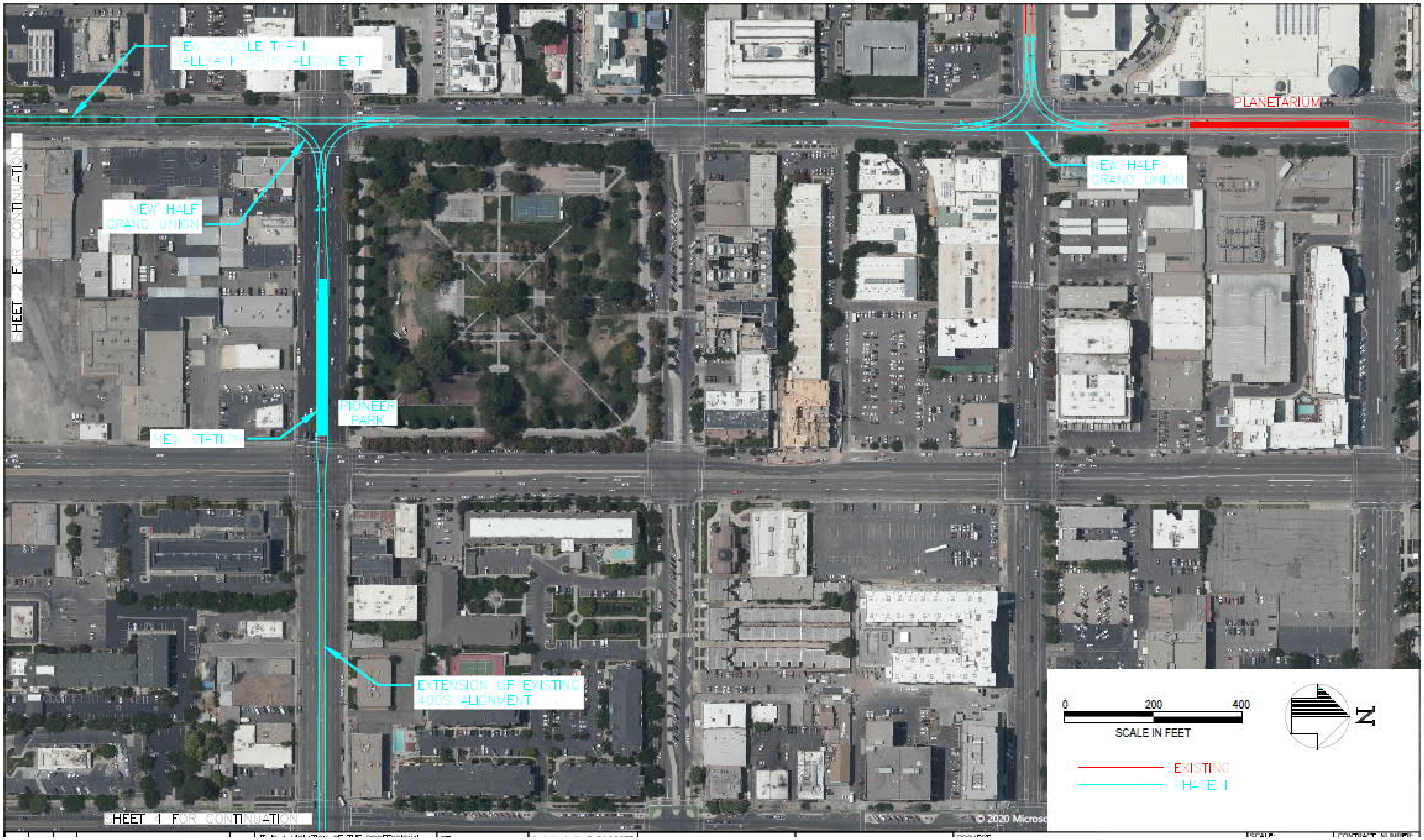

Figure 63 – Granary District Ballpark Spur Extension and Orange Line Concept Design at Pioneer Park

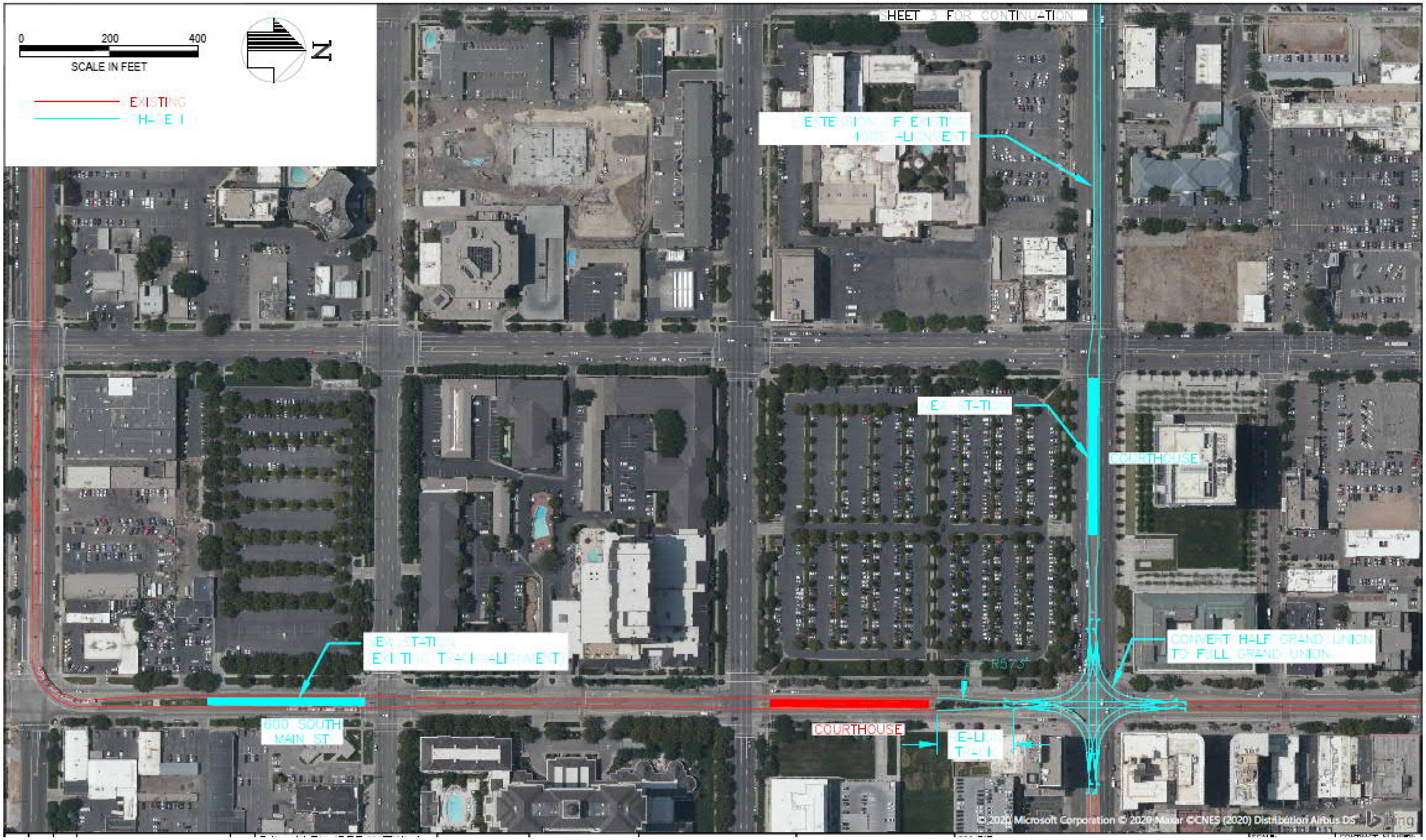

Figure 64 – Granary District Ballpark Spur Extension and Orange Line Concept Design at Courthouse Grand Union

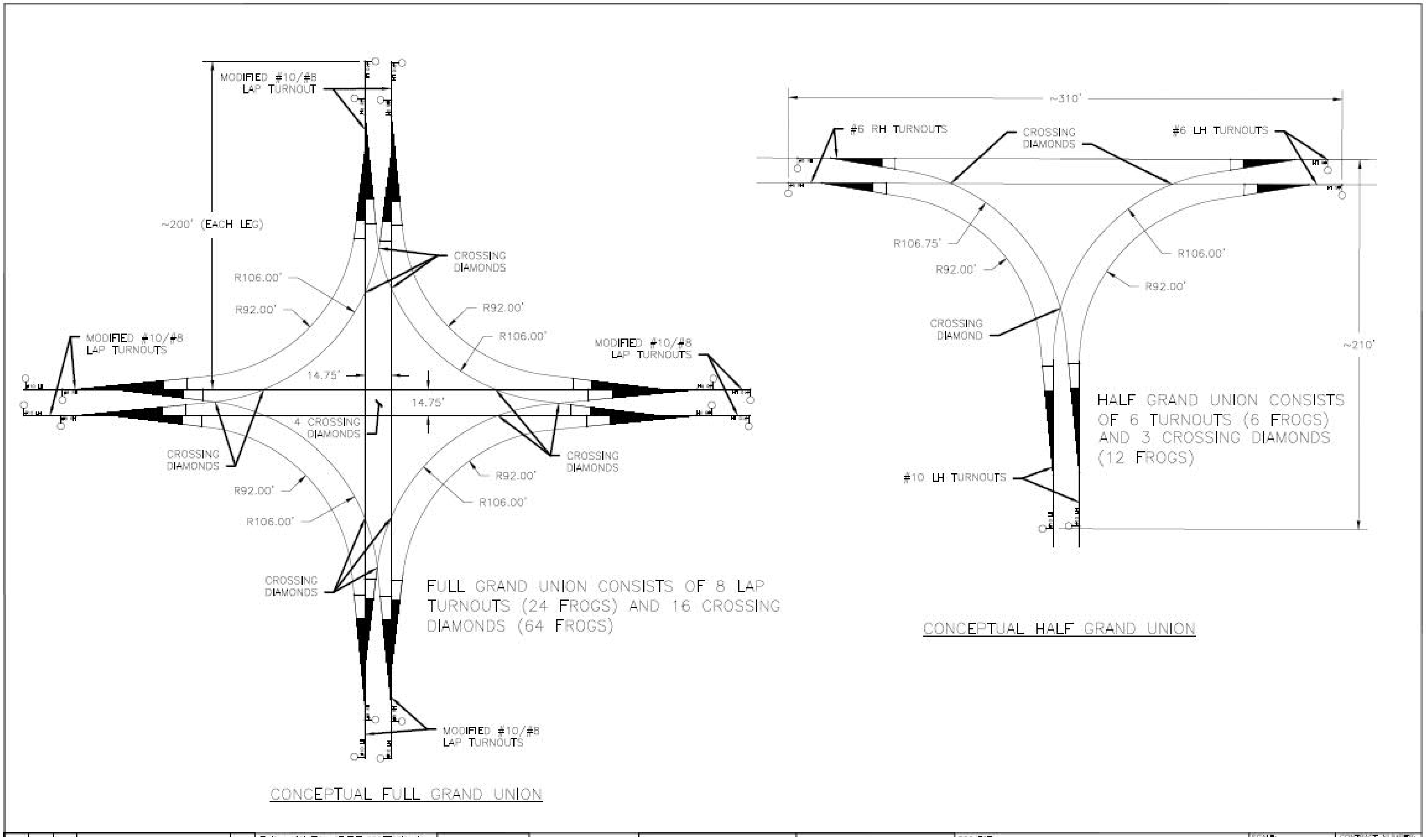

Figure 65 – Granary District Ballpark Spur Extension and Orange Line Concept Design – Grand Union and Half Grand Union Layouts

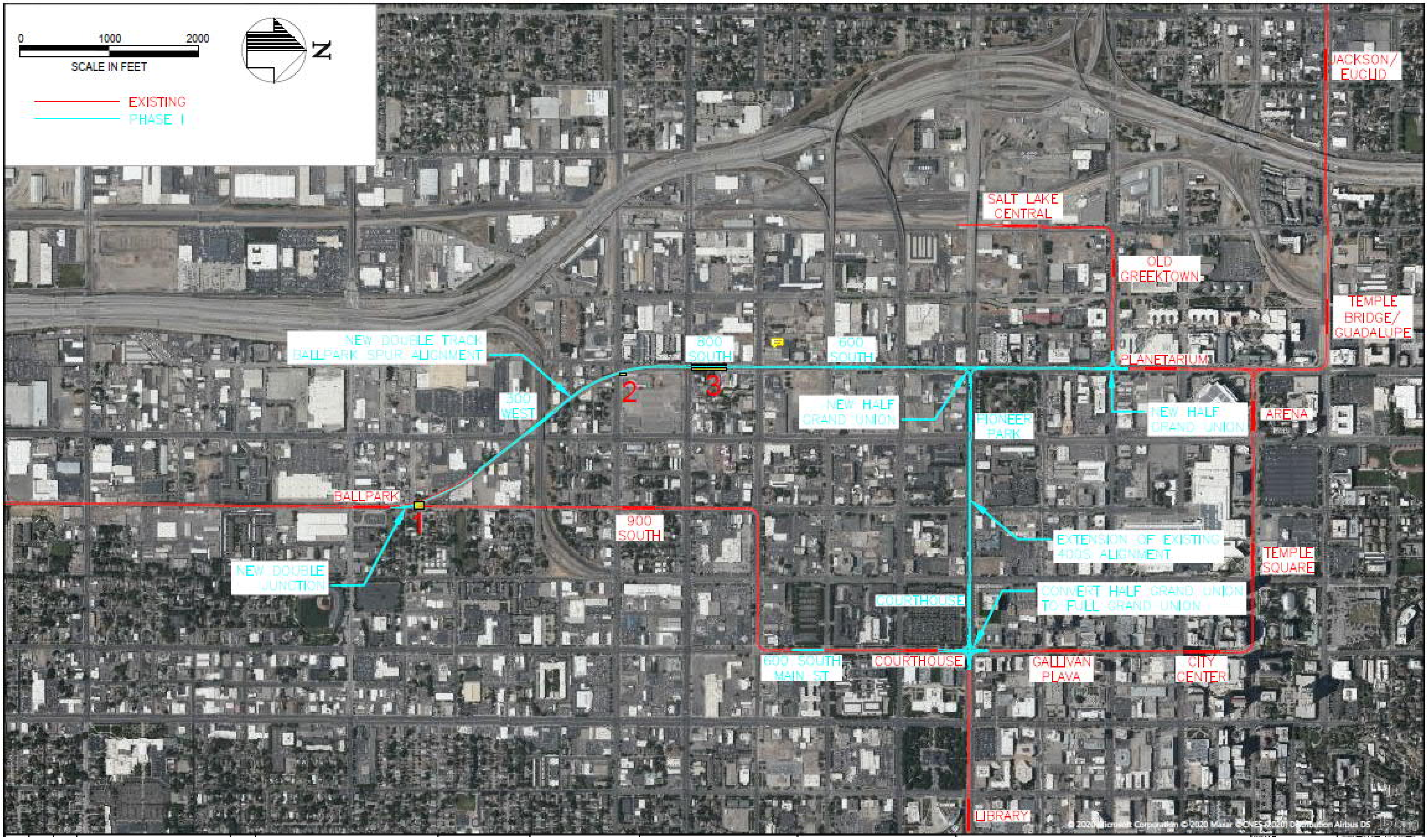

Figure 66 – Granary District Ballpark Spur Extension and Orange Line Concept Design Overview with Potential Property Acquisition Locations

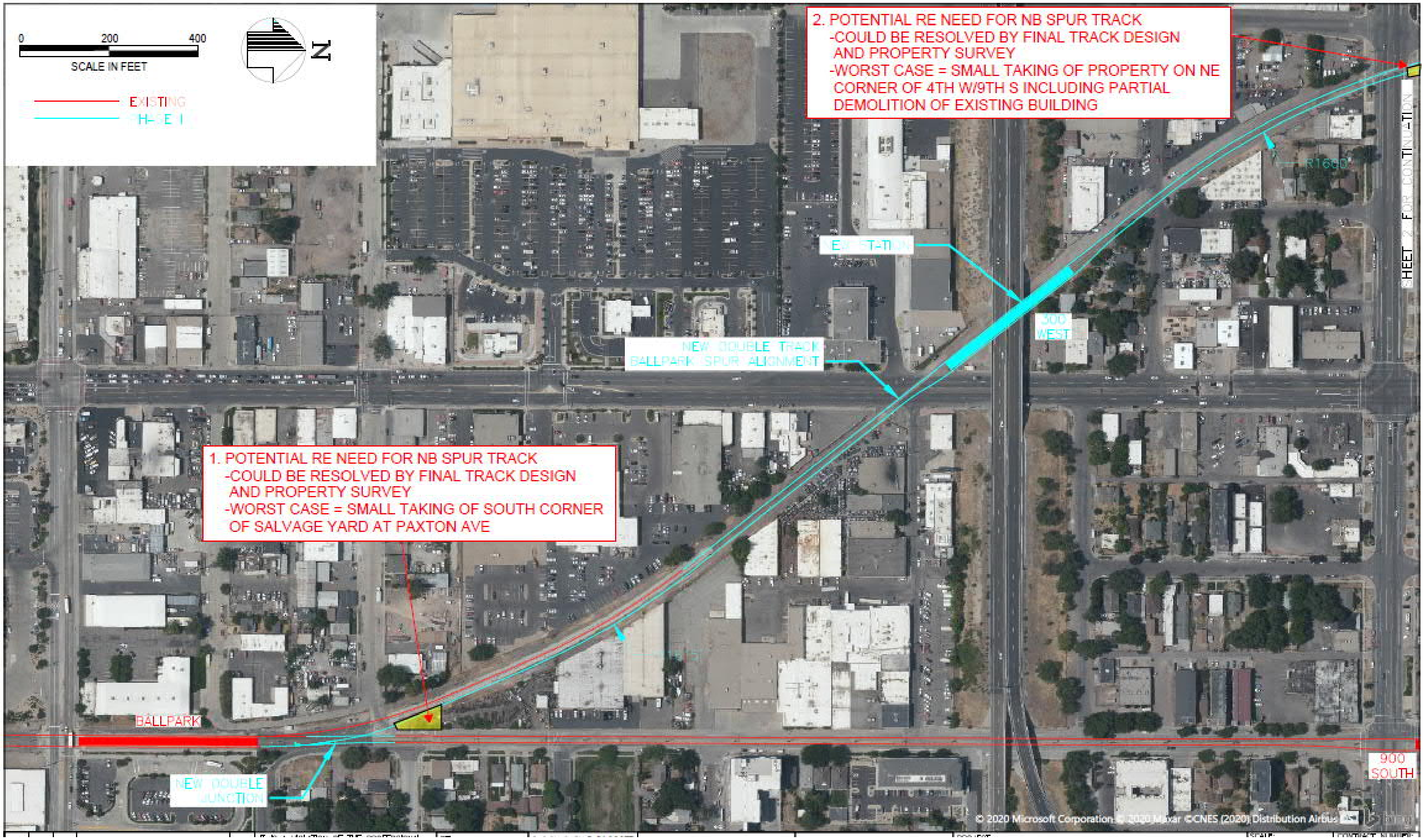

Figure 67 – Granary District Ballpark Spur Extension and Orange Line Concept Design – Potential Ballpark Property Acquisition

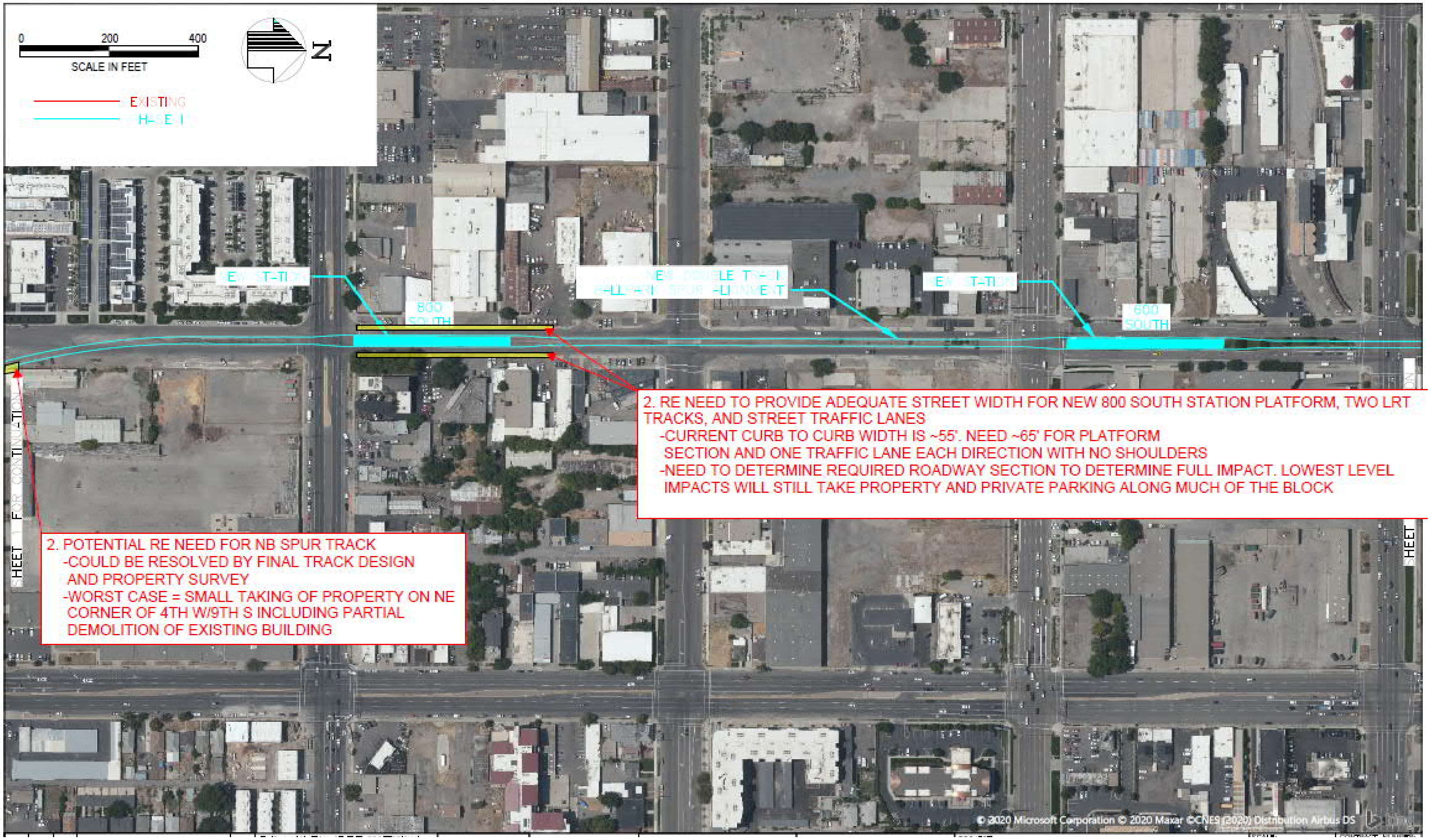

Figure 68 – Granary District Ballpark Spur Extension and Orange Line Concept Design – Potential 900 South and 800 South Property Acquisitions

Appendix F – Trunk Line Curve Speed Upgrade Concept Design

This appendix includes the concept track design computations for the TRAX Trunk Line curve speed upgrade concept design. The table is color-coded as follows:

+ Green – Either already has a design speed of 65 mph or can be upgraded with no impacts beyond superelevation increase (these curves were simulated in Scenario 2 with a proposed design speed of 65 mph),
+ Blue – Can be upgraded to 65 mph, but infrastructure impacts such as minor platform modifications or grade crossing reprofiling will need to be assessed (these curves were simulated in Scenario 2 with a proposed design speed of 65 mph),
+ Yellow – Cannot be upgraded to 65 mph but some curve speed improvements are possible. The values in this appendix show the maximum design speed based on UTA design standards including actual superelevation (Ea) not to exceed 4 inches (these curves were simulated in Scenario 2 at the proposed design speed shown below).

Note that Curves 123/125/132/134 do require a slight design exception for minimum tangent length. This design exception is likely to be granted and, therefore, the improved speeds at these four locations was included in the Scenario 2 simulation.

Table 86 – Trunk Line Curve Speed Upgrade Concept Design

	Curve Number	Current Design Speed	Current E_a	Proposed Design Speed	Proposed E_a	Notes
Draper Extension	S110	65	3.75	65.00	3.75	
	N110	65	3.75	65.00	3.75	
	S112	40	0.00	65.00	1.25	
	N112	40	0.00	65.00	2.75	
	S120	30	1.00	50.00	4.00	Compound Curve, Crossovers
	S122	30	0.00	60.00	4.00	Draper Parkway Grade Crossing
	N120	30	1.00	50.00	4.00	Compound Curve, Crossovers
	N122	30	0.00	60.00	4.00	Draper Parkway Grade Crossing
	S130	65	0.00	65.00	0.00	

Table 86 – Trunk Line Curve Speed Upgrade Concept Design

	Curve Number	Current Design Speed	Current E_a	Proposed Design Speed	Proposed E_a	Notes
	N125	65	0.00	65.00	0.00	
	S135	65	0.00	65.00	0.00	
	N128	65	0.00	65.00	0.00	
	S140	65	0.00	65.00	0.00	
	S150	65	0.00	65.00	0.00	
	S160	65	0.00	65.00	0.00	
	S170	55	1.50	65.00	2.25	11400 south Grade Crossing
	N130	60	1.75	65.00	2.25	11400 south Grade Crossing
	S180	55	3.00	65.00	4.00	Runoff next to 11400 S Platform
	N140	55	3.00	65.00	4.00	Runoff next to 11400 S Platform
	S190	65	2.75	65.00	3.25	
	N150	65	2.75	65.00	2.75	
	S200	65	0.00	65.00	0.00	
	N160	65	0.00	65.00	0.00	
	S210	65	0.00	65.00	0.00	
	N170	65	0.00	65.00	0.00	
	S220	55	1.00	65.00	1.75	
	N180	55	1.50	65.00	2.25	
North/South	100	55	0.00	65.00	0.00	
	102	55	0.00	65.00	0.00	
	105	35	0.00	65.00	1.50	Runoff next to 10000 S Platform
	104	55	1.25	65.00	1.50	
	107	55	1.25	65.00	1.50	
	106	55	1.25	65.00	0.00	
	108	55	0.62	65.00	0.00	
	110	55	0.00	65.00	0.00	
	109	55	1.00	65.00	1.25	
	112	55	0.00	65.00	0.00	
	114	55	1.00	65.00	1.25	Short Tangent
	111	55	1.00	65.00	2.00	
	120	55	1.00	65.00	2.00	
	113	50	1.50	65.00	3.00	Runoff next to 7800 S Platform

Table 86 – Trunk Line Curve Speed Upgrade Concept Design

Curve Number	Current Design Speed	Current E_a	Proposed Design Speed	Proposed E_a	Notes
115	55	1.25	65.00	1.50	
120	55	1.00	65.00	2.00	
122	55	0.00	65.00	0.00	
124	55	1.25	65.00	1.50	
117	55	1.75	65.00	3.00	
119	40	1.50	60.00	4.00	
121	30	0.00	60.00	4.00	
126	55	1.75	65.00	3.00	
128	40	1.50	60.00	4.00	
130	40	0.00	65.00	2.75	Runoff next to 7200 S Platform / 7200 S Grade Crossing
123	55	1.25	65.00	1.75	Design Exception for Tangent Length
125	55	1.25	65.00	1.75	Design Exception for Tangent Length
132	55	1.25	65.00	1.75	Design Exception for Tangent Length
134	55	1.25	65.00	1.75	Design Exception for Tangent Length
136	55	0.00	65.00	0.00	
138	55	0.00	65.00	0.00	
140	15	0.00	35.00	4.00	
142	55	1.25	65.00	1.75	
127	50	3.25	55.00	4.00	
144	50	3.25	55.00	4.00	
129	50	2.50	60.00	4.00	
133	50	0.50	65.00	2.25	Runoff next to 5300 S Platform / Vine Street Grade Crossing
146	40	1.50	60.00	4.00	
148	50	0.50	65.00	2.25	Runoff next to 5300 S Platform / Vine Street Grade Crossing
150	50	0.50	65.00	2.25	
135	55	1.75	65.00	2.75	
150	50	1.50	65.00	2.25	
152	55	1.75	65.00	2.75	
137	55	0.00	65.00	0.00	

Table 86 – Trunk Line Curve Speed Upgrade Concept Design							
	Curve Number	Current Design Speed	Current E_a	Proposed Design Speed	Proposed E_a	Notes
	139	55	0.00	65.00	0.00	
	141	50	1.75	65.00	3.50	Runoff next to 4500 S Platform
	154	55	0.00	65.00	0.00	
	156	55	0.00	65.00	0.00	
	158	50	1.25	65.00	2.25	
	160	50	1.25	65.00	2.25	Runoff next to 4500 S Platform / 4366 S Grade Crossing
	162	50	1.75	65.00	3.50	Runoff next to 4500 S Platform / 4366 S Grade Crossing
	143	55	1.50	65.00	2.25	
	164	55	1.50	65.00	2.25	
	147	55	0.00	65.00	0.00	
	154	55	0.00	65.00	0.00	
	166	55	0.00	65.00	0.00	
	149	45	3.50	45.00	4.00	
	168	45	3.50	45.00	4.00	
	151	55	0.00	65.00	0.00	
	153	55	0.00	65.00	0.00	
	155	55	0.00	65.00	0.00	
	157	55	0.00	65.00	0.00	
	175	45	0.00	65.00	1.00	
	176	55	0.00	65.00	0.00	
	167	55	0.00	65.00	0.00	
	169	55	0.00	65.00	0.00	
	170	55	0.00	65.00	0.00	
	171	55	0.00	65.00	0.00	
	172	55	0.00	65.00	0.00	
	173	55	0.00	65.00	0.00	
	174	55	0.00	65.00	0.00	
	179	55	0.00	65.00	0.00	
	177	45	0.00	65.00	1.00	
	178	55	0.00	65.00	0.00	

Table 86 – Trunk Line Curve Speed Upgrade Concept Design							
	Curve Number	Current Design Speed	Current E_a	Proposed Design Speed	Proposed E_a	Notes
	179	55	0.00	65.00	0.00	
	181	55	0.00	65.00	0.00	
	180	55	0.00	65.00	0.00	
	182	55	0.00	65.00	0.00	
	183	55	0.00	65.00	0.00	
	186	55	0.00	65.00	0.00	
	188	55	0.00	65.00	0.00	
	190	25	0.00	55.00	4.00	
	184	55	0.00	65.00	0.00	
	185	55	0.00	65.00	0.00	
	187	25	0.00	65.00	0.00	
	189	25	0.00	65.00	0.00	
	192	25	0.00	55.00	4.00	

Appendix G – Light Simulation Dwell Time Distributions

Table 87 – Light Simulation Dwell Time Distributions (in seconds)				
Distribution	Min (%)	Max (%)	Mean (%)	STD Dev (%)
G-1940 W North Temple-PM Peak-NB	18	76	39.00	24.57
G-1940 W North Temple-PM Peak-SB	19	63	34.97	21.04
G-1940 W North Temple-AM Peak-NB	18	57	32.01	17.58
G-1940 W North Temple-AM Peak-SB	19	63	34.18	21.89
G-1940 W North Temple-Off-Peak-NB	18	56	31.22	21.39
G-1940 W North Temple-Off-Peak-SB	17	56	30.04	20.35
R-2700 W. Sugar Factory Rd-PM Peak-SB	14	23	18.35	6.81
R-2700 W. Sugar Factory Rd-PM Peak-NB	13	27	19.11	7.22
R-2700 W. Sugar Factory Rd-AM Peak-SB	12	21	16.30	4.88
R-2700 W. Sugar Factory Rd-AM Peak-NB	15	26	19.94	5.77
R-2700 W. Sugar Factory Rd-Off-Peak-SB	13	23	17.88	5.66
R-2700 W. Sugar Factory Rd-Off-Peak-NB	13	27	18.95	8.28
S-300 East-PM Peak-WB	15	36	25.62	17.82
S-300 East-PM Peak-EB	16	27	21.58	15.51
S-300 East-AM Peak-WB	15	32	23.77	11.66
S-300 East-AM Peak-EB	13	26	20.28	12.32
S-300 East-Off-Peak-WB	14	33	23.75	17.17
S-300 East-Off-Peak-EB	13	28	20.35	10.90
R-4800 W. Old Bingham Hwy-PM Peak-SB	16	26	20.51	6.42
R-4800 W. Old Bingham Hwy-PM Peak-NB	14	28	19.91	8.36
R-4800 W. Old Bingham Hwy-AM Peak-SB	13	22	16.84	4.51
R-4800 W. Old Bingham Hwy-AM Peak-NB	16	29	21.99	9.75
R-4800 W. Old Bingham Hwy-Off-Peak-SB	14	27	19.36	7.67
R-4800 W. Old Bingham Hwy-Off-Peak-NB	13	27	19.51	10.43
S-500 East-PM Peak-WB	17	57	32.90	23.93
S-500 East-PM Peak-EB	19	50.3	34.68	26.76
S-500 East-AM Peak-WB	17	56	34.57	29.91
S-500 East-AM Peak-EB	17	49	30.64	17.42
S-500 East-Off-Peak-WB	16	60	35.00	26.99
S-500 East-Off-Peak-EB	16	45	29.61	20.43
R-5600 W. Old Bingham Hwy-PM Peak-SB	14	21	17.47	4.03
R-5600 W. Old Bingham Hwy-PM Peak-NB	12	22	16.65	6.16
R-5600 W. Old Bingham Hwy-AM Peak-SB	12	20	16.07	7.00
R-5600 W. Old Bingham Hwy-AM Peak-NB	14	24	18.46	6.26
R-5600 W. Old Bingham Hwy-Off-Peak-SB	12	22	16.90	6.20
R-5600 W. Old Bingham Hwy-Off-Peak-NB	12	22	17.13	9.77
S-700 East-PM Peak-WB	22	113	70.60	38.54
S-700 East-PM Peak-EB	17	101	51.23	34.73

Table 87 – Light Simulation Dwell Time Distributions (in seconds)				
Distribution	**Min (%)**	**Max (%)**	**Mean (%)**	**STD Dev (%)**
S-700 East-AM Peak-WB	20	109	63.49	32.82
S-700 East-AM Peak-EB	22	81	52.22	21.40
S-700 East-Off-Peak-WB	18	102	56.70	32.08
S-700 East-Off-Peak-EB	18	87	39.77	26.39
R-900 East-PM Peak-SB	16	58	29.73	19.12
R-900 East-PM Peak-NB	20	41	31.41	10.68
R-900 East-AM Peak-SB	15	59.9	29.28	26.95
R-900 East-AM Peak-NB	28	60	46.25	18.77
R-900 East-Off-Peak-SB	16	75	37.87	26.82
R-900 East-Off-Peak-NB	16	77	34.54	25.24
G-900 South-PM Peak-NB	16	38	25.31	12.90
R-900 South-PM Peak-SB	17	39	26.36	12.61
B-900 South-PM Peak-SB	19	53	31.24	19.41
R-900 South-PM Peak-NB	15	46	26.53	24.94
B-900 South-PM Peak-NB	17	52	29.40	17.24
G-900 South-PM Peak-SB	17	43	27.22	13.71
G-900 South-AM Peak-NB	17	46	26.50	14.00
R-900 South-AM Peak-SB	15	33	23.52	13.29
B-900 South-AM Peak-SB	17	37	26.38	14.58
R-900 South-AM Peak-NB	15	37	25.25	34.74
B-900 South-AM Peak-NB	17	50	28.19	18.67
G-900 South-AM Peak-SB	15	34	24.33	16.82
G-900 South-Off-Peak-NB	16	44	25.59	17.90
R-900 South-Off-Peak-SB	16	39	26.52	20.09
B-900 South-Off-Peak-SB	18	43	29.14	24.28
R-900 South-Off-Peak-NB	15	41	25.42	41.48
B-900 South-Off-Peak-NB	17	52	29.16	28.16
G-900 South-Off-Peak-SB	16	36	25.45	18.78
G-Arena-PM Peak-NB	26	116	70.86	34.95
B-Arena-PM Peak-SB	23	60	44.46	43.24
B-Arena-PM Peak-NB	63	143	101.59	36.34
G-Arena-PM Peak-SB	21	62	43.38	49.75
G-Arena-AM Peak-NB	21	105	60.59	32.81
B-Arena-AM Peak-SB	22	54	41.16	38.41
B-Arena-AM Peak-NB	60	135	98.15	32.86
G-Arena-AM Peak-SB	19	53	40.94	52.63
G-Arena-Off-Peak-NB	22	107	63.46	38.26
B-Arena-Off-Peak-SB	23	61	45.31	44.97
B-Arena-Off-Peak-NB	64	146	104.67	40.71
G-Arena-Off-Peak-SB	20	56	41.96	50.22

Table 87 – Light Simulation Dwell Time Distributions (in seconds)				
Distribution	Min (%)	Max (%)	Mean (%)	STD Dev (%)
G-Ballpark-PM Peak-NB	18	36	25.49	8.46
R-Ballpark-PM Peak-SB	20	36	27.26	11.54
B-Ballpark-PM Peak-SB	22	40	30.55	11.92
R-Ballpark-PM Peak-NB	16	34	25.51	30.18
B-Ballpark-PM Peak-NB	20	40	29.07	15.76
G-Ballpark-PM Peak-SB	31	55	43.07	11.46
G-Ballpark-AM Peak-NB	17	31	23.67	17.94
R-Ballpark-AM Peak-SB	17	33	25.17	13.41
B-Ballpark-AM Peak-SB	20	35	27.42	10.78
R-Ballpark-AM Peak-NB	15	29	22.01	13.75
B-Ballpark-AM Peak-NB	18	34	25.56	11.79
G-Ballpark-AM Peak-SB	32	53	43.42	14.22
G-Ballpark-Off-Peak-NB	17	33	24.41	11.77
R-Ballpark-Off-Peak-SB	19	35	27.15	15.87
B-Ballpark-Off-Peak-SB	22	39	29.81	13.54
R-Ballpark-Off-Peak-NB	16	33	23.92	17.90
B-Ballpark-Off-Peak-NB	18	38	27.50	20.03
G-Ballpark-Off-Peak-SB	30	57	44.26	13.50
R-Bingham Junction-PM Peak-SB	15	28	20.19	5.60
R-Bingham Junction-PM Peak-NB	16	32	24.27	21.22
R-Bingham Junction-AM Peak-SB	15	29	21.31	5.87
R-Bingham Junction-AM Peak-NB	15	29	21.80	13.58
R-Bingham Junction-Off-Peak-SB	14	27	19.56	8.09
R-Bingham Junction-Off-Peak-NB	14	31	22.08	20.88
G-Central Pointe-PM Peak-NB	21	53	33.95	15.70
R-Central Pointe-PM Peak-SB	21	46	32.33	15.44
B-Central Pointe-PM Peak-SB	23	56	37.30	21.27
R-Central Pointe-PM Peak-NB	19	39	28.57	11.21
B-Central Pointe-PM Peak-NB	22	44.2	33.47	20.27
G-Central Pointe-PM Peak-SB	21	41	30.59	13.06
G-Central Pointe-AM Peak-NB	20	40	28.67	14.48
R-Central Pointe-AM Peak-SB	17	39	26.26	13.31
B-Central Pointe-AM Peak-SB	20	53	33.35	22.39
R-Central Pointe-AM Peak-NB	17	33	24.53	10.59
B-Central Pointe-AM Peak-NB	20	40	29.52	13.55
G-Central Pointe-AM Peak-SB	19	41	28.00	13.87
G-Central Pointe-Off-Peak-NB	19	46	30.60	18.62
R-Central Pointe-Off-Peak-SB	18	58	34.40	26.31
B-Central Pointe-Off-Peak-SB	21	63	38.65	25.65
R-Central Pointe-Off-Peak-NB	18	58	36.07	34.69

Table 87 – Light Simulation Dwell Time Distributions (in seconds)				
Distribution	Min (%)	Max (%)	Mean (%)	STD Dev (%)
B-Central Pointe-Off-Peak-NB	21	43	31.97	17.64
G-Central Pointe-Off-Peak-SB	19	44	30.64	20.36
G-City Center-PM Peak-NB	26	84	53.30	24.89
B-City Center-PM Peak-SB	31	96	57.45	35.26
B-City Center-PM Peak-NB	26	93	56.79	30.08
G-City Center-PM Peak-SB	24	79	46.35	32.70
G-City Center-AM Peak-NB	23	70	41.90	20.68
B-City Center-AM Peak-SB	23	83	47.56	28.95
B-City Center-AM Peak-NB	26	83	51.56	25.30
G-City Center-AM Peak-SB	20	72	40.21	23.28
G-City Center-Off-Peak-NB	21	76	45.43	24.53
B-City Center-Off-Peak-SB	25	88	52.18	34.55
B-City Center-Off-Peak-NB	23	91	54.11	36.12
G-City Center-Off-Peak-SB	21	76	43.72	43.62
G-Courthouse-PM Peak-NB	38	176	113.91	54.25
R-Courthouse-PM Peak-SB	31	104.8	68.56	31.07
B-Courthouse-PM Peak-SB	32	93	58.70	31.97
R-Courthouse-PM Peak-NB	38	138.3	82.70	52.14
B-Courthouse-PM Peak-NB	38	175.4	111.05	54.01
G-Courthouse-PM Peak-SB	31	79.7	53.70	25.72
G-Courthouse-AM Peak-NB	28	131	79.42	53.60
R-Courthouse-AM Peak-SB	22	73	43.37	28.41
B-Courthouse-AM Peak-SB	24	84	47.83	25.60
R-Courthouse-AM Peak-NB	48	145	102.13	39.11
B-Courthouse-AM Peak-NB	26	165.9	87.11	55.68
G-Courthouse-AM Peak-SB	22	71	41.00	22.81
G-Courthouse-Off-Peak-NB	24	140	75.75	49.82
R-Courthouse-Off-Peak-SB	26	84	49.83	34.09
B-Courthouse-Off-Peak-SB	29	74	47.68	33.58
R-Courthouse-Off-Peak-NB	42	146	96.47	48.63
B-Courthouse-Off-Peak-NB	26	161	91.54	60.45
G-Courthouse-Off-Peak-SB	24	65	42.02	23.51
B-Crescent View-PM Peak-SB	18	31	25.85	67.87
B-Crescent View-PM Peak-NB	16	30	23.12	12.83
B-Crescent View-AM Peak-SB	14	25	19.96	18.30
B-Crescent View-AM Peak-NB	18	35	25.38	8.96
B-Crescent View-Off-Peak-SB	14	28	21.50	9.07
B-Crescent View-Off-Peak-NB	14	29	21.29	9.56
G-Decker Lake-PM Peak-NB	16	33	23.72	28.90
G-Decker Lake-PM Peak-SB	17	31	22.59	6.97

Table 87 – Light Simulation Dwell Time Distributions (in seconds)				
Distribution	**Min (%)**	**Max (%)**	**Mean (%)**	**STD Dev (%)**
G-Decker Lake-AM Peak-NB	17	33	23.87	10.12
G-Decker Lake-AM Peak-SB	15	28	21.69	15.80
G-Decker Lake-Off-Peak-NB	15	30	21.68	9.50
G-Decker Lake-Off-Peak-SB	15	30	21.51	10.07
G-Fairpark-PM Peak-NB	14	39	23.39	10.61
G-Fairpark-PM Peak-SB	15	34	23.02	12.71
G-Fairpark-AM Peak-NB	13	31	20.17	8.83
G-Fairpark-AM Peak-SB	13	25	19.18	8.02
G-Fairpark-Off-Peak-NB	14	39	23.38	11.27
G-Fairpark-Off-Peak-SB	13	30	20.81	10.13
R-Fashion Place West-PM Peak-SB	18	33	24.73	8.22
B-Fashion Place West-PM Peak-SB	22	44	33.01	23.46
R-Fashion Place West-PM Peak-NB	17	33	24.12	10.30
B-Fashion Place West-PM Peak-NB	20	41	30.45	16.87
R-Fashion Place West-AM Peak-SB	16	32	23.28	8.21
B-Fashion Place West-AM Peak-SB	18	39	27.00	13.96
R-Fashion Place West-AM Peak-NB	17	34	25.19	15.28
B-Fashion Place West-AM Peak-NB	20	43	31.46	32.70
R-Fashion Place West-Off-Peak-SB	17	33	24.28	15.49
B-Fashion Place West-Off-Peak-SB	19	58	34.24	26.23
R-Fashion Place West-Off-Peak-NB	16	35	25.22	19.86
B-Fashion Place West-Off-Peak-NB	19	72	38.91	38.59
R-Fort Douglas-PM Peak-SB	16	72	35.56	25.99
R-Fort Douglas-PM Peak-NB	16	29	21.80	6.44
R-Fort Douglas-AM Peak-SB	14	70	33.59	25.33
R-Fort Douglas-AM Peak-NB	16	29	21.43	8.11
R-Fort Douglas-Off-Peak-SB	15	66	31.28	148.95
R-Fort Douglas-Off-Peak-NB	16	34	23.28	9.41
G-Gallivan Plaza-PM Peak-NB	21	63	34.99	18.38
B-Gallivan Plaza-PM Peak-SB	26	87.6	53.19	36.24
B-Gallivan Plaza-PM Peak-NB	21	60	33.79	16.97
G-Gallivan Plaza-PM Peak-SB	21	75	44.69	32.67
G-Gallivan Plaza-AM Peak-NB	20	71	40.13	23.89
B-Gallivan Plaza-AM Peak-SB	21	71	44.20	36.66
B-Gallivan Plaza-AM Peak-NB	23	71	44.61	23.32
G-Gallivan Plaza-AM Peak-SB	19	72	40.35	31.15
G-Gallivan Plaza-Off-Peak-NB	19	65	34.75	24.71
B-Gallivan Plaza-Off-Peak-SB	22	73	43.22	31.20
B-Gallivan Plaza-Off-Peak-NB	20	67	37.67	23.86
G-Gallivan Plaza-Off-Peak-SB	19	78	41.29	35.24

Table 87 – Light Simulation Dwell Time Distributions (in seconds)				
Distribution	Min (%)	Max (%)	Mean (%)	STD Dev (%)
R-Historic Gardner-PM Peak-SB	13	23	17.56	4.76
R-Historic Gardner-PM Peak-NB	13	37	21.85	10.21
R-Historic Gardner-AM Peak-SB	12	22	16.40	5.19
R-Historic Gardner-AM Peak-NB	13	25	18.59	6.51
R-Historic Gardner-Off-Peak-SB	13	23	17.66	8.71
R-Historic Gardner-Off-Peak-NB	13	35	20.83	11.03
B-Historic Sandy Station-PM Peak-SB	20	36	27.05	13.05
B-Historic Sandy Station-PM Peak-NB	19	37	27.34	15.76
B-Historic Sandy Station-AM Peak-SB	17	35	25.03	12.46
B-Historic Sandy Station-AM Peak-NB	20	40	28.38	10.94
B-Historic Sandy Station-Off-Peak-SB	18	42	27.43	12.97
B-Historic Sandy Station-Off-Peak-NB	16	35	25.12	14.46
G-Jackson/Euclid-PM Peak-NB	20	61.2	36.06	20.06
G-Jackson/Euclid-PM Peak-SB	21	75	39.57	21.72
G-Jackson/Euclid-AM Peak-NB	16	51	28.55	15.48
G-Jackson/Euclid-AM Peak-SB	18	53	30.82	16.64
G-Jackson/Euclid-Off-Peak-NB	18	56	32.58	18.81
G-Jackson/Euclid-Off-Peak-SB	19	63	33.99	19.84
G-Jordan River Service Center Relief-PM Peak-NB	12	40	21.57	18.35
G-Jordan River Service Center Relief-PM Peak-SB	11	50	23.32	14.43
G-Jordan River Service Center Relief-AM Peak-NB	13	27	18.68	7.47
G-Jordan River Service Center Relief-AM Peak-SB	13	38	24.83	14.64
G-Jordan River Service Center Relief-Off-Peak-NB	12	55	30.57	50.13
G-Jordan River Service Center Relief-Off-Peak-SB	12	43	63.18	770.86
R-Jordan Valley-PM Peak-SB	14	27	19.47	8.08
R-Jordan Valley-PM Peak-NB	14	27	20.14	6.92
R-Jordan Valley-AM Peak-SB	13	23	18.13	6.17
R-Jordan Valley-AM Peak-NB	16	30	21.70	7.86
R-Jordan Valley-Off-Peak-SB	14	29	19.99	8.60
R-Jordan Valley-Off-Peak-NB	14	27	19.82	9.55
B-Kimballs Lane-PM Peak-SB	17	36	25.20	8.98
B-Kimballs Lane-PM Peak-NB	16	29	22.13	10.45
B-Kimballs Lane-AM Peak-SB	16	41	28.13	10.83
B-Kimballs Lane-AM Peak-NB	17	33	23.94	11.18
B-Kimballs Lane-Off-Peak-SB	15	42	26.62	11.99
B-Kimballs Lane-Off-Peak-NB	13	29	21.56	35.64
R-Library-PM Peak-SB	22	88	54.60	30.11
R-Library-PM Peak-NB	19	95.8	45.81	43.68
R-Library-AM Peak-SB	22	84	58.03	32.38
R-Library-AM Peak-NB	17	84	36.87	31.79

Table 87 – Light Simulation Dwell Time Distributions (in seconds)				
Distribution	Min (%)	Max (%)	Mean (%)	STD Dev (%)
R-Library-Off-Peak-SB	19	86	50.50	45.81
R-Library-Off-Peak-NB	18	84	45.84	28.04
R-Meadowbrook-PM Peak-SB	16	32	23.29	8.82
B-Meadowbrook-PM Peak-SB	19	36	26.62	13.88
R-Meadowbrook-PM Peak-NB	16	36	24.07	9.16
B-Meadowbrook-PM Peak-NB	20	44	31.88	15.46
R-Meadowbrook-AM Peak-SB	15	27	20.14	9.53
B-Meadowbrook-AM Peak-SB	17	33	24.41	11.65
R-Meadowbrook-AM Peak-NB	16	34	23.88	8.98
B-Meadowbrook-AM Peak-NB	20	44.5	30.79	14.17
R-Meadowbrook-Off-Peak-SB	15	29	21.57	30.39
B-Meadowbrook-Off-Peak-SB	17	35	25.48	14.28
R-Meadowbrook-Off-Peak-NB	15	36	24.03	12.25
B-Meadowbrook-Off-Peak-NB	19	45	31.03	14.63
B-Midvale Center-PM Peak-SB	19	35	26.69	26.64
B-Midvale Center-PM Peak-NB	21	39	29.27	12.01
B-Midvale Center-AM Peak-SB	17	34.5	24.86	13.87
B-Midvale Center-AM Peak-NB	20	37	27.53	9.40
B-Midvale Center-Off-Peak-SB	17	39	26.43	14.82
B-Midvale Center-Off-Peak-NB	19	37	27.81	10.54
B-Midvale Fort Union-PM Peak-SB	19	35	25.98	10.23
B-Midvale Fort Union-PM Peak-NB	20	40	29.68	30.18
B-Midvale Fort Union-AM Peak-SB	17	32	24.16	8.38
B-Midvale Fort Union-AM Peak-NB	18	36	25.66	10.76
B-Midvale Fort Union-Off-Peak-SB	18	34	25.37	11.05
B-Midvale Fort Union-Off-Peak-NB	18	42	28.32	15.97
R-Midvale Rail Service Center-PM Peak-SB	12	30	21.30	16.20
R-Midvale Rail Service Center-PM Peak-NB	12	32.9	19.38	20.97
R-Midvale Rail Service Center-AM Peak-SB	11	47	21.21	17.45
R-Midvale Rail Service Center-AM Peak-NB	11	31	18.90	10.11
R-Midvale Rail Service Center-Off-Peak-SB	11	41	28.06	106.41
R-Midvale Rail Service Center-Off-Peak-NB	12	66	37.96	87.76
R-Millcreek-PM Peak-SB	18	34	25.57	11.96
B-Millcreek-PM Peak-SB	20	44	30.44	12.73
R-Millcreek-PM Peak-NB	17	37	26.46	8.92
B-Millcreek-PM Peak-NB	22	43	31.92	11.85
R-Millcreek-AM Peak-SB	15	28	21.19	7.78
B-Millcreek-AM Peak-SB	17	34	24.57	9.53
R-Millcreek-AM Peak-NB	16	32	22.72	8.03
B-Millcreek-AM Peak-NB	20	38	27.90	9.61

Table 87 – Light Simulation Dwell Time Distributions (in seconds)				
Distribution	Min (%)	Max (%)	Mean (%)	STD Dev (%)
R-Millcreek-Off-Peak-SB	16	31.1	22.97	9.91
B-Millcreek-Off-Peak-SB	18	38	27.35	31.86
R-Millcreek-Off-Peak-NB	16	36	25.63	17.89
B-Millcreek-Off-Peak-NB	21	44	31.71	15.17
R-Murray Central-PM Peak-SB	27	55	40.86	11.11
B-Murray Central-PM Peak-SB	23	44	33.04	19.31
R-Murray Central-PM Peak-NB	20	63	42.28	65.73
B-Murray Central-PM Peak-NB	23	51	35.68	18.07
R-Murray Central-AM Peak-SB	29	58	43.58	15.51
B-Murray Central-AM Peak-SB	19	44	30.20	20.14
R-Murray Central-AM Peak-NB	20	55.4	36.94	33.74
B-Murray Central-AM Peak-NB	22	47	33.97	23.60
R-Murray Central-Off-Peak-SB	29	58	44.50	26.78
B-Murray Central-Off-Peak-SB	19	42	29.66	28.99
R-Murray Central-Off-Peak-NB	17	55	33.81	34.20
B-Murray Central-Off-Peak-NB	20	46	31.67	16.19
R-Murray North-PM Peak-SB	16	30	21.88	6.57
B-Murray North-PM Peak-SB	18	39	26.86	15.17
R-Murray North-PM Peak-NB	15	31	22.18	7.17
B-Murray North-PM Peak-NB	19	47	30.70	14.54
R-Murray North-AM Peak-SB	15	33	21.66	9.46
B-Murray North-AM Peak-SB	16	32.8	23.36	7.72
R-Murray North-AM Peak-NB	15	31	22.23	8.27
B-Murray North-AM Peak-NB	19	47	30.62	14.61
R-Murray North-Off-Peak-SB	15	30	21.03	8.36
B-Murray North-Off-Peak-SB	17	39	25.91	13.06
R-Murray North-Off-Peak-NB	15	30	21.41	8.05
B-Murray North-Off-Peak-NB	18	50	31.16	32.09
G-North Temple Bridge/Guadalupe-PM Peak-NB	23	45	33.10	11.49
G-North Temple Bridge/Guadalupe-PM Peak-SB	29	104	69.62	30.74
G-North Temple Bridge/Guadalupe-AM Peak-NB	18	59	33.87	19.07
G-North Temple Bridge/Guadalupe-AM Peak-SB	31	117.7	74.28	36.18
G-North Temple Bridge/Guadalupe-Off-Peak-NB	19	53	32.62	25.25
G-North Temple Bridge/Guadalupe-Off-Peak-SB	25	101	64.79	36.93
B-Old GreekTown-PM Peak-SB	19	84	40.20	26.94
B-Old GreekTown-PM Peak-NB	20	67	39.58	32.49
B-Old GreekTown-AM Peak-SB	20	81	39.95	31.79
B-Old GreekTown-AM Peak-NB	19	77	40.43	27.97
B-Old GreekTown-Off-Peak-SB	19	82	40.03	87.16
B-Old GreekTown-Off-Peak-NB	20	80	41.67	33.23

Table 87 – Light Simulation Dwell Time Distributions (in seconds)				
Distribution	**Min (%)**	**Max (%)**	**Mean (%)**	**STD Dev (%)**
B-Planetarium-PM Peak-SB	20	47	32.44	20.21
B-Planetarium-PM Peak-NB	25	107.9	69.53	31.64
B-Planetarium-AM Peak-SB	17	38	27.27	24.90
B-Planetarium-AM Peak-NB	19	90	54.36	27.91
B-Planetarium-Off-Peak-SB	18	45	30.30	22.31
B-Planetarium-Off-Peak-NB	19	100	58.88	31.82
G-Power-PM Peak-NB	16	40	24.36	11.68
G-Power-PM Peak-SB	18	45	28.34	11.72
G-Power-AM Peak-NB	16	29	22.04	8.38
G-Power-AM Peak-SB	17	40	25.45	11.67
G-Power-Off-Peak-NB	15	31	22.61	18.47
G-Power-Off-Peak-SB	16	38	24.96	11.42
G-Redwood Junction-PM Peak-NB	19	40	28.72	13.73
G-Redwood Junction-PM Peak-SB	16	31	23.15	11.11
G-Redwood Junction-AM Peak-NB	17	34	24.76	18.39
G-Redwood Junction-AM Peak-SB	16	28	21.20	7.80
G-Redwood Junction-Off-Peak-NB	17	36	26.62	13.88
G-Redwood Junction-Off-Peak-SB	15	30	21.26	8.14
G-River Trail-PM Peak-NB	16	37	25.95	24.92
G-River Trail-PM Peak-SB	15	32	22.67	17.88
G-River Trail-AM Peak-NB	15	31	22.08	13.45
G-River Trail-AM Peak-SB	15	27	21.37	12.51
G-River Trail-Off-Peak-NB	15	34	23.32	14.14
G-River Trail-Off-Peak-SB	14	28	20.58	13.29
B-Sandy Civic Center-PM Peak-NB	18	36	27.15	27.16
B-Sandy Civic Center-PM Peak-SB	17	30	23.60	11.55
B-Sandy Civic Center-AM Peak-SB	17	31	24.15	20.00
B-Sandy Civic Center-AM Peak-NB	18	37	26.98	57.48
B-Sandy Civic Center-Off-Peak-SB	15	33	23.36	10.97
B-Sandy Civic Center-Off-Peak-NB	17	36	25.49	16.09
B-Sandy Expo-PM Peak-SB	15	26	20.68	10.13
B-Sandy Expo-PM Peak-NB	16	34	24.58	28.64
B-Sandy Expo-AM Peak-SB	15	29	21.42	7.34
B-Sandy Expo-AM Peak-NB	15	30	21.72	8.35
B-Sandy Expo-Off-Peak-SB	14	29	20.99	9.98
B-Sandy Expo-Off-Peak-NB	14	33	22.68	12.90
R-South Jordan Parkway-PM Peak-SB	13	21	17.24	7.78
R-South Jordan Parkway-PM Peak-NB	12	22	16.91	8.13
R-South Jordan Parkway-AM Peak-SB	12	22	16.50	5.47
R-South Jordan Parkway-AM Peak-NB	14	23	20.72	74.46

Table 87 – Light Simulation Dwell Time Distributions (in seconds)				
Distribution	**Min (%)**	**Max (%)**	**Mean (%)**	**STD Dev (%)**
R-South Jordan Parkway-Off-Peak-SB	12	24	17.76	7.20
R-South Jordan Parkway-Off-Peak-NB	12	23	17.28	26.16
S-South Salt Lake City-PM Peak-WB	17	137	66.40	48.30
S-South Salt Lake City-PM Peak-EB	23	123	86.99	37.45
S-South Salt Lake City-AM Peak-WB	13	104	42.86	38.03
S-South Salt Lake City-AM Peak-EB	17	147	80.48	48.90
S-South Salt Lake City-Off-Peak-WB	14	106	42.12	37.75
S-South Salt Lake City-Off-Peak-EB	18	118	67.38	44.40
R-Stadium-PM Peak-SB	22	117	67.76	44.16
R-Stadium-PM Peak-NB	17	32	23.69	8.39
R-Stadium-AM Peak-SB	19	121	66.17	61.73
R-Stadium-AM Peak-NB	18	34	26.39	15.68
R-Stadium-Off-Peak-SB	20	96	42.40	34.00
R-Stadium-Off-Peak-NB	16	32	23.94	11.99
S-Sugarmont-PM Peak-WB	17	74	42.41	26.16
S-Sugarmont-PM Peak-EB	18	80	44.95	24.30
S-Sugarmont-AM Peak-WB	14	46	25.01	14.97
S-Sugarmont-AM Peak-EB	15	51	26.99	15.27
S-Sugarmont-Off-Peak-WB	13	49	27.28	18.14
S-Sugarmont-Off-Peak-EB	15	57	30.05	17.62
G-Temple Square-PM Peak-NB	19	81	40.99	30.11
B-Temple Square-PM Peak-SB	21	70	40.97	23.91
B-Temple Square-PM Peak-NB	19	87	45.12	37.77
G-Temple Square-PM Peak-SB	18	54	33.68	18.42
G-Temple Square-AM Peak-NB	17	68	33.91	23.38
B-Temple Square-AM Peak-SB	19	59	36.04	19.63
B-Temple Square-AM Peak-NB	18	72	37.35	29.46
G-Temple Square-AM Peak-SB	17	49	30.89	15.97
G-Temple Square-Off-Peak-NB	17	72	36.35	28.39
B-Temple Square-Off-Peak-SB	19	69	39.95	33.23
B-Temple Square-Off-Peak-NB	18	84	42.77	32.26
G-Temple Square-Off-Peak-SB	17	51	32.01	25.89
R-Trolley-PM Peak-SB	20	76	47.31	29.98
R-Trolley-PM Peak-NB	72	117	101.08	61.50
R-Trolley-AM Peak-SB	15	51	26.53	24.92
R-Trolley-AM Peak-NB	19	104	61.44	36.09
R-Trolley-Off-Peak-SB	17	72	37.30	33.48
R-Trolley-Off-Peak-NB	22	102	67.72	30.57
R-University South Campus-PM Peak-SB	17	70	33.93	22.00
R-University South Campus-PM Peak-NB	15	32	22.67	14.15

Table 87 – Light Simulation Dwell Time Distributions (in seconds)				
Distribution	**Min (%)**	**Max (%)**	**Mean (%)**	**STD Dev (%)**
R-University South Campus-AM Peak-SB	14	66	29.73	28.71
R-University South Campus-AM Peak-NB	18	33	25.17	7.74
R-University South Campus-Off-Peak-SB	15	65	29.10	20.48
R-University South Campus-Off-Peak-NB	15	36	24.35	16.74
R-West Jordan City Center-PM Peak-SB	15	29	21.59	14.31
R-West Jordan City Center-PM Peak-NB	15	33	21.53	7.55
R-West Jordan City Center-AM Peak-SB	14	25	20.21	25.99
R-West Jordan City Center-AM Peak-NB	15	28	21.08	7.25
R-West Jordan City Center-Off-Peak-SB	14	29	21.13	22.86
R-West Jordan City Center-Off-Peak-NB	14	30	21.17	9.14

Appendix H – Light Simulation Calibration - GPS Data Recording of Actual Operations vs Existing Baseline Simulation Trip Graphs

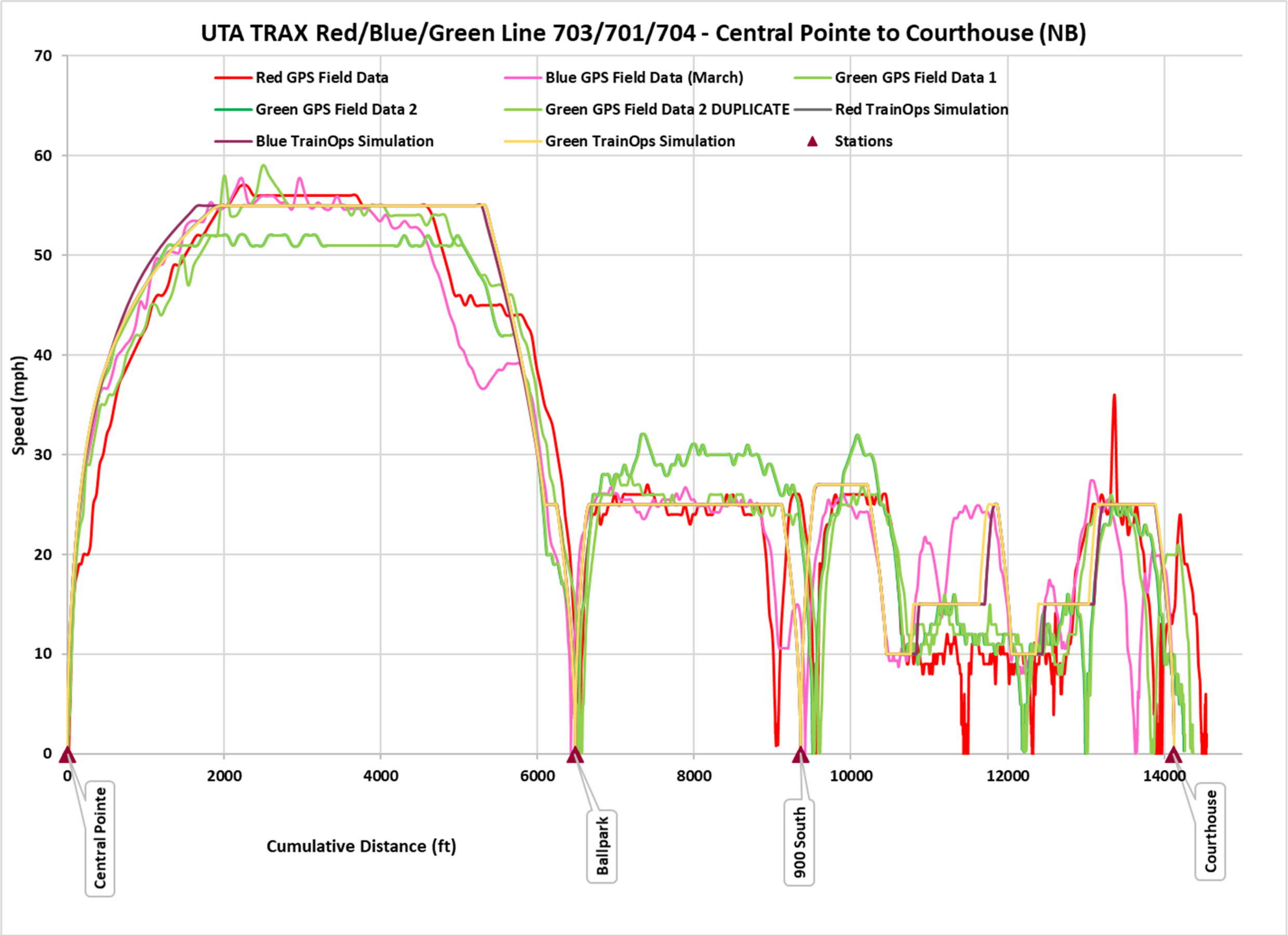

Figure 69 – GPS Data vs Existing Baseline Simulation Trip Graph Overlay – Central Point to Courthouse

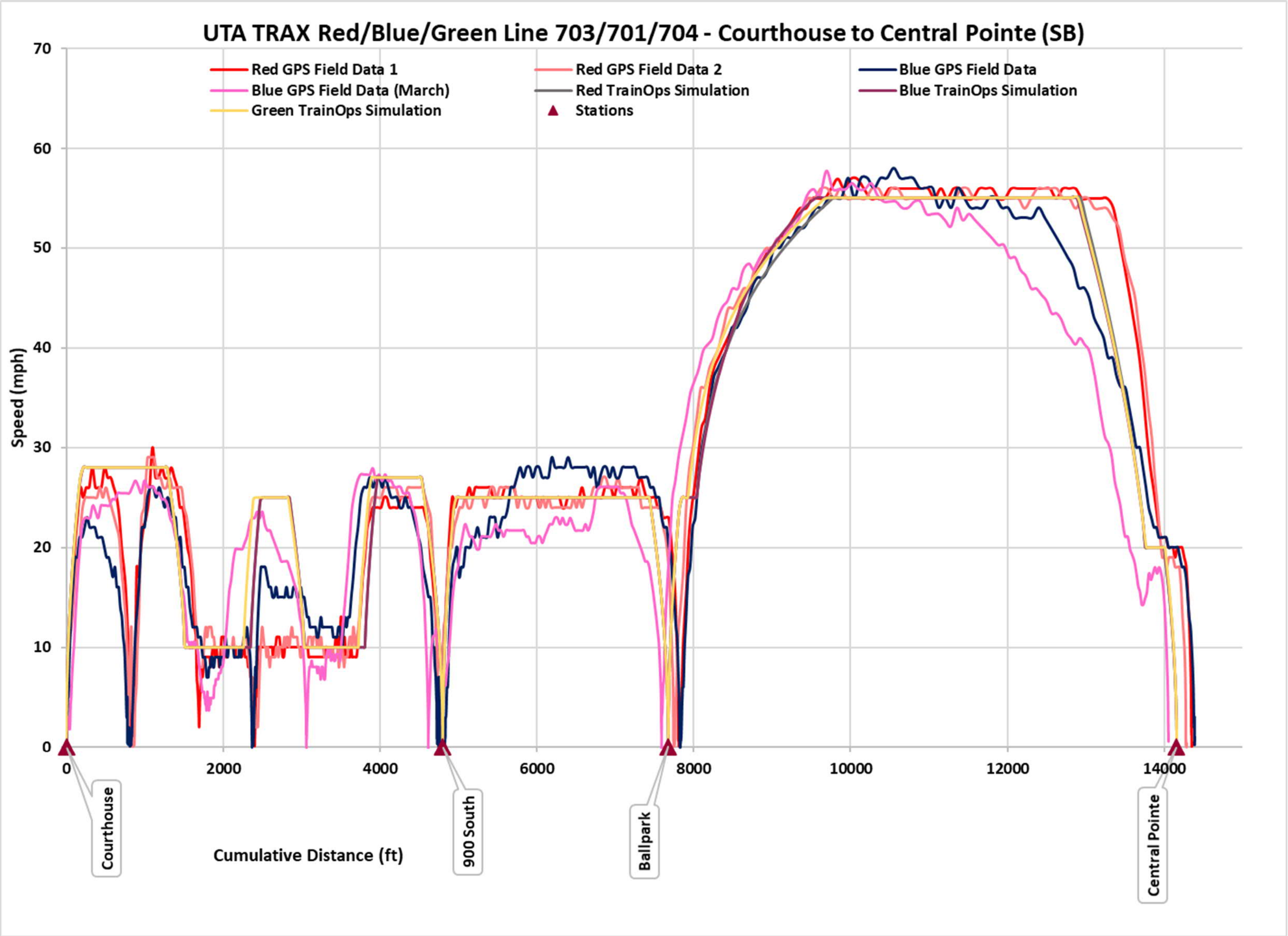

Figure 70 – GPS Data vs Existing Baseline Simulation Trip Graph Overlay – Courthouse to Central Pointe

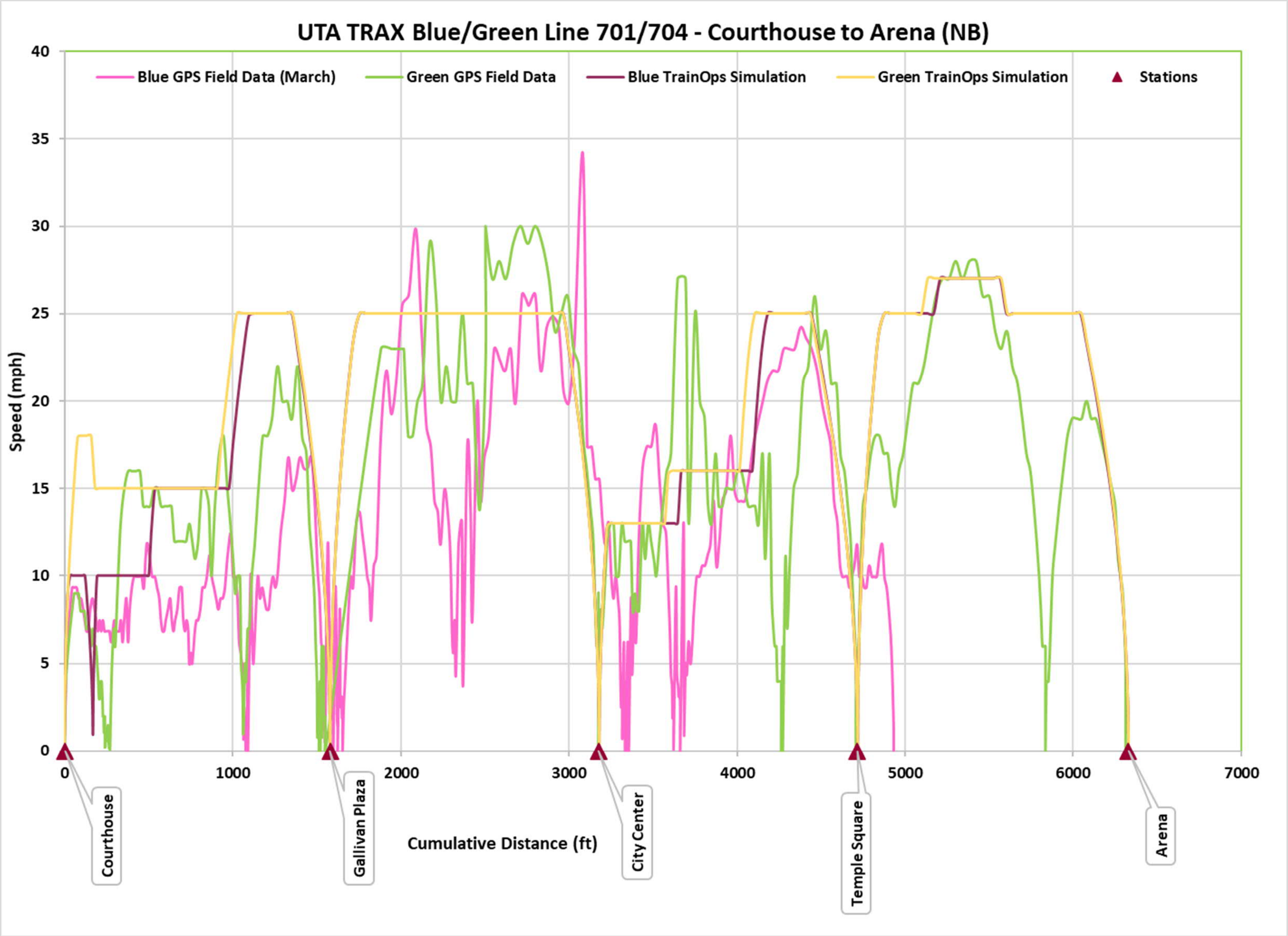

Figure 71 – GPS Data vs Existing Baseline Simulation Trip Graph Overlay – Courthouse to Arena

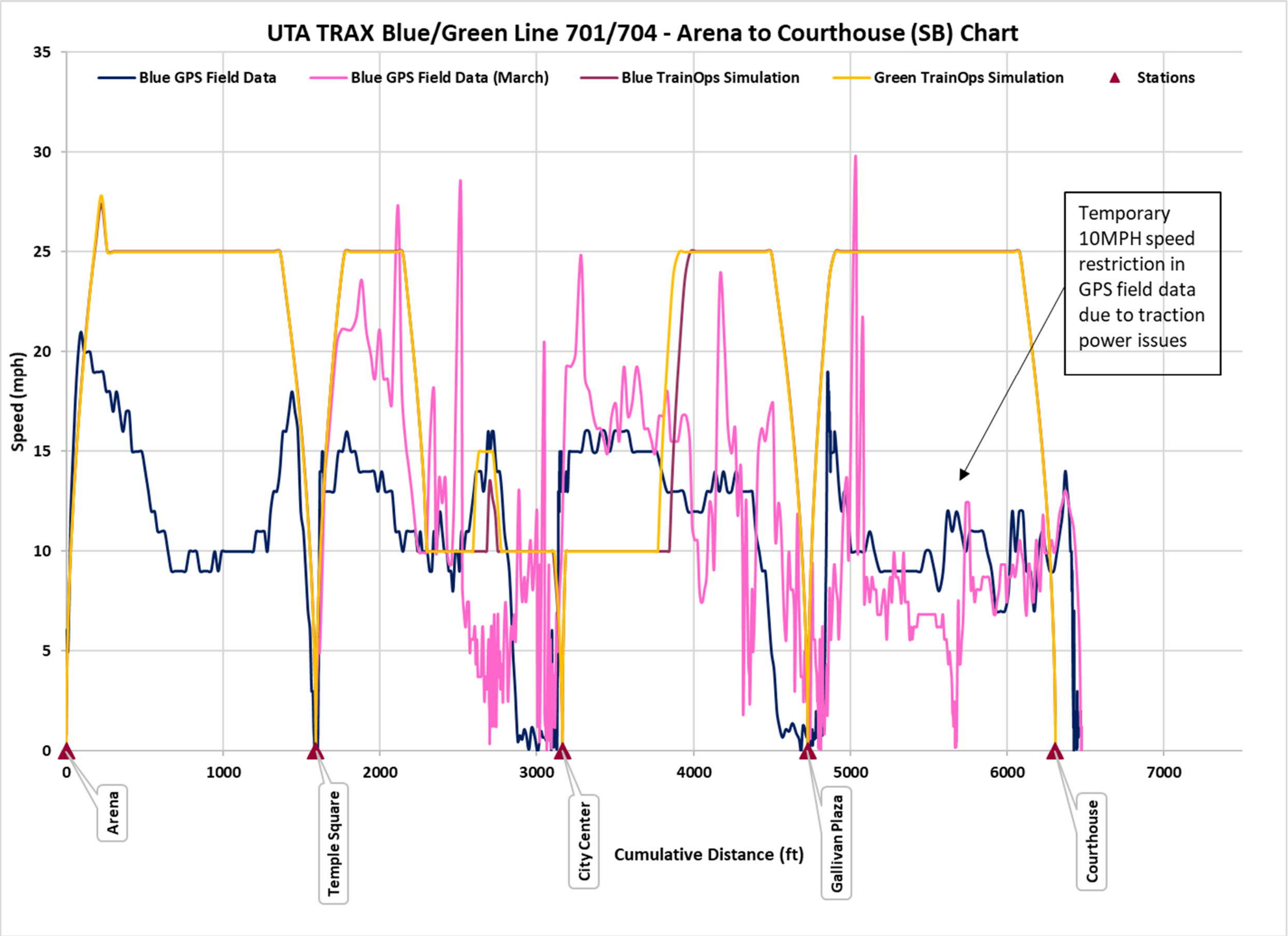

Figure 72 – GPS Data vs Existing Baseline Simulation Trip Graph Overlay – Arena to Courthouse

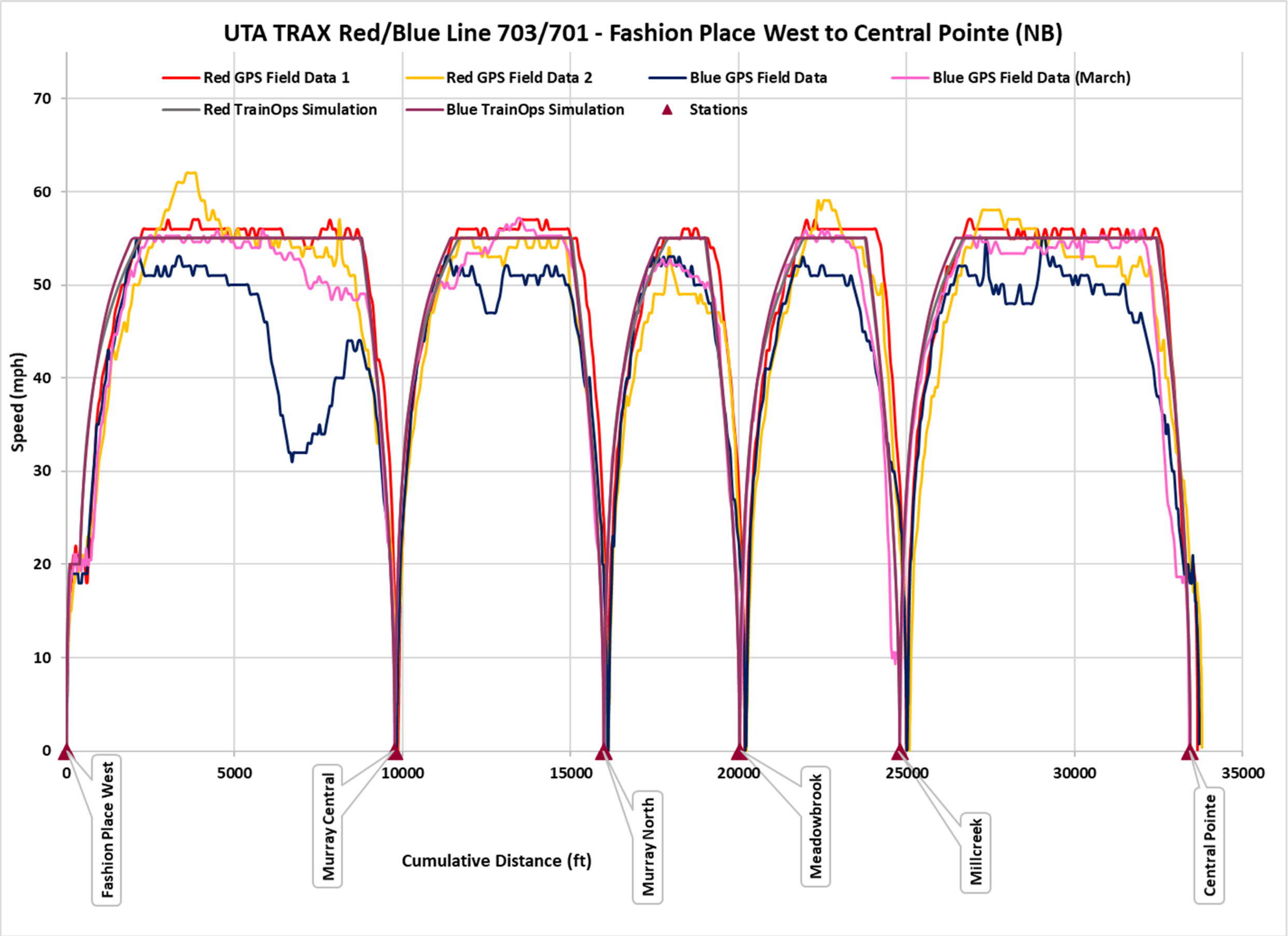

Figure 73 – GPS Data vs Existing Baseline Simulation Trip Graph Overlay – Fashion Place West to Central Pointe

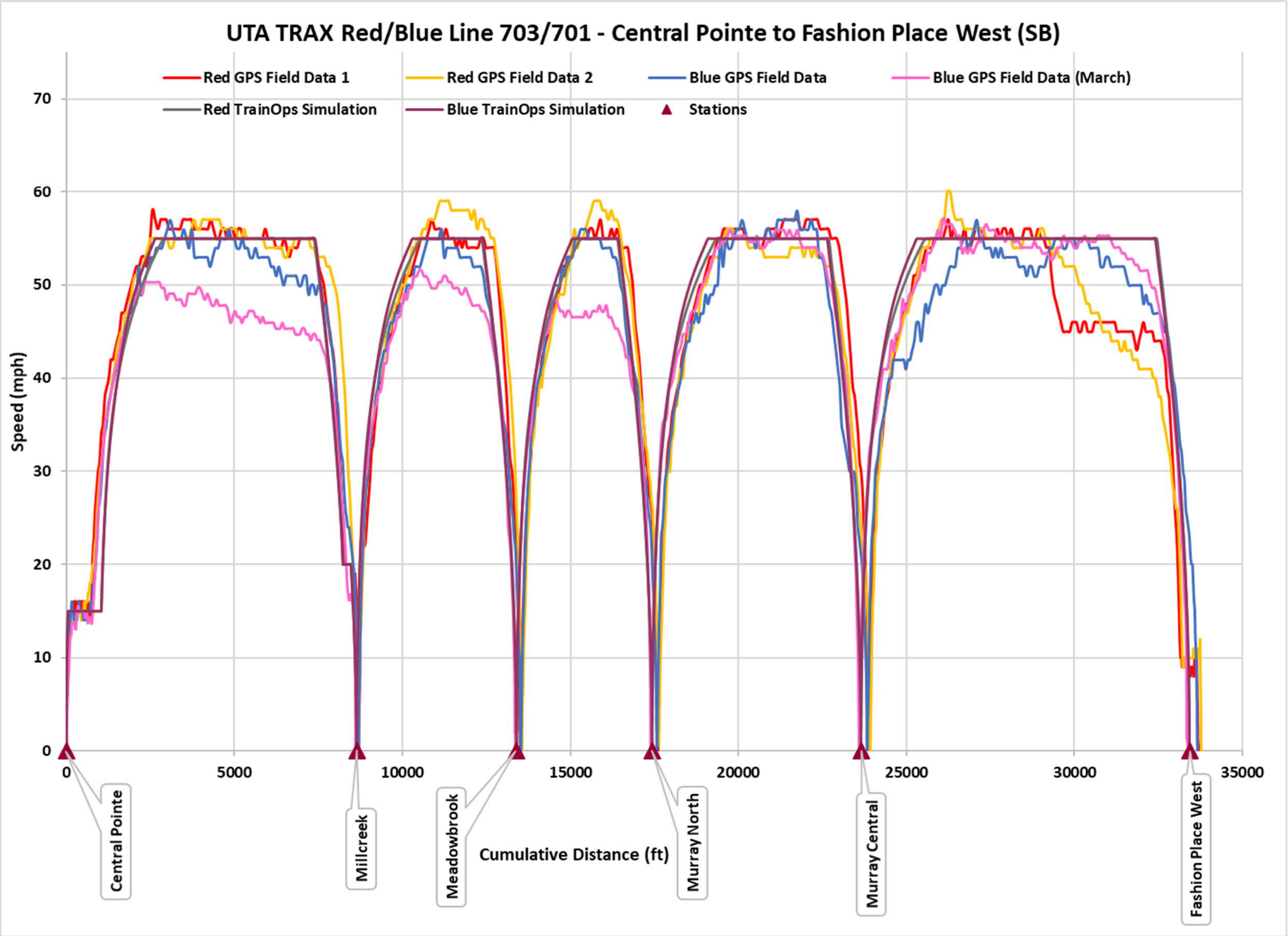

Figure 74 – GPS Data vs Existing Baseline Simulation Trip Graph Overlay – Central Pointe to Fashion Place West

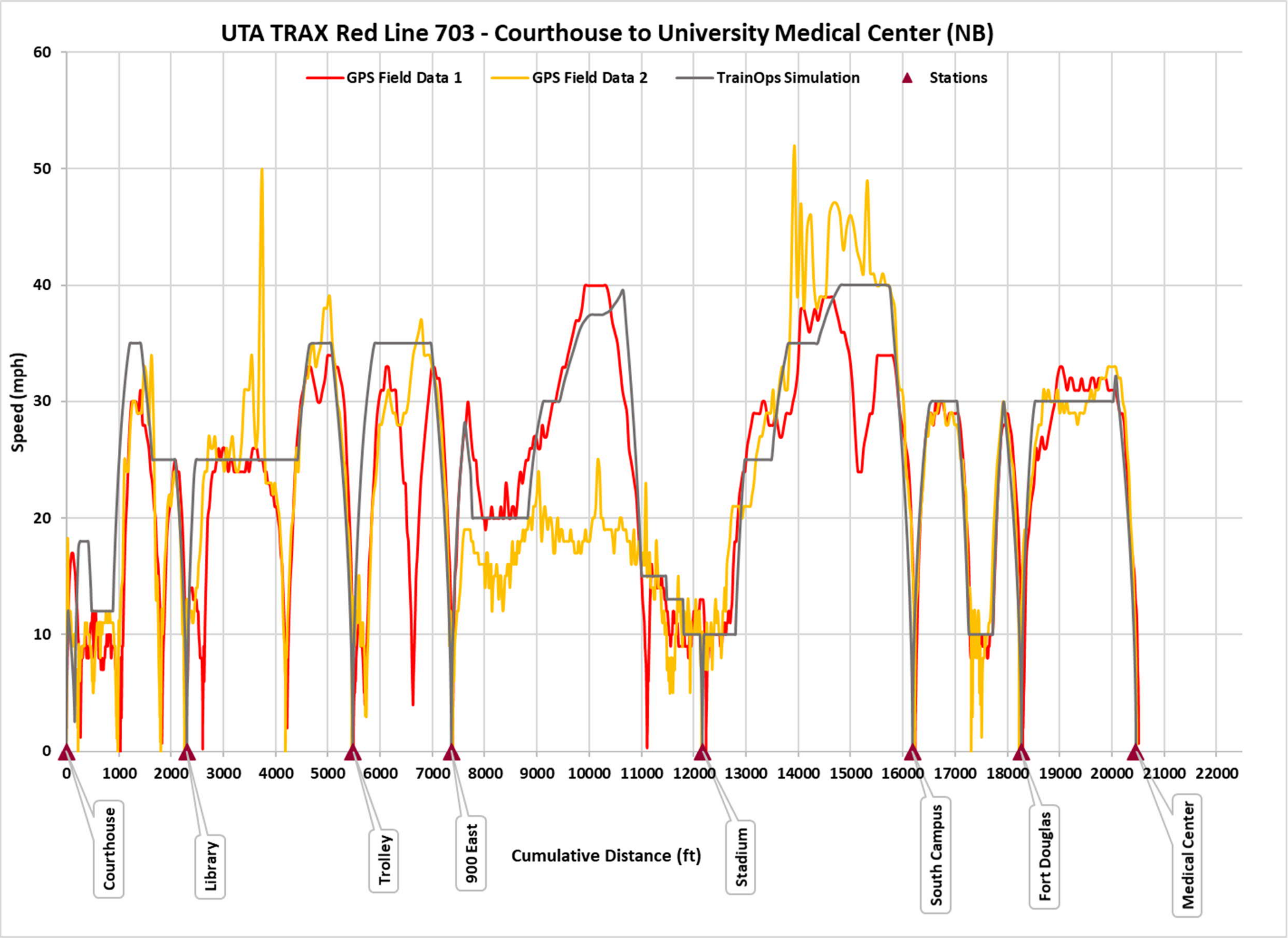

Figure 75 – GPS Data vs Existing Baseline Simulation Trip Graph Overlay – Courthouse to University Medical Center

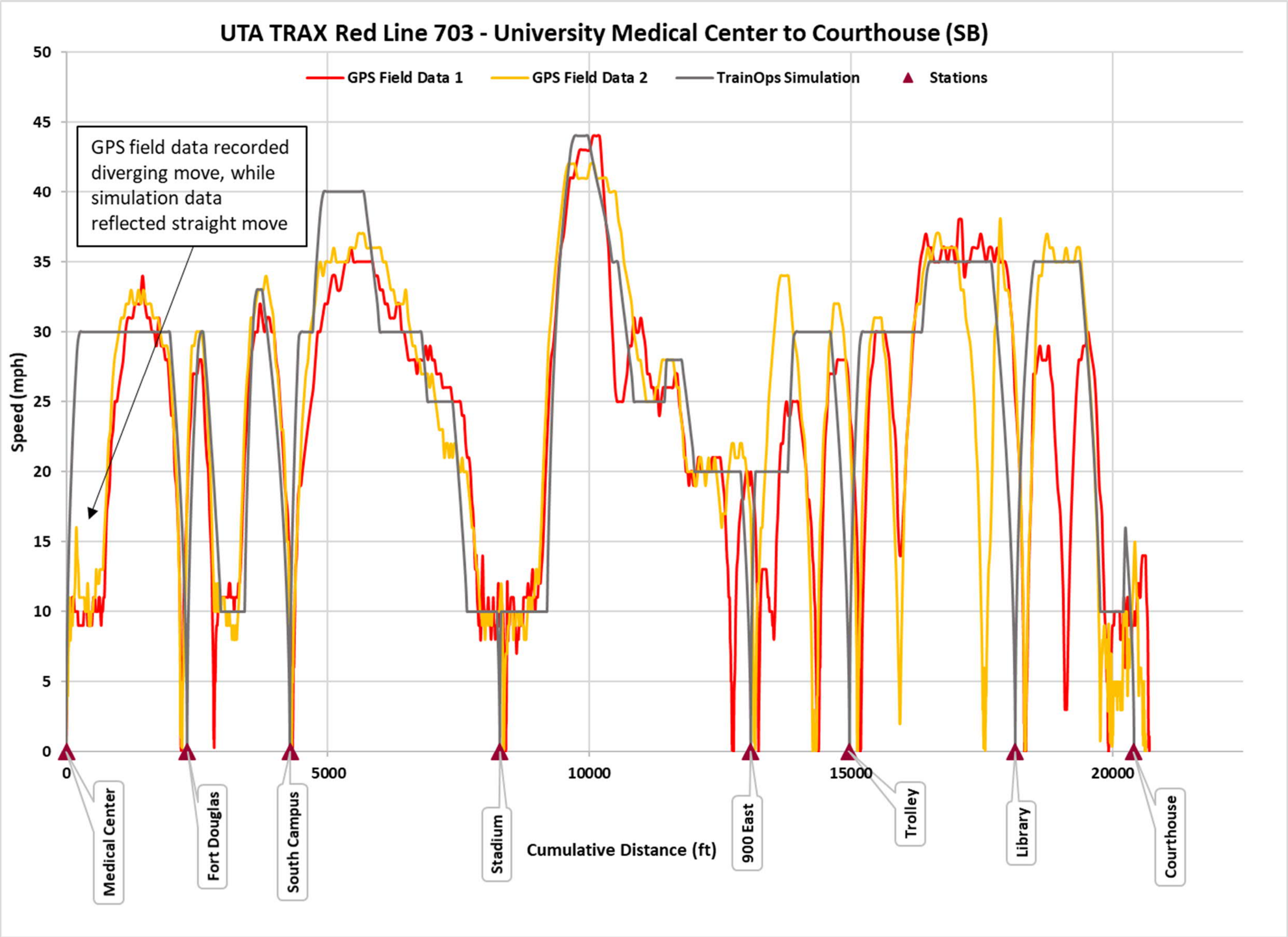

Figure 76 – GPS Data vs Existing Baseline Simulation Trip Graph Overlay – University Medical Center to Courthouse

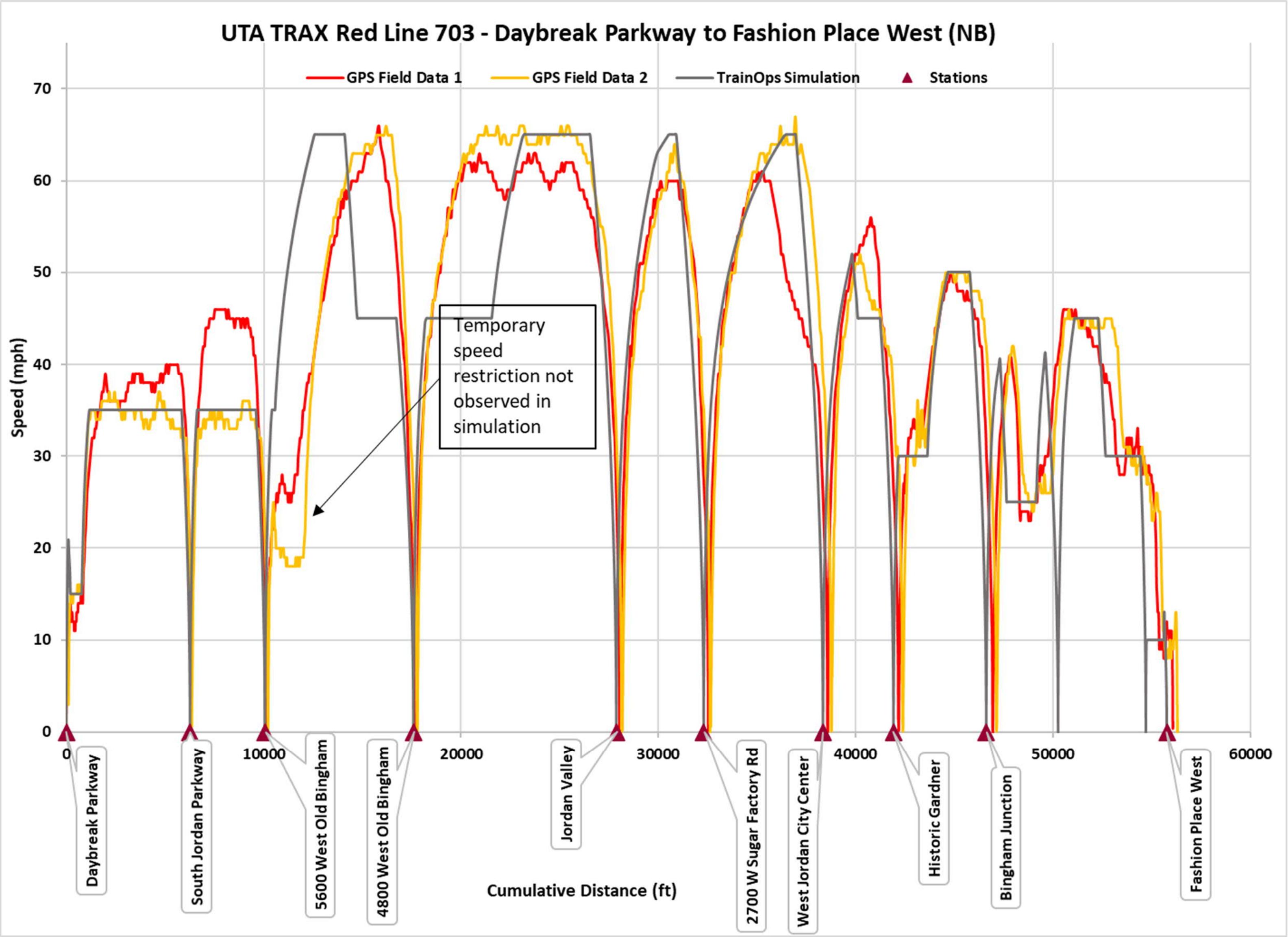

Figure 77 – GPS Data vs Existing Baseline Simulation Trip Graph Overlay – Daybreak Parkway to Fashion Place West

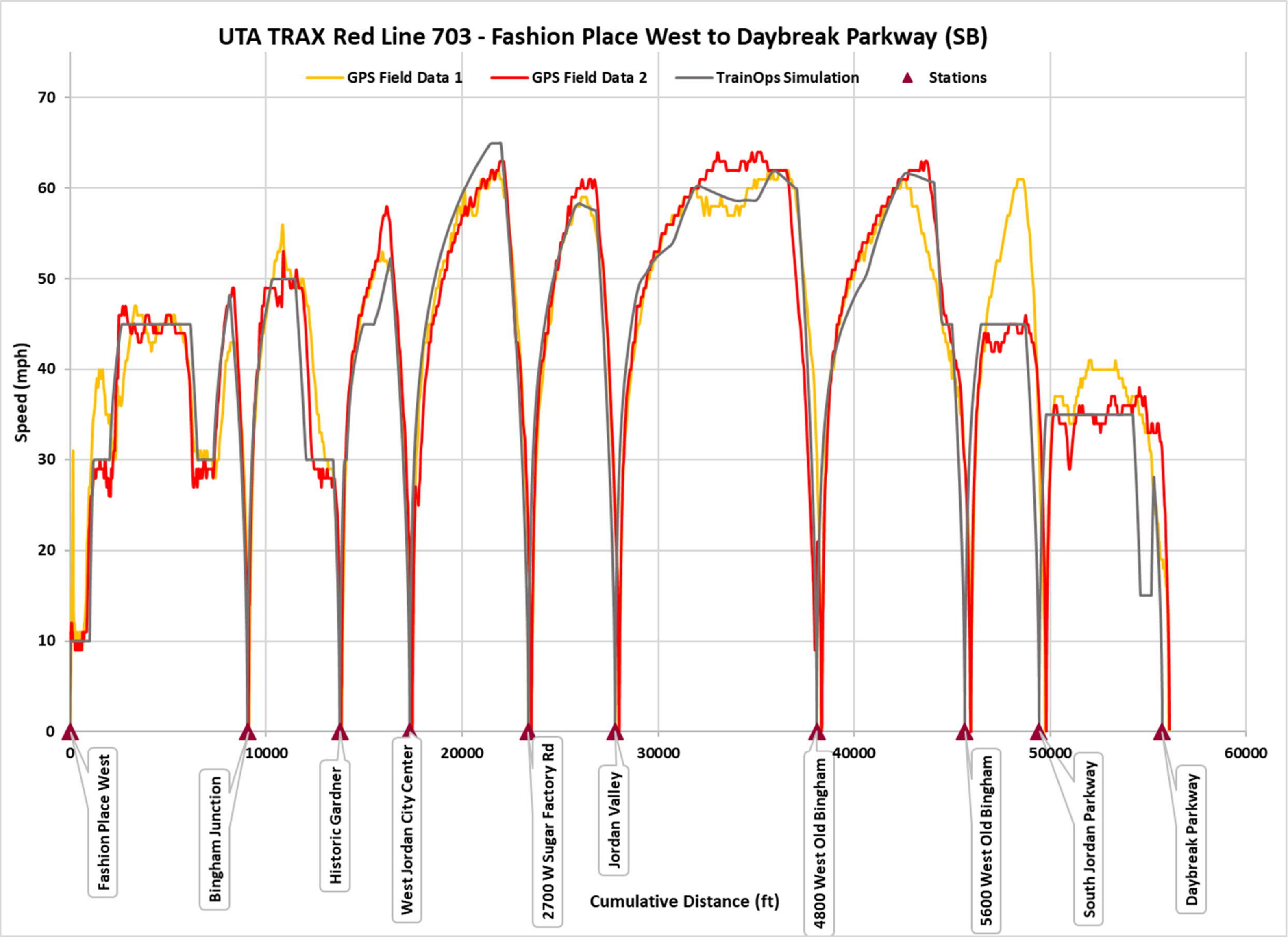

Figure 78 – GPS Data vs Existing Baseline Simulation Trip Graph Overlay – Fashion Place West to Daybreak Parkway

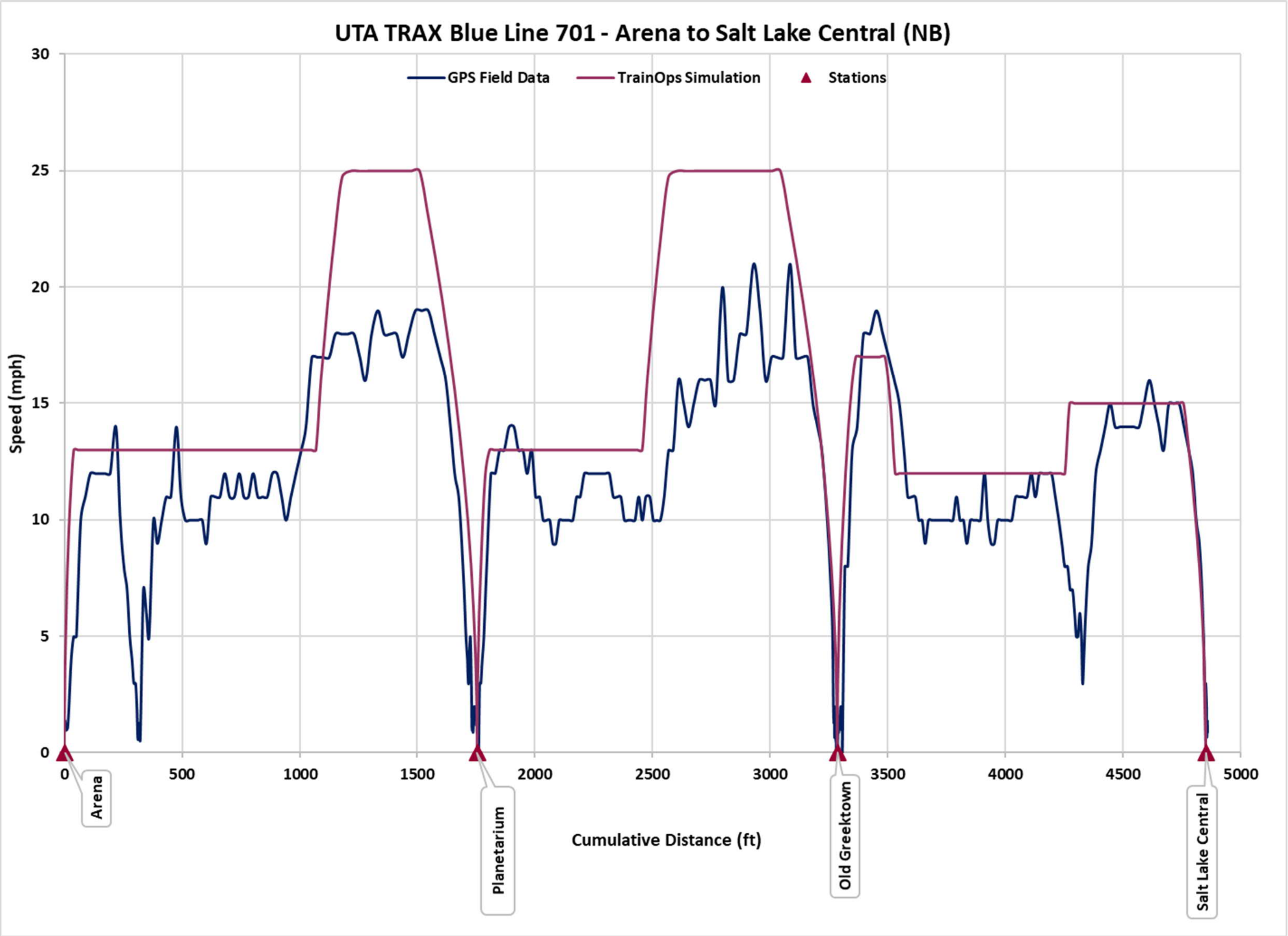

Figure 79 – GPS Data vs Existing Baseline Simulation Trip Graph Overlay – Arena to Salt Lake Central

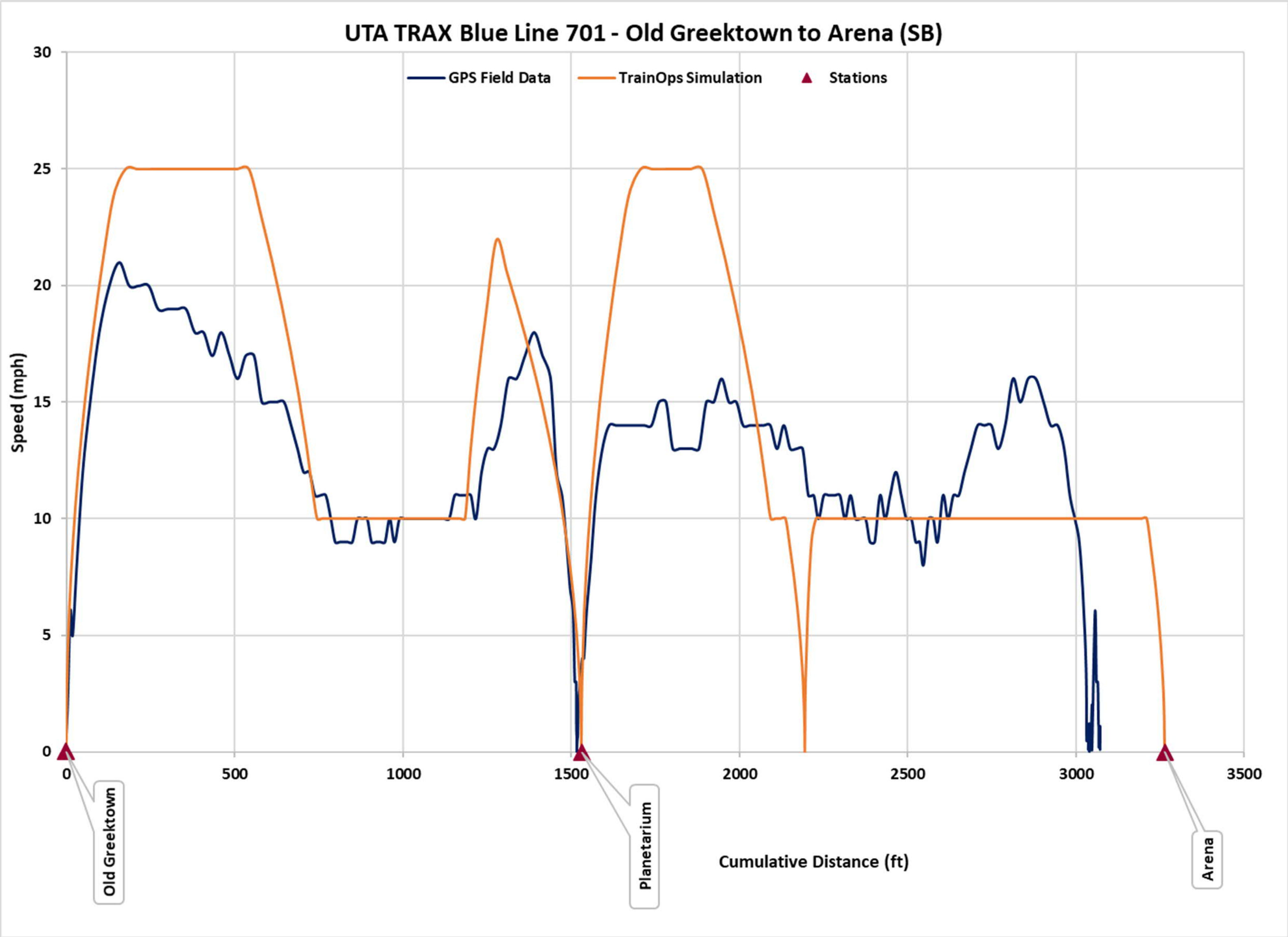

Figure 80 – GPS Data vs Existing Baseline Simulation Trip Graph Overlay – Old Greektown to Arena

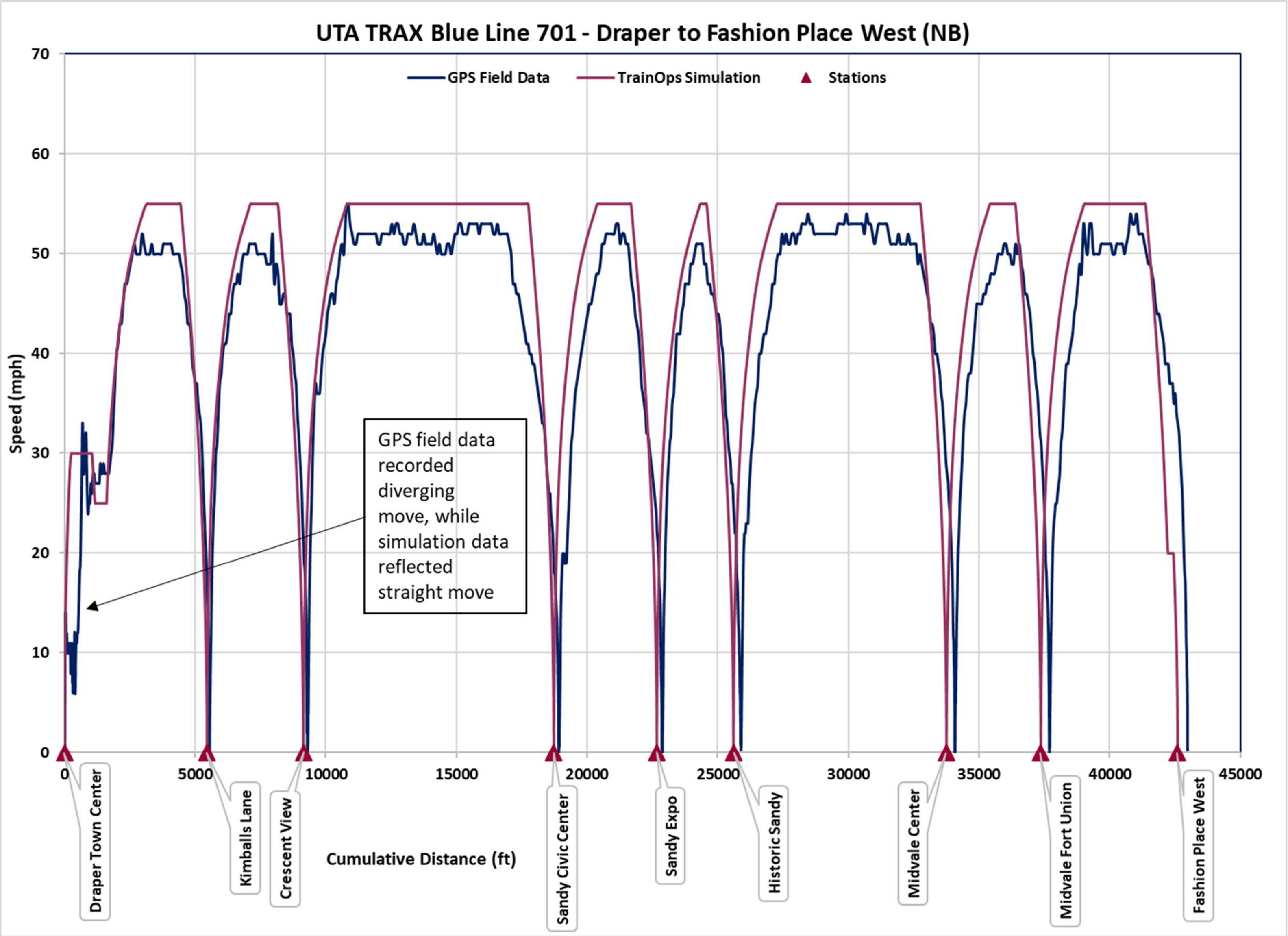

Figure 81 – GPS Data vs Existing Baseline Simulation Trip Graph Overlay – Draper to Fashion Place West

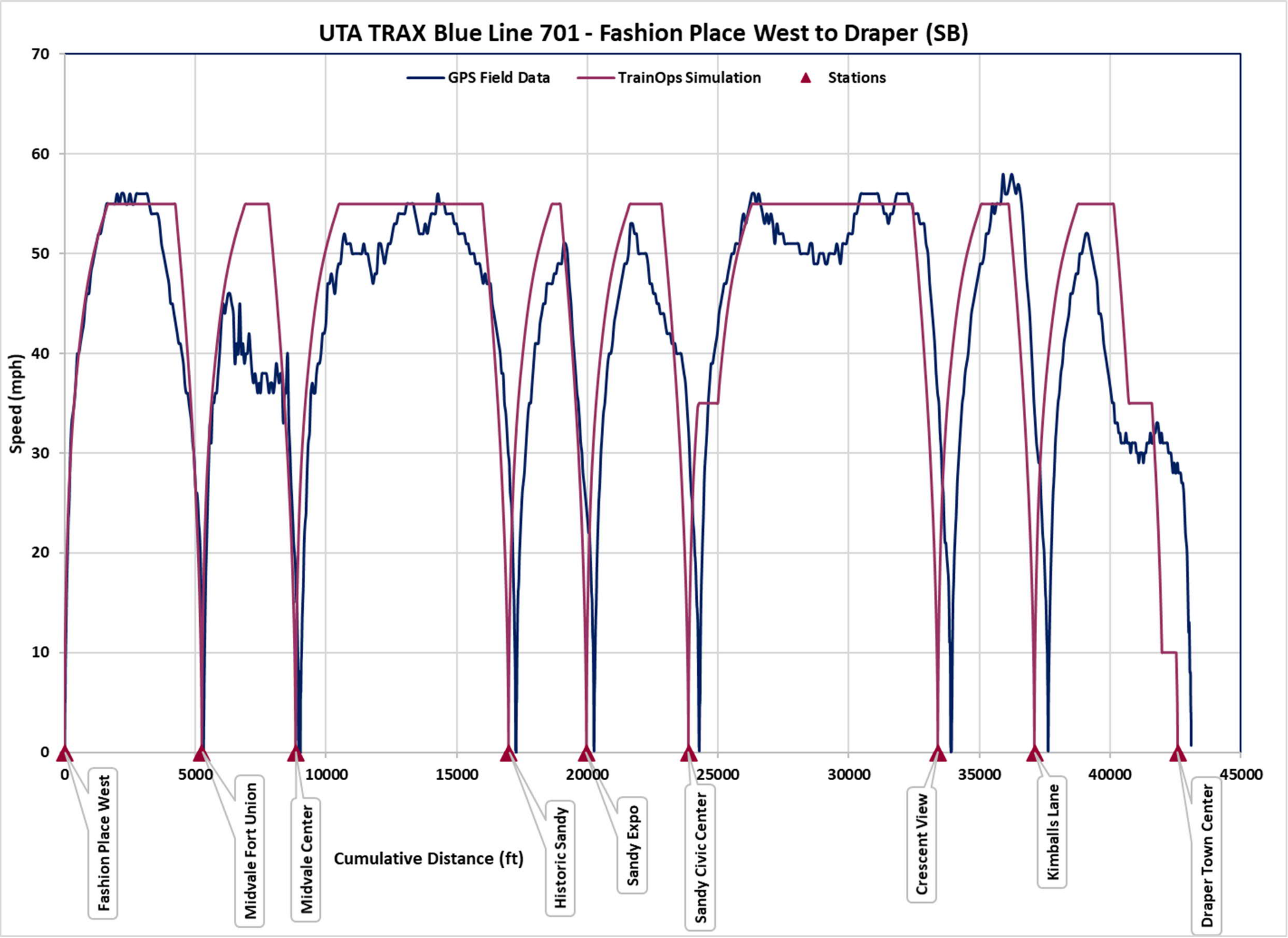

Figure 82 – GPS Data vs Existing Baseline Simulation Trip Graph Overlay – Fashion Place West to Draper

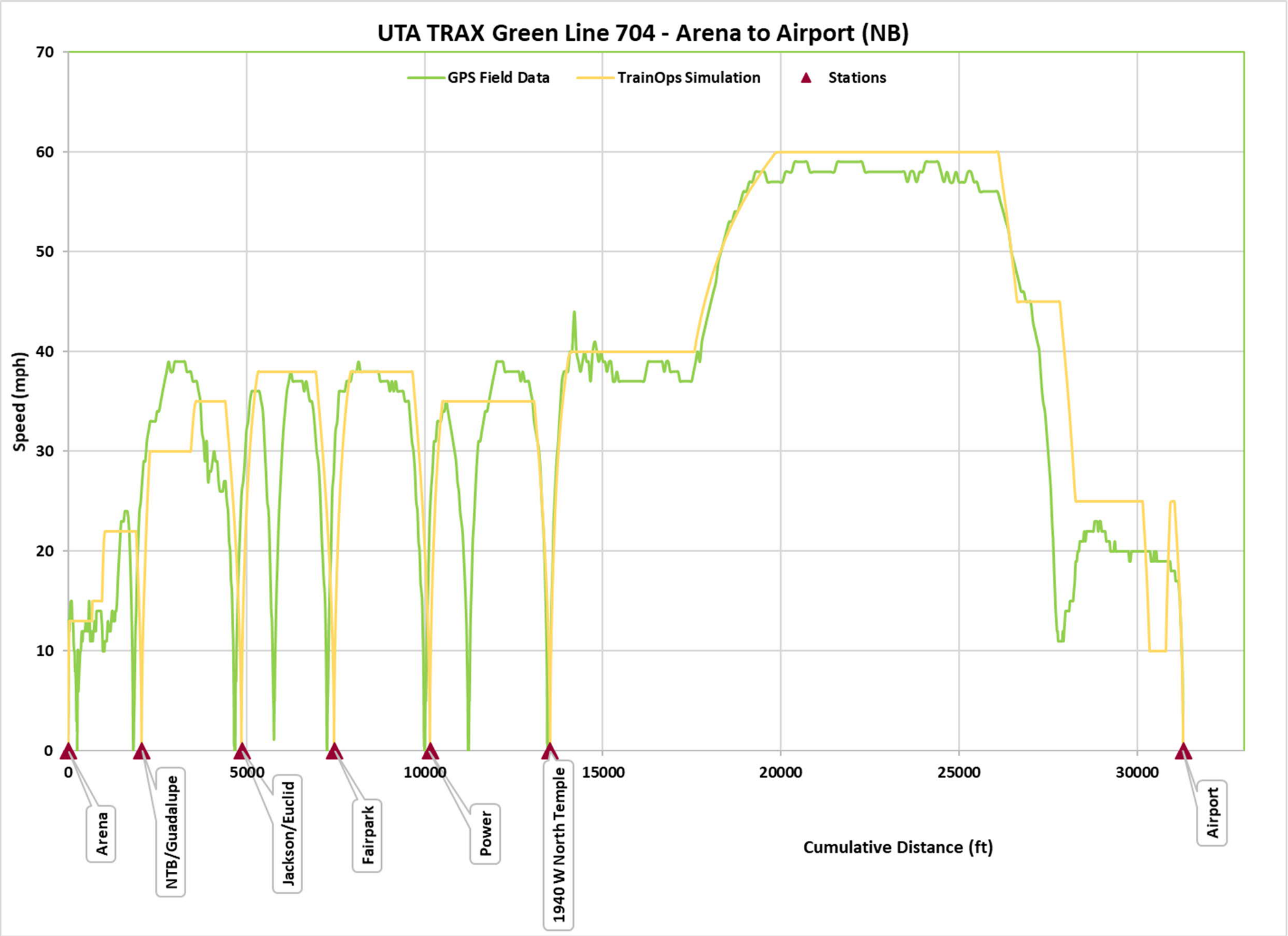

Figure 83 – GPS Data vs Existing Baseline Simulation Trip Graph Overlay – Arena to Airport

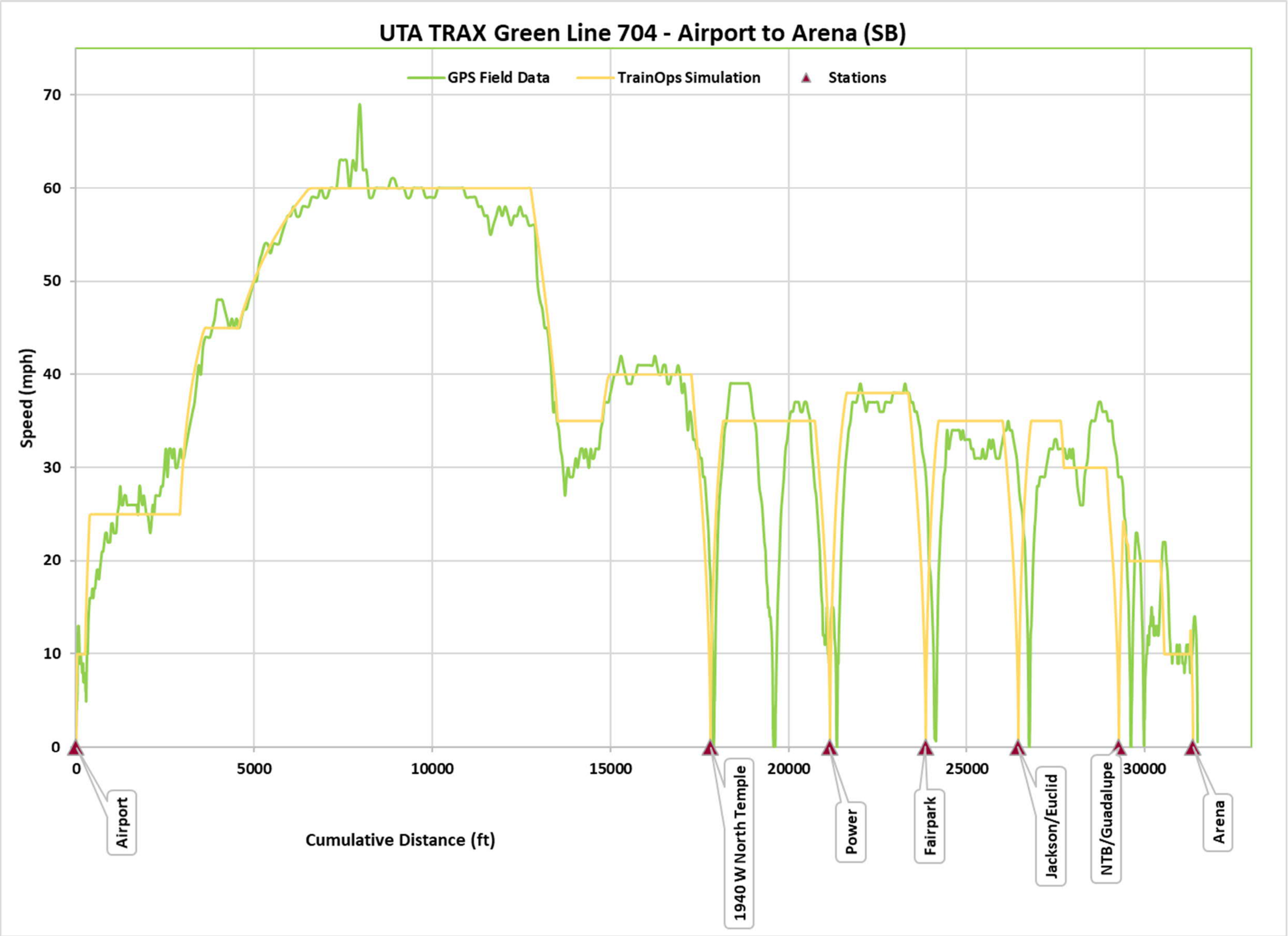

Figure 84 – GPS Data vs Existing Baseline Simulation Trip Graph Overlay – Airport to Arena

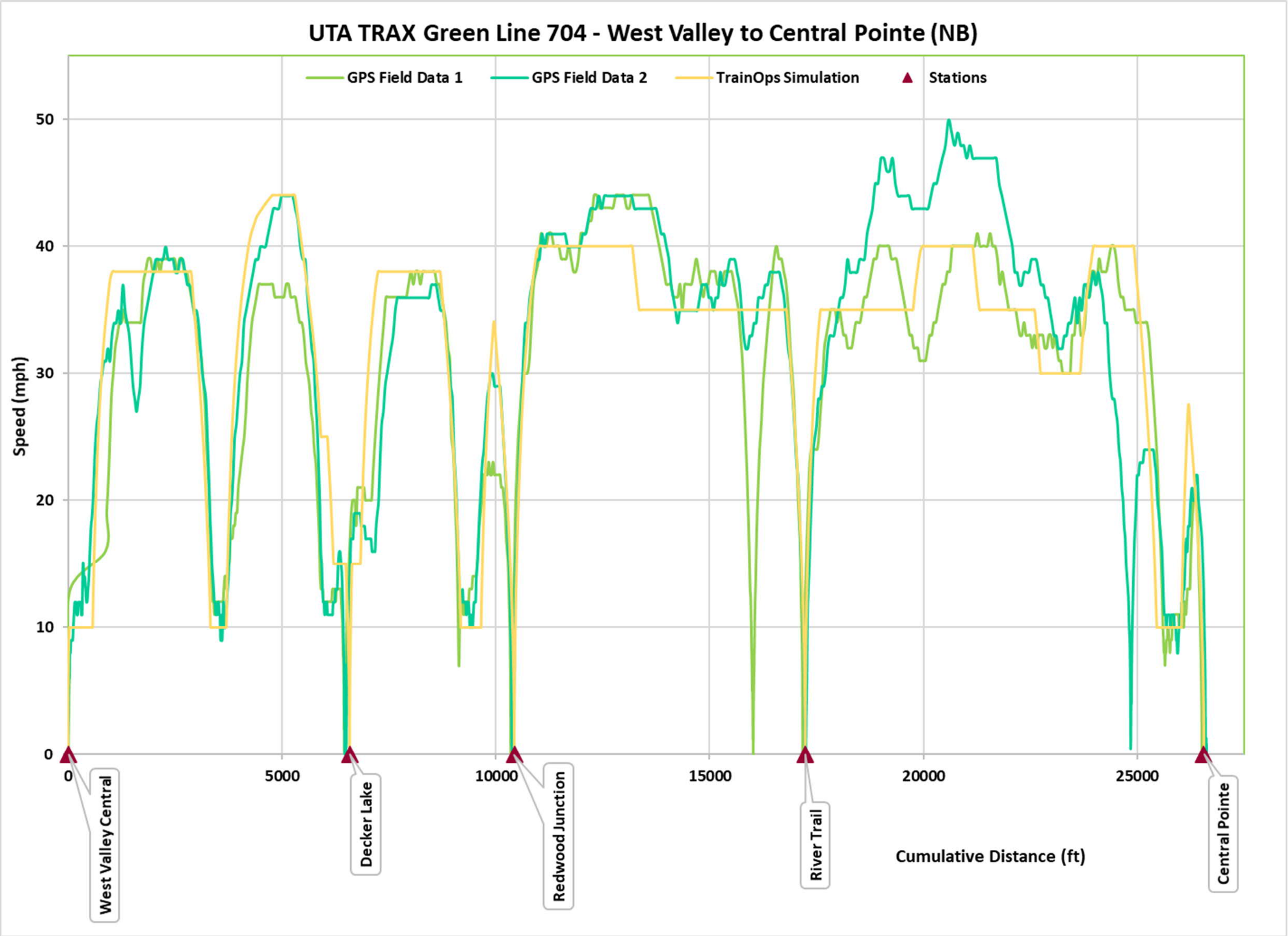

Figure 85 – GPS Data vs Existing Baseline Simulation Trip Graph Overlay – West Valley Central to Central Pointe

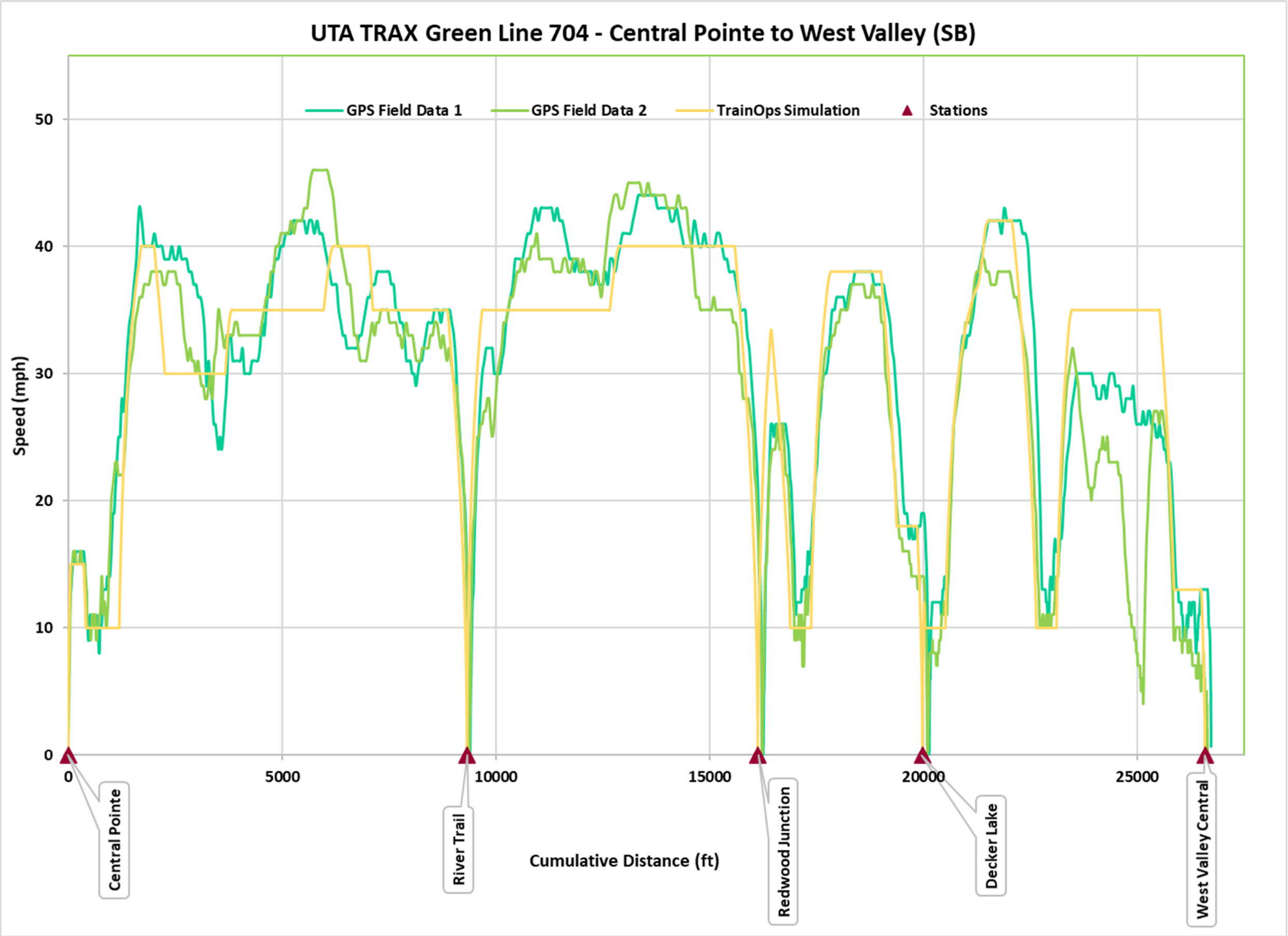

Figure 86 – GPS Data vs Existing Baseline Simulation Trip Graph Overlay – Central Pointe to West Valley Central