U.S. Department of Transportation
Federal Railroad Administration

ADOT

PASSENGER RAIL CORRIDOR STUDY

Tucson to Phoenix

Arizona Passenger Rail Corridor

Service Development Plan

June 2017

Table of Contents

Table of Figures

Table of Tables

1 Introduction

This document is the Service Development Plan (SDP) for the Arizona Passenger Rail Corridor Study: Tucson to Phoenix (APRCS). A SDP is a key step toward federal funding eligibility for establishing a new passenger rail service. The SDP is mandated by the Federal Railroad Administration (FRA), which provides guidance on its contents.

This SDP documents the rationale for proposed passenger rail service, describes the operation and identifies the required infrastructure improvements to accommodate the proposed introduction of intrastate passenger service and its estimated cost. It also presents the estimated ridership and revenues for passenger rail service in the Tucson to Phoenix corridor. The SDP is a planning level document that provides the State of Arizona and affected agencies within the corridor, as well as the FRA, the necessary information to assess the utility of establishing passenger rail transportation service between the two largest metropolitan areas in the state. In addition, the SDP provides planning-level information about the scope of a subsequent, more detailed Tier 2 (Project NEPA) environmental review, a prerequisite for federal construction funding.

From 2011 to 2016, the Arizona Department of Transportation (ADOT), as project sponsor, has evaluated the potential for introduction of passenger rail service in the Tucson to Phoenix corridor. The FRA was the Lead Agency for the Tier 1 Environmental Impact Statement (EIS) conducted under the National Environmental Policy Act (NEPA). The Final Tier 1 EIS and Record of Decision (ROD) was published in December 2016. Prior to the SDP, ADOT also prepared an Alternatives Analysis (AA), following pre-MAP-21 Federal Transit Administration (FTA) guidance, and a Tier 1 Environmental Impact Statement (EIS) or Service NEPA document. The overlap contained in these three documents presented the opportunity to coordinate their contents to ensure compatibility among them and minimize unnecessary duplication. With that objective, the AA and the Final Tier 1 EIS have provided much of the supporting information for the SDP, though some information has been updated for the SDP based on more refined service analyses.

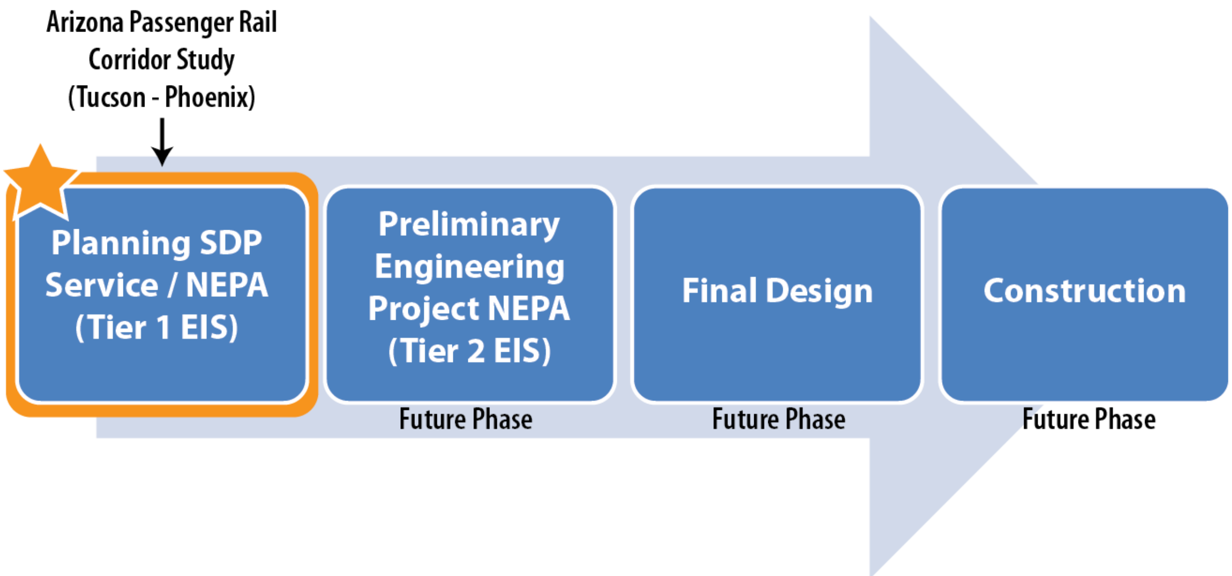
The SDP for new passenger service forecasts ridership, revenue and the capital and operating cost estimates from an analysis of the opportunities within the corridor along with supporting technical studies. All details in the SDP are based on the Locally Preferred Alternative (LPA) of the AA which is also the Preferred Alternative of the Final Tier 1 EIS.

The SDP also describes at a programmatic level the necessary steps, requirements, and costs involved in providing passenger rail service in the corridor. Additionally, it summarizes the existing conditions along the corridor, describes connectivity with surrounding communities, provides a rationale for the service, and summarizes the challenges, opportunities, and regional effects of corridor development.

1.1 FRA Passenger Rail Development Process

The FRA has defined certain steps to implement new passenger rail service. The process starts with the development of a Passenger Rail Corridor Investment Plan, comprising a Tier 1 EIS and SDP. This report has been prepared to satisfy the SDP requirement. Figure 1-1 shows the elements of the FRA Passenger Rail Development Process.

Figure 1-1: FRA Passenger Rail Development Process Elements



An important step in the passenger rail development process and in the development of the SDP is the preparation of a Tier 1 EIS or Service Level NEPA document as defined by the NEPA. The Tier 1 EIS is a high level environmental review of the project as a system. It evaluates the effect of alternative corridors and locations, the service to be provided, estimated ridership levels and the effect of proposed infrastructure elements on the natural and built environments. The Tier 1 EIS process resulted in a Tier 1 joint Final Tier 1 EIS and Record of Decision (ROD) issued by the FRA in December 2016. The issuance of the Tier 1 ROD enables ADOT or another governance entity to seek funding for future project phases, including additional Tier 2 EISs. The Project NEPA, or Tier 2 EIS referenced in Figure 1-1, includes a more detailed examination of the environmental impacts that proposes specific mitigation measures to be applied at project implementation. Preliminary engineering is required to develop the information necessary for a Tier 2 EIS. Final design takes place following preliminary engineering and approval of the Tier 2 EIS ROD. After the Tier 2 ROD, assuming enough funding, final design and construction can begin.

This project covers only the Tier 1 EIS and the Planning SDP (along with the companion AA). The entire sequence of activities required to fulfill FRA's and EPA's requirements and to complete preliminary engineering, final design and construction will usually take a number of years depending upon the size and complexity of the project. Acquisition of new rolling stock can also be a time-consuming process depending on the availability of new or used equipment.

1.2 History of Rail in the Corridor

Railroads have had a profound influence on the development of the State. The cornerstones of early Arizona commerce (cattle, citrus, copper, climate and cotton) would not have been possible without the transportation provided by the railroad industry. There has also been a mixed passenger rail history in the State. The Sun Corridor specifically, which extends from Nogales to Prescott and includes the Phoenix-Tucson Corridor, has had a variety of passenger services over past years. However, at present, there is no passenger rail service between Tucson and Phoenix.

Today, the Arizona rail network provides an important link to the national system. The two Class I railroads in Arizona, BNSF Railway Company (BNSF) and Union Pacific Railroad (UPRR), facilitate the coast-to-coast movement of various commodities. UP is the primary freight operator in the Tucson-Phoenix Corridor and also the owner of the Sunset Route that supports Amtrak service (Sunset Limited service) in the southerly segment of the Sun Corridor (also referred to the Tucson-Phoenix Corridor).

In addition, multiple active regional and short line railroads are located in Arizona. Many serve the natural resource industries, such as mining for which they were originally constructed. Of those, at least one is located with the broader Tucson-Phoenix Corridor.

1.3 Amtrak Service over the Years

Until the early 1970s, the two Class I carriers provided passenger as well as freight service in Arizona. Currently, Amtrak operations through Arizona are part of a long-distance, coast-to-coast service which follows the two Class I carrier mainlines through northern and southern Arizona, and represent the existing intercity rail service for the State.

Today, Amtrak operates the *Sunset Limited* within the Tucson-Phoenix Corridor three times a week. Phoenix is served by a station in the City of Maricopa, which is in Pinal County forty miles south of downtown Phoenix. There is no bus or Amtrak Thruway Motorcoach service to Maricopa from Phoenix. A private company, White's Taxi Shuttle, operates a taxi service to the Phoenix metro area. The *Sunset Limited* also serves Tucson. This very limited service is presently the full extent of intercity passenger rail services in the corridor between Phoenix and Tucson.

Service through Phoenix Union Station was available until 1994 when the Wellton Branch of the Phoenix Subdivision was removed from service.

1.4 Speed of Operation

The term “High Speed Rail” or HSR has been widely used, but the definition of HSR pertaining to passenger rail service varies. Internationally, HSR is generally regarded as the class of passenger trains operating at speeds higher than 270 km/Hr (170 MPH). These include operations in Japan, France, Germany, and China, where passenger service speeds up to 220 MPH are possible on exclusive rights-of-way using advanced steel-wheel-on-steel-rail technology.

The Midwest HSR Initiative includes projects with 110 MPH top speed, generally referred to as HrSR, or “*higher* speed rail.” Projects underway include Chicago-St. Louis and Chicago–Detroit. Routes are typically shared with freight operations, where upgrades to true high-speed rail systems are limited due to the cost of upgrading existing track, grade separating road crossings, etc.

The California High-Speed Rail Project is the only publicly-funded US passenger rail service under development planned for the top speeds of 220 mph, connecting Los Angeles with the Bay Area on primarily new, exclusive rights-of-way.

This SDP considers the feasibility and cost of intercity passenger operations with a maximum speed of 125 MPH given the environment within which the service would operate. This type of operation would require significant infrastructure investment and system changes to adapt a current freight rail corridor to passenger service, albeit on a separate track to minimize passenger and freight conflicts. Though the proposed line would host both commuter and intercity services, the intercity service is proposed to make only limited stops between Tucson and Phoenix, and is expected to reach 125 mph for extended segments along the route. Commuter service, with many more stops, would operate at lower speeds but could achieve more than 100 mph in some segments. Figure 1-2 shows a locomotive built in the United States designed to operate at up to 125 mph.

Figure 1-2: Siemens Diesel-Electric Locomotive

The high speeds planned for this system would necessitate safety measures to meet FRA requirements. These include the use of 'cab signals,' (a system that displays the train control indication in the locomotive engineer's control panel), extensive safety measures at at-grade crossings (quad gates, alarms, notifications, etc.), and possible closed crossings or at-grade separations.

In addition to safety considerations, other improvements would be required wherever increased passenger-freight interference is likely. Higher speed trains use more of the available rail capacity requiring greater spacing between trains to provide for safe stopping distances. Added double track and longer passing sidings would be needed at any location where a potential conflict exists with freight or other passenger trains (at higher speeds, the passenger service would require an entirely separate rail line and energy absorbing equipment).

In summary, passenger rail service with speeds up to 79 MPH should be able to economically and adequately meet the projected ridership demand within urban areas without triggering numerous escalations in infrastructure costs, but it will still require construction of a separate passenger track within or along the existing UP freight rail right-of-way. The installation of a primarily independent infrastructure should also be able to more easily adapt the proposed service to future corridor growth and the investigation of true high speed operation. While the long-term plan would be for a double track connection between Tucson and Phoenix, proposed service does not warrant a complete double-tracking in the near term based on the ridership forecast and benefit cost analysis in this SDP (Sections 6.1 and 12).

2 Purpose and Need

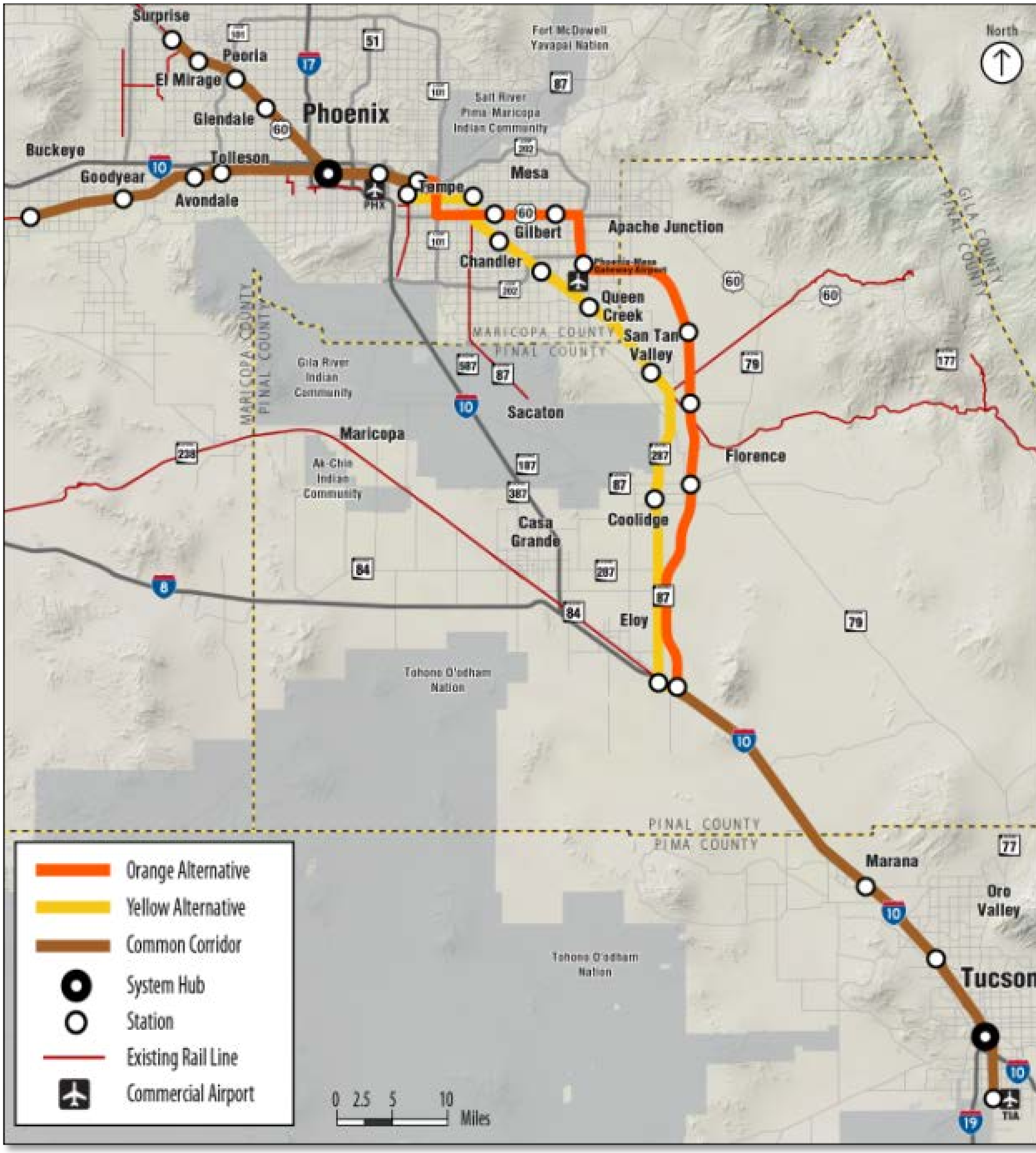
As part of the mission of providing a safe, efficient, cost-effective transportation system, ADOT is evaluating commuter and intercity travel needs and enhanced travel opportunities within and among Maricopa, Pima, and Pinal counties. Statewide and regional transportation planning efforts undertaken from 2007 to 2011 (e.g., “Building a Quality Arizona,” or bqAZ and the State Rail Plan) have recommended introducing passenger rail to add travel capacity to what highways already provide or would provide in the future. For this reason, ADOT is studying passenger rail service options between the metro areas of Tucson and Phoenix to provide more travel choices in this 115-mile-long corridor. This would provide an alternative travel mode and would reduce travel times between the two main cities. In providing an alternative to private vehicle travel, passenger rail would also help avoid traveler delays caused by highway congestion, contribute to enhanced highway safety, and reduce pollutant emissions on Interstate 10 (I-10).

ADOT’s 2010 Statewide Rail Framework Study (ADOT 2010) and 2011 State Rail Plan (ADOT 2011) include a passenger rail vision for the state. The first step in the implementation of the plan would be to link Tucson and Phoenix, the state’s largest metropolitan areas. Both the State Rail Plan and the 2010 Statewide Rail Framework Study (ADOT 2010) showed that of all possible locations within Arizona, a passenger rail line between the Tucson and Phoenix metropolitan areas would serve the most people. Such a line could connect communities within the region and form the starting point for later rail connections to other regions.

FRA is the lead Federal agency for the Arizona Passenger Rail Corridor Study (APRCS): Tucson to Phoenix (also referred to as “the study” in this document). FRA provides financial and technical assistance for intercity passenger rail systems (focusing on regional trips). FTA, which is serving as a cooperating agency on the APRCS, provides financial and technical assistance to local public transit systems, including commuter rail. Because the APRCS addresses both intercity travel and commuter transit trips, both FRA and FTA have a role in project planning. The Federal Highway Administration (FHWA) provided guidance on the feasibility of using existing highways, such as I-10, as potential rail corridors since agency and public scoping identified existing highways such as I-10 as potential passenger rail corridors. The EIS lists and examines the potential environmental effects from providing commuter and intercity rail travel along the alternative corridors shown on Figure 2-1.

This study examines and evaluates different route corridors between the Tucson and Phoenix areas. As the federal lead agency, FRA is responsible for compliance with the National Environmental Policy Act of 1969 (NEPA) and determined that a Tier 1 Environmental Impact Statement was an appropriate document for examining the regional context of a future passenger rail system before focusing on the more detailed Tier 2 analysis that considers site-specific effects.

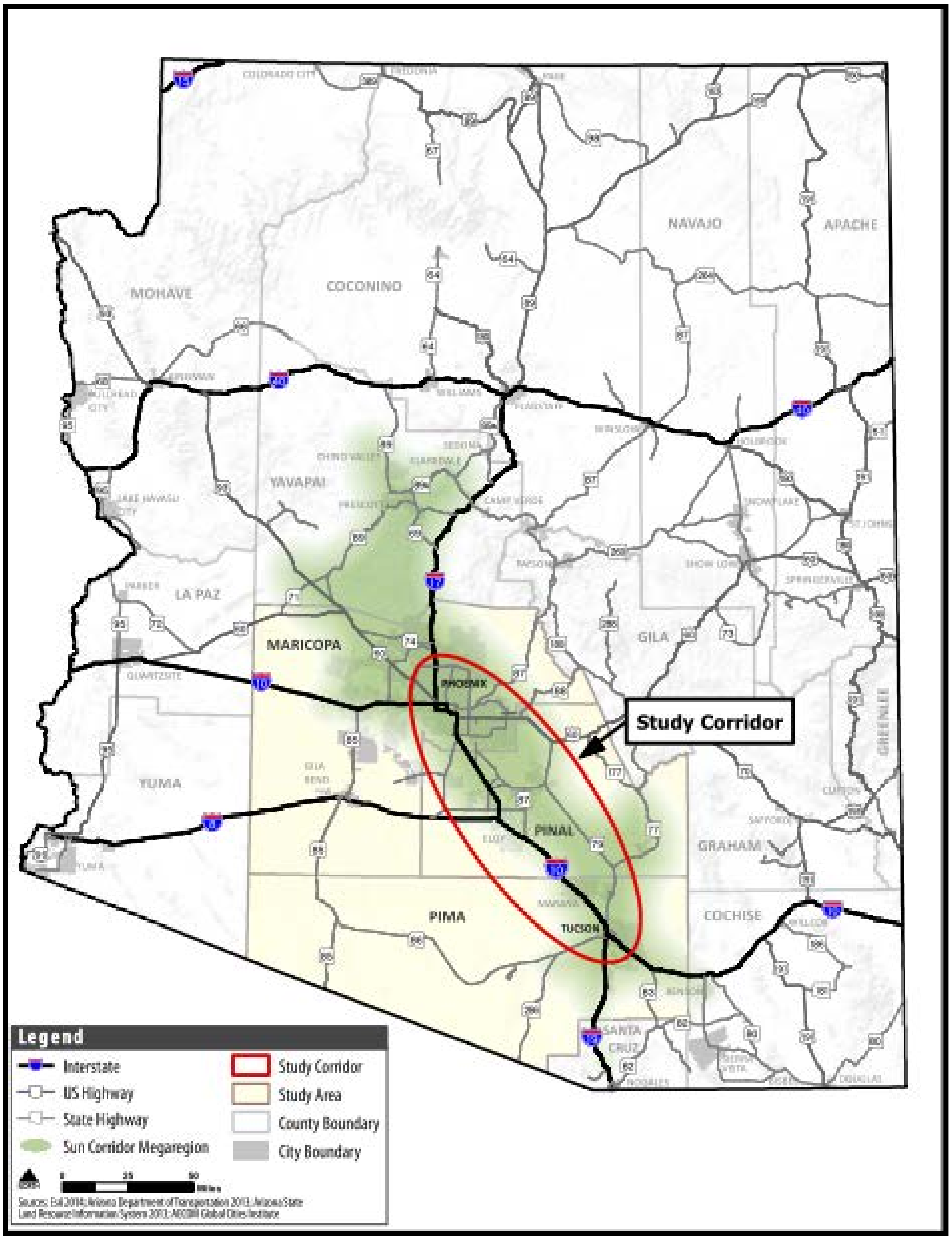
Figure 2-1: Tier 1 EIS Alternatives



2.1 The Need for Passenger Rail Service

Between 1990 and 2010, the combined population of Maricopa, Pima, and Pinal counties increased by over 78 percent, from 2.9 million to nearly 5.2 million, with an over 61 percent increase between 1991 and 2010 in the number of nonfarm jobs. This three-county study area forms part of a clustered network of cities—a “megaregion”— known informally the “Sun Corridor” (See Figure 2-2). A look at travel patterns, available transit services, and trip times shows that the need to move people from one place to another is also growing. Based on population and travel forecasts and the amount of available open land within the corridor, travel markets are expected to continue to grow in the future. However, opportunities to increase the carrying capacity of the region’s roadway network are limited.

Figure 2-2: Study Area



The Phoenix and Tucson metropolitan areas will continue to be major population and employment centers within the region. Most of Arizona's developable land is situated between these cities and development of this area is projected to form a continuous urban corridor connecting the metropolitan areas. As a result of recent and projected growth, the City of Casa Grande joined with the Pinal County communities of Eloy and Coolidge to form a new metropolitan planning organization (MPO), the Sun Corridor MPO, in 2013. With Arizona on a steady economic upswing after experiencing a downturn in the second half of the last decade, the increasing development in the corridor is projected to contribute to a need for increased commuter and intercity mobility within the corridor which must be addressed.

Travel between Tucson and Phoenix currently takes place almost entirely on Interstate 10 (I-10), the only high-capacity freeway between the two cities. Increasing congestion along this highway is lengthening travel times. Based on forecasts from studies conducted within this corridor, even a planned widening of the existing interstate to eight lanes and the construction of a planned new North-South Corridor will not provide adequate capacity to meet the expected demand in the year 2035 (ADOT 2007d, 2012).

As western Pinal County continues to grow, traffic congestion on area highways will cause an increase in travel times within the study area. Considering projected population growth and current travel patterns, Table 2-1 illustrates travel times projected using the Arizona Statewide Travel Demand Model - Version2 (AZTDM2). These projected increases in travel time have the potential to discourage mobility of people and freight, stifle productivity, and increase the cost of goods in the region.

Table 2-1: 2010, 2035, and 2050 Travel Time Comparison for Trips in Study Corridor

Origin and destination (trip distance)	Congested travel time (minutes)[a]				
	2010	2035 baseline	Percent increase over 2010	2050	Percent increase over 2010
Apache Junction to Coolidge via US 60 (37 miles)	54	72	33%	97	80%
Eloy to Phoenix-Mesa Gateway Airport by way of I-10 (56 miles)	62	93	50%	122	97%
Phoenix to Marana (93 miles)	85	106	25%	134	58%
Marana to Tucson (25 miles)	33	43	30%	51	55%
Tucson to Phoenix by way of I-10 (116 miles)	113	142	26%	180	59%

[a] Estimated using Arizona Travel Demand Model, version.2 (AZTDM2).

Available transportation choices between Tucson and Phoenix are currently limited to private automobile, common carrier (bus), commercial flights, and ridesharing, with most travelers—commuter, regional, and intercity—using I-10. Despite recent widening of sections of the interstate within the study corridor, motorists on I-10 experience severe congestion and traffic jams of increasing frequency and duration.

The growing demand placed on I-10 as the primary intercity route in the corridor—and the resulting congestion—will increase the likelihood of traffic congestion and collisions, which will further reduce the overall effectiveness and reliability of I-10 to serve commuter and intercity travel needs.

2.2 Commuter Travel Need

Demand for commuter services, where most travelers make same-day round trips, exists within the Phoenix and Tucson metro areas. Valley Metro, the regional transit provider serving Maricopa County, reported a record high annual ridership of 73.4 million boardings in Fiscal Year 2013 (Valley Metro 2013). That demand is expected to grow in the future, as population growth in the service area is projected to remain high over the next few decades.

The average journey to work within the study area has grown longer as residential development has spread from the major cities to outlying areas and as population growth has increased traffic congestion. As development in Pinal County proceeds, commuter activity will continue to expand in the areas between Phoenix and Tucson, with major daily commutes taking place between Pinal County and neighboring Maricopa and Pima Counties.

Arizona's population grew by 81 percent between 1990 and 2010, from approximately 3.7 million to over 6.6 million. Projected population and job growth in the Sun Corridor are shown in Table 2-2 in Section 2.4. Only about 17 percent of the state's land is privately owned and because the majority of this private land is located within the Sun Corridor megaregion, population growth is likewise focused within this region.

2.3 Intercity Travel Need

Travel between cities in the Sun Corridor for non-work purposes also accounts for many trips. As population and travel demand grow, intercity travel by auto and air will suffer from increasing congestion and time delays—especially in metropolitan areas, at and around airports, and on weekends and holidays. This decline in transportation service and the quality of the travel experience adversely affects intercity travelers, other users of the system, commercial carriers, and the general public.

As shown in Table 2-1, a statewide demand model indicates the duration of a trip from Phoenix to Tucson would increase by nearly 40 percent by 2050, from under 2 hours to over 3 hours, even if I-10 is widened to eight (8) lanes between these cities and a proposed North-South Corridor expressway between East Mesa and Eloy is constructed and opened.

2.4 Need for Improved Connectivity within the Region and Beyond

Several modes of passenger service—both intercity and commuter—are currently available in parts of the Tucson to Phoenix corridor, including conventional rail (Amtrak), common carrier (private bus), commercial airline, and ridesharing options. Public transit service such as bus, light rail and street car is also available within urban communities. While each mode partially addresses some aspect of the region's travel needs, most operate independently of one another. They could be construed as emerging elements of a regional transit network but are missing a unifying corridor plan and strong backbone that tie a network together. A reliable Tucson-to-Phoenix rail connection could provide this backbone, close the gap that currently exists for potential commuters and intercity travelers, and achieve synergies by creating and delivering a robust customer base for a future network of commuter and intercity services.

Section 4 describes the existing non-automobile travel choices within the study corridor, along with their passenger capacity, where available.

Population and Employment Estimate

Statewide, Arizona's population is projected to more than double in the next 40 years, from 6.4 million to 16 million, with most of the increase resulting from growth in the Sun Corridor. By 2035, the area between Tucson and Phoenix will be characterized by dense employment and population centers in and around the Tucson and Phoenix metropolitan areas and substantial population and employment centers throughout Pinal County. Forecast population and employment changes in the Sun Corridor are presented in Table 2-2.

Table 2-2: Projected Population and Employment Growth within the Sun Corridor

	Maricopa County	Pima County	Pinal County
2010 Population	3,763,853	956,082	349,688
2035 Projected Population	5,684,351	1, 277,301	728,729
Percent Increase from 2010	51.0%	33.6%	108.4%
2010 Jobs	1,597,898	337,218	51,788
2035 Projected Jobs	2,636,798	472,599	244,096
Percent Increase from 2010	65.0%	40.1%	371.3%
Sources: US Census Bureau, Arizona Department of Administration, Office of Employment and Population Statistics 2014, US Bureau of Labor Statistics **(Population); and Maricopa Association of Governments, Pima Association of Governments, and Central Arizona Governments geographic growth forecasts (Jobs)**.			

While these population estimates are from previously adopted planning documents, during the agency scoping process, the population and employment forecasts for Pinal County were identified as potentially overestimating build-out conditions. During the scoping process, the estimates in Pima and Maricopa Counties were consistent with the agencies' and public's general understanding of how the two urban areas will grow.

2.5 Purpose of Passenger System Rail in Arizona

The need for improved intercity and commuter services and regional connectivity throughout the entire Tucson-to-Phoenix corridor is the driving purpose behind the development of a high-capacity passenger rail system serving the communities between Tucson and Phoenix. The APRCS would help ensure coordination between agencies in defining the project, providing a corridor so that local and regional planning agencies can limit development to preserve rights-of-way, pursuing opportunities for funding, and ensuring plan compatibility with communities along the studied corridor alignment(s). The APRCS also strives to achieve efficiencies by undertaking a single analysis of alternatives and potential environmental consequences and by proposing a single infrastructure investment that would serve both travel markets. The overall 115-mile corridor between Tucson and Phoenix is being studied to address intercity travel needs in an area where the demand for such travel is growing while opportunities for highway expansion are limited. An intercity connection could serve as a foundation for commuter service overlays in the urban areas, designed with the ability to grow along with commuter travel demand, reaching into and across Pinal County from both ends. Commuter services could span the entire corridor within the forecast timeframe of this study as Pinal County's employment base grows to rival Pima County's and establishes new patterns of daily trip interchanges from Pima and Maricopa counties to daytime destinations in Pinal County and back.

By evaluating both intercity and commuter travel needs simultaneously, the APRCS reports on all aspects of the alternative corridors and addresses the combined requirements of the Federal lead and cooperating agencies. The purpose of proposed passenger rail service in Arizona is to provide high capacity intercity and commuter transit service in the identified study corridor that addresses the identified transportation problems within the larger framework of promoting regional connectivity throughout Arizona and the Southwestern United States. The purpose of proposed passenger rail service in Arizona includes:

- Providing transportation alternatives to the automobile within the Tucson-to-Phoenix travel corridor and reducing the growth in traffic congestion

- Increasing access to existing and planned employment and activity centers within the three-county study area

- Supporting reliable travel times and safe travel within an increasingly congested region that currently affords few transportation alternatives to the private automobile

- Facilitating continued development of a comprehensive, multimodal, and interconnected regional and multiregional transportation network that provides mobility choices for existing and future needs and allows connectivity to systems beyond the Tucson-to-Phoenix corridor

In satisfying these stated purposes, a transportation solution would also achieve the following beneficial outcomes:

• Support economic vitality by providing efficient, dependable, and convenient access to economic activity centers in the Sun Corridor

• Efficiently and predictably accommodate local, regional, commuter, and intercity movement of travelers throughout the corridor

• Enhance system linkages, multimodal connections, and accessibility to major population centers

• Support regional plans and policies that call for a balanced transportation system

• Incur potentially lower capital and operating costs than traditional highway facilities

• Avoid, reduce, minimize, or otherwise mitigate impacts on the environment.

2.6 Recent History of Passenger Rail Efforts in the Corridor

The State of Arizona has completed a number of studies in recent years to better understand and address the demands of its rapidly growing population and the associated demands on the State's transportation system. Statewide efforts such as Building a Quality Arizona (bqAZ), the State Rail Framework, and regional efforts such as Maricopa Association of Government's (MAG's) Commuter Rail Study, Pima Association of Governments (PAG's) 2040 Regional Transportation Plan (RTP) and Pinal County's Comprehensive Plan provide a foundation for a multimodal and sustainable transportation future. The development of these plans, and others, engaged the entire state in identifying transportation needs. They all contribute to identifying solutions for the anticipated demand and the best ways to meet those needs. The APRCS builds on these previous plans and proposes mobility concepts to create and evaluate commuter and intercity opportunities in the Sun Corridor, which is the first step toward the implementation of these plans.

These previous and concurrent studies, performed by ADOT and other agencies within the Study Area, identified the planned growth, need for additional transportation facilities, and evaluated or recommended specific transportation solutions. These relevant studies are listed below.

- 2003 - MAG High Capacity Transit Study
- 2006 - Pinal County Corridor Definition Study
- 2007 - ADOT Railroad Inventory and Assessment
- 2007 - Pinal County Comprehensive Plan Smart Growth Concept and Open Space & Trails Master Plan
- 2008 - MAG Commuter Rail Strategic Plan
- 2008 - Morrison Institute for Public Property: Megapolitan, Arizona's Sun Corridor
- 2009 - MAG Regional Transit Framework
- 2010 - PAG Regional Transportation Plan
- 2010 - MAG Commuter Rail System Study
- 2010 - Statewide Rail Framework Study
- 2010 - ADOT Building a Quality Arizona: Statewide Transportation Planning Framework
- 2011 - What Moves You Arizona: Long-Range Transportation Plan
- 2011 - ADOT Interstate 10 Corridor Study, Design Concept Report (DCR) and Environmental Assessment (EA): Junction I-8 to Tangerine Road

- 2011 - Arizona State Rail Plan
- Current - ADOT North-South Corridor Study EIS/DCR
- The timeline of these studies indicates the long history of growth and transportation facility planning within the area, directly leading to the APRCS study.

3 Rationale

The rationale illustrates the factors that show how the introduction of passenger rail service in the state would address the region's transportation needs in the context of the entire passenger transportation system within the corridor. It outlines the alternative travel modes, their roles in the corridor system, their capabilities, the segments of market demand each addresses, and the underserved market segments.

3.1 General Costs, Benefits, Risks, Impacts

Providing convenient, reliable, safe, energy-efficient, and environmentally-friendly passenger transportation is critical to meeting the growing need for travel within the region while enhancing the quality of life and economic opportunity for those who live and work along this corridor.

Connectivity among the communities within the corridor, other than by highway, is limited. Reestablishment of passenger rail service along the corridor would greatly improve connectivity, and expand transportation options for communities within the corridor, offering citizens and visitors transportation choices currently unavailable.

As an important by-product, improvements to rail infrastructure required to establish passenger service may also have the potential to enhance the speed and reliability of freight service within the corridor. This would improve rail freight service to shippers and improve the competitiveness of rail for freight transportation.

State-supported intercity passenger rail service expansion in states such as Illinois, North Carolina, Washington, and California using existing rail lines has improved connectivity between key cities and metropolitan areas. Corridors that are well served by regional intercity rail lines generally contain two or more metropolitan areas approaching populations of one million and are in the 100 to 600- mile length range. The results have been enhanced mobility and have led to greater economic development opportunities and vitality to communities along the routes. With 115miles between Tucson and Phoenix, these major metropolitan areas are in the desirable range where intercity passenger rail is an effective and competitive transportation mode.

Railroads are capital intensive businesses. Investment in infrastructure and equipment is high, but recurring operating costs are relatively low per passenger mile compared to other modes such as highways or aviation. Following and existing freight corridor will help manage the required investment compared to other route options, but improvements needed to establish reliable passenger and freight service are still significant.

Recent gasoline price movements have had and will continue to have an influence on travelers' mode choice. This could influence the use of a future passenger rail service. In addition, there is the risk that ridership will not match travel forecasts. The STOPS model used to estimate both intercity and commuter ridership was recently developed specifically for urban areas and can be expected to be closely scrutinized for intercity applications. (Future forecasts for Tier 2 EIS analyses will reevaluate ridership using a more refined modeling strategy.) In general, both within cities and between them, rail ridership has shown a steady growth trend with minor bumps and dips over the years. To illustrate, since its inception in the 1990s, the Capitol Corridor in California has grown to 16 daily roundtrips and nearly 2 million annual passengers and the UTA FrontRunner has grown from 5,900 riders a day in 2008 to over 16,800 as the system has been expanded and attracted more patrons. There is, however, limited recent experience in Arizona with passenger rail service.

3.2 Synergies with Established Plans and Goals

The passenger rail service that is under consideration could address multi-modal passenger transportation needs in the corridor. The proposed service is planned to expand the transportation options in the corridor beyond the automobile. Moreover, the proposed service will contribute to meeting the long-range transportation goals within the state.

The 2011 Arizona Long-Range Transportation Plan ("What Moves You, Arizona?") identified four policy investment categories for ADOT[1]:

- Preservation - protect the state's investment in its transportation infrastructure.
- Modernization - promote upgrading the system to eliminate congestion and improve safety
- Expansion – add capacity in key corridors where economic growth and system needs demand it.
- Non-highway – broaden its role as a transportation department to address alternative modes and other needs.

Introduction of passenger rail service and an investment in the region's rail network would address the expansion of non-highway categories and could produce multiple benefits that specifically address the region's transportation goals, including rail freight movements. Based upon existing conditions, intercity travel within the Sun Corridor currently relies almost exclusively on the interstate highway system and the private vehicle. Alternative modes of travel are limited within the study corridor. The connection between the two largest metropolitan areas in the state with passenger service is a recommendation of the State Rail Plan and is further supported by the FRA Southwest Multi-State Rail Planning Study. An investment in passenger rail service would increase the travel options between Tucson and Phoenix, would improve access to additional communities not currently served by commercial intercity bus and would position Arizona for linkages to other major metropolitan areas in the West.

Benefits specifically include:

- Infrastructure preservation: Movements of people and goods share the transportation infrastructure along the proposed corridor today. Improvements to rail infrastructure along the corridor would enhance the carrying capacity of both passenger and freight operations. Investments could improve the reliability of travel within the corridor thus enhancing the attractiveness of rail transportation in the transportation market.
  While the shift of trips from highway to rail will have only a modest effect on highway maintenance demand, the improved facilities could have a positive effect on the attractiveness of freight

[1] The latest Arizona Long Range Transportation Plan (LRTP) is being updated and may recommend different investment categories. The final version of the plan is expected to be complete in 2017.

transport on rail over highway, and have a positive effect on highway maintenance demand as more freight could move by rail than truck.

- Multi-modal enhancement: Enhancing alternative transportation options for persons in the corridor reduces reliance on low-occupancy private vehicle travel. Convenient passenger rail service would provide an additional viable travel alternative. Additionally, network enhancements that improve speed and service reliability for passengers, as proposed, would also improve the reliability of rail freight movements. These improvements would enhance attractiveness of timely and cost-competitive delivery to existing and potential rail customers.
- Safety: By offering alternatives to driving and trucking over long distances, highway safety should improve for the traveling public in the corridor by reducing VMT on roads. Rail transportation has been shown to be safer than highway travel based on ton-miles for freight or person-miles traveled for passengers. Highway fatalities occur at approximately four times the rate of rail passenger fatalities based on person-miles traveled.
- Economic development: Improvements to rail in the Sun Corridor would permit increased rail speeds and capacity. This enhances the viability of rail options for intercity travelers, commuters and freight customers. In addition, the access to new destinations along the corridor, in particular within Pinal County and the East Valley of the Phoenix metro area, would increase accessibility and present the opportunity for greater economic activity along the corridor. The degree to which any particular town or station area benefits from the economic potential will largely depend on local government policies and entrepreneurs that take advantage of the new transportation mode. The improved mobility could potentially have a negative impact on localities by making it easy for shoppers to leave home and spend their money elsewhere. Historically, this concern has not been borne out as improved mobility has an overall positive effect on economic activity. Attendance at major league and college sports or cultural events in Phoenix, Tempe, Glendale, Mesa, Tucson, and other locations would likely attract riders. This effect has been seen in other rail corridors.

  From the private perspective, UP has also identified this corridor as a key freight arterial and the only access by rail into the Phoenix metro area from its Sunset Route. The Sunset Route, running between Eloy and Tucson within the proposed corridor, connects New Orleans and Los Angeles through Arizona. UP has significant expansion plans for the Sunset Route, including the construction of a major new classification yard within the corridor. (The proposed intercity passenger service between the Tucson and Phoenix would minimize the use of UP rights-of-way along the Sunset Route freight corridor.)

- Environmental Stewardship: ADOT has recognized in its long-range planning that it is difficult to predict how current environmental trends will affect the evolution of the Arizona transportation system. While trucks and cars emit pollutants that can harm air and water quality, they remain an essential mobility option for Arizona residents and businesses. Truck engines release approximately 16 times the hazardous emissions of diesel rail locomotives although the ton-miles of hazardous emissions carried by the two modes are approximately equal. The proposed passenger rail operation would be expected to produce comparatively even less pollution.

As knowledge about environmental concerns and strategies for managing them grows, ADOT and its stakeholders are developing new options for avoiding, minimizing, or mitigating environmental impacts. These options will include how the existing transportation network is being used and include discussion, evaluation, and investment in multi-modal solutions.

The long-range transportation plans for the corridor recognize that multiple strategies must be considered in the development of the transportation network. One strategy identified indicates that Arizona environmental policy should include non-highway elements that can help with the integration of different transportation systems to provide the best performance and effective promotion of environmental sustainability. The review of rail investments as part of a comprehensive transportation network serving the Sun Corridor and helping to relieve demand on I-10 is an essential step toward meeting this goal.

4 Identification of Base Case and Alternatives

4.1 Corridor Travel Characteristics

Travelers in the Tucson to Phoenix corridor currently have limited travel choices. In addition to the highway system, air and bus service is available between the two metro areas, but they provide minimal benefit in terms of capacity and travel time compared to driving. There is no rail passenger service within the corridor except the Amtrak service between the City of Maricopa and the City of Tucson which runs three times a week at times that are difficult for many travelers and is subject to frequent delays.

Interstate and State Highways

The corridor includes a quality highway link, I-10, which covers the entire route between Tucson and Phoenix. Typical driving time between Tucson and Phoenix is just under 2 hours. Depending on traffic the trip can take substantially longer. The cost of a one-way trip for an auto driver is estimated at $54 using the 2014 federal mileage rate of $0.45.

Other state highways exist, but are circuitous for most travelers, have limited capacity and do not provide a good alternative to the heavily travelled and more direct I-10. As a result, passenger vehicle traffic has increased 20% on I-10 since 2002[2], in terms of both passenger vehicle trips and passenger-vehicle miles. Growth is expected to continue as the open spaces between the two major metropolitan areas add residential and employment development. I-10 is also located on the Gila River Indian Community (GRIC) which increases the complexity of expanding the existing freeway. As traffic volumes grow, there is a growing need for alternative modes of travel beyond freeways.

As indicated, mobility between the Tucson and Phoenix metropolitan areas is negatively impacted by growing congestion within the I-10 corridor and is expected to worsen over time. Despite recent widening of sections of I-10 in the study area, increasing durations of severe congestion and failed operation occur frequently and are expected to worsen as the population and employment in the corridor grow. Future expansion of I-10 and the construction of an additional North-South freeway are expected to be insufficient to accommodate travel demand in the corridor based on travel projections. The duration of a trip from Tucson to Phoenix—which now takes approximately 113 minutes in a private auto under free-flow conditions—would increase to over 128 minutes in 2035 and 158 minutes by 2050 with all the noted improvements in place[3]. Scoping comments indicated general concern about mobility within the corridor, primarily focusing on reliability, safety and overall travel time as travel demand increases.

[2] According to the Interstate Guide (2002) and ADOT AADT data
[3] AZTDM2 travel demand model results

Corridor Amtrak Services

Phoenix is the largest city in the United States without intercity passenger rail service. Amtrak has not served the Phoenix metropolitan area directly since 1994 when operations ceased and were moved to the City of Maricopa along the UP Sunset Route about 40 miles south of Phoenix. Amtrak's Sunset Limited service, which travels from New Orleans to Los Angeles, stops at two locations within the study area, Tucson and the City of Maricopa (in Pinal County). Trains run three times a week, stopping on Tuesday, Thursday, and Sunday nights in the westbound direction and Monday, Thursday, and Saturday early morning in the eastbound direction.

Corridor Intercity Bus Service

Greyhound Lines makes six intercity trips from Tucson to Phoenix each weekday with a 55-seat bus. Bus service begins at the Greyhound terminal near Tucson's central business district (CBD) and ends at the Greyhound terminal near Sky Harbor International Airport. Six trips are operated each weekday between Phoenix and Tucson as well. Some of these trips have intermediate stops in the City of Casa Grande (Pinal County).

Arizona Shuttle is a common carrier that makes 18 daily round-trips between Tucson and Phoenix Sky Harbor International Airport using 29-seat passenger buses. Three stops are in the Tucson area: Craycroft (east Tucson), University of Arizona Campus (central Tucson), and Ina Road at I-10 (north Tucson).

Based on the total number of trips and vehicle carrying capacity, the daily capacity of these scheduled services between Tucson and Phoenix is approximately 1,000 person-trips in each direction. Round-the-clock bus schedules currently offered by private carriers between Tucson and Phoenix show that demand exists for a transportation solution, other than the automobile, that offers convenient, safe, and reliable intercity travel between these two metropolitan areas.

Air Travel

American Airlines operates daily nonstop flights between Phoenix Sky Harbor International Airport (PHX) and Tucson International Airport (TUS). Between 7 and 10 weekday trips operate from PHX to TUS depending upon the day of the week, while 6 to 12 weekday trips are operated from TUS to PHX depending upon the day of the week. Most flights use a 90-seat passenger plane, while one trip each weekday uses a 140-seat passenger plane. Flight durations range from 39 to 51 minutes (PHX to TUS) and 45 to 72 minutes (TUS to PHX), and nonrefundable one-way coach fares in either direction range from $111 for a reservation made three or more weeks in advance to $223 for a next-day reservation.

Based on the range of flights offered each weekday and the types of planes operated, the daily passenger capacity between PHX and TUS is 950, while the daily passenger capacity between TUS and PHX is 1,130, depending upon the day of the week. According to the U.S. Bureau of Transportation Statistics (BTS 2014), between January and December 2010, the daily average number of passengers on these flights was 545 and 574, respectively.

The existing air service are overwhelmingly intended as feeder flights to PHX for American Airlines and the number of passengers traveling solely between Tucson and Phoenix by air is insignificant as a percentage of travel in the corridor. This is largely because the in-air travel time is only a small component of total travel time for the trip between Phoenix and Tucson for an airline passenger. Airport access/egress times and time spent waiting for a departure in the airport make the trip non-competitive with other modes in terms of total travel time.

Ridesharing

Public and private ridesharing options within the study area include vanpooling and carpool ride matching services. The largest public rideshare operator is Valley Metro in Phoenix, which coordinates vanpools originating in and destined to all three study area counties. In fiscal year 2013, Valley Metro owned 412 vanpool vehicles having an annual ridership of 1,227,297 (Valley Metro 2013).

The preceding information demonstrates the need for both commuter and intercity transportation services within and throughout the study corridor. Both needs are addressed in the Passenger Rail Corridor Study AA and Tier 1 EIS.

Urban Public Transit Services

The Phoenix (Maricopa County) and Tucson (Pima County) metropolitan areas are both served by local and regional fixed-route bus and commuter express bus service. Additionally, a light rail system in the Phoenix region connects the communities of Mesa, Phoenix, and Tempe. The line is 20 miles long, with 3-mile eastward and 3-mile westward extensions under construction and additional segments to the east, north and west in planning and design phases. In Tucson, a 4-mile modern streetcar line linking downtown Tucson with the University of Arizona campus opened for service in July 2014. Combined, the Phoenix and Tucson metro area fixed route bus and rail services board over 70 million passenger trips annually, on a par with Minneapolis and Houston’s bus ridership, which rank the 15th and 16th highest in the nation, respectively (APTA 2013).

Commuter express bus service operates in the I-10 corridor in both the Phoenix and Tucson urban areas, with routes extending nearly to their respective borders with Pinal County. In the Phoenix region, a public park-and-ride facility located on 40th Street and Pecos Road is utilized by Pinal County residents, according to a 2005 passenger survey, to access the I-10 East RAPID, a heavily used commuter express bus route with over 166,000 annual riders into Phoenix.

Public transit service in Pinal County is limited but growing. The Cotton Express is a local circulator that operates four routes within Coolidge; and the Central Arizona Regional Transit (CART) travels between Florence, Coolidge, Central Arizona College, and Casa Grande.

Currently, CART buses run every 90 minutes. A Tucson-to-Phoenix train with a station located along this 20-mile east-west CART route could extend passenger service beyond the localized connection. This could serve a substantial number of commuters from these established communities and the growing areas surrounding them and may increase ridership on CART.

4.2 Future Corridor Travel Demand Patterns

The private automobile is the dominant mode of passenger transportation within the corridor. It will continue to serve most of the travel within the Sun Corridor and new facilities are being evaluated to expand highway capacity as the demand for travel grows. There is little opportunity to offer a choice in travel options within the corridor under the current auto-focused structure.

Some small modal shifts may occur as fuel prices increase, but the options, as noted earlier, are inefficient and few. Although gasoline prices are volatile and are currently at a near decade low, there is a general upward trend in energy prices which will likely reestablish itself in future years as worldwide demand grows. This trend will increase the demand for more energy efficient modes of transportation. The steel-wheeled railway is the most energy efficient powered transportation mode and expanded passenger rail service would help the balance between energy use and cost. Without the availability of more energy efficient modes of transportation within the corridor, mobility will suffer and limit economic growth opportunities in the region.

There is another sociological shift that needs to be considered in the design of future transportation systems. The Millennial Generation has shown less inclination toward driving and purchasing their own vehicles than previous cohorts. At the same time, Baby Boomers are showing similar trends and may be less able to maintain their driving privileges as they age. These factors will shape to some degree how transportation options are delivered.

4.3 Passenger Rail Base Case and Alternatives

Corridor Passenger Rail Alternatives

Based on the work performed as part of the Alternatives Analysis (AA) for the project, an extensive assessment of possible corridors was completed prior to narrowing the discussion to the Locally Preferred Alternative (LPA) for detailed evaluation in this SDP. The alternative evaluation process began with a "universe" of 150 unique corridor alternatives that was culled to seven Conceptual Alternatives through technical analysis as well as public and agency input, then reduced to two Final Alternatives and a No-Build Alternative and, finally, to an LPA (also known as the Yellow Alternative in the AA and Final Tier 1 EIS) that provided the best connections between the two system hub locations and to the communities in between. The No-Build Alternative would continue current practice and not include passenger rail service in the corridor. (More detail about the alternative evaluation and selection process can be found in the companion Alternatives Analysis Report.)

The alternatives considered for passenger service in the Tucson to Phoenix corridor were ultimately limited by the need to provide passenger rail service to major population and economic centers if the service is to be successful. While I-10 is the most direct and fastest route option between the system hubs in Tucson and Phoenix, it does not effectively connect communities between the hubs. It also suffers from major jurisdictional and environmental challenges. Given that the proposed corridor will offer both commuter as well as intercity services, the need to access activity and employment centers is critical. The East Valley of the Phoenix metro area, including the cities of Mesa, Tempe, Gilbert, etc. is essential to the future success of the service and is not well-served by I-10.

The Teal Alternative also had potential benefits but differed from the Yellow only in the segment between Copper Basin and Eloy and ran through an open greenfield area. Given the choice of using an existing transportation corridor and a greenfield alignment with more potential for environmental challenges, it was prudent to opt for the existing use.

Based on the results of the AA, identified major conflicts, and public and agency coordination, the Orange and Yellow Alternatives were identified as the Final Alternatives because they would best meet the purpose and need for the project and provide the highest potential for successful implementation. Each alternative consists of a unique routing, set of stations, and operating characteristics. These Final Alternatives, shown in Figure 4-1 and described below, were screened as part of the AA and were the basis of the Tier 1 EIS.

- **Yellow Alternative**—this alternative would be built entirely at-grade on or adjacent to UPRR right-of-way from Phoenix to Eloy within the Southeast Branch of the UP Phoenix Subdivision, as well as within ADOT owned I-10 rights-of-way between Eloy and Tucson. In the Tucson downtown area, the alternative follows the UP Sunset Route right-of-way.
- **Orange Alternative**— this rail alternative uses or runs adjacent to UP right-of-way near the Phoenix and Tucson downtown areas. In addition, the route would utilize the ADOT owned State Route 202 Red Mountain Freeway, State Route 101 Pima Freeway, US 60 Superstition Freeway, Ellsworth Road, and I-10 rights-of-way. This alternative also assumes the use of the planned North-South multimodal corridor between Picacho and Superstition Vistas as well as an exclusive transit corridor planned in the proposed Superstition Vistas development located on land held in trust by the Arizona State Land Department. The northern and most urban portion of the alternative route is assumed to be constructed partially on an elevated guideway between Tempe and Phoenix Mesa Gateway Airport.

Both Final Alternatives share several common corridor segments within which both the Yellow and Orange routes would use the same general alignment. These sections include the UP Phoenix subdivision alignment between downtown Phoenix and Tempe, the I-10 right-of-way between Eloy and Tucson, and the last mile connection that follows the UP Sunset Route into downtown Tucson. In addition, both Final Alternatives include connections into the West Valley in the Phoenix metropolitan area (to Surprise along the Burlington Northern Santa Fe (BNSF) Railway line on Grand Avenue and to Buckeye along the UP Wellton Branch and to the Tucson International Airport (TUS) south from downtown Tucson along the UP Nogales Branch).

Preferred Alternative

FRA approved the Yellow Corridor Alternative with routing options (Orange Alternative), as shown below in Figures 4-1 and 4-2, for further review in Tier 2 studies for passenger rail service between Tucson and Phoenix, Arizona. The Yellow Corridor Alternative follows existing ADOT or UPRR right-of-way (ROW), including the UP Phoenix Subdivision's Southeast Branch. A passenger rail facility within the selected corridor alternative will meet the identified transportation need of providing an alternative mode to help address existing and future travel demand in the Pima, Pinal, and Maricopa tri-county area.

In selecting the Yellow Corridor Alternative, FRA considered the information and analysis contained in the Draft Tier 1 EIS dated September 2015 and the Final Tier 1 EIS dated December 2016. FRA also considered comments from agencies, tribes, and the public received during the scoping process and the public comment period for the Draft Tier 1 EIS. Routing options will be evaluated in Tier 2 studies through Tempe using a portion of the Orange Corridor Alternative to avoid or minimize the potential use of Section 4(f) resources and/or potential adverse effects to historic properties that are known to exist within the Yellow Corridor. Optional routing will also be evaluated in Tier 2 studies within Pinal County utilizing a portion of what was the Orange Corridor Alternative, should an alignment avoiding known cultural resources along the existing UP ROW or elsewhere within the 1-mile-wide corridor alternative not be feasible. Only the Preferred Alternative is considered in this SDP.

Figure 4-1: Final Alternatives

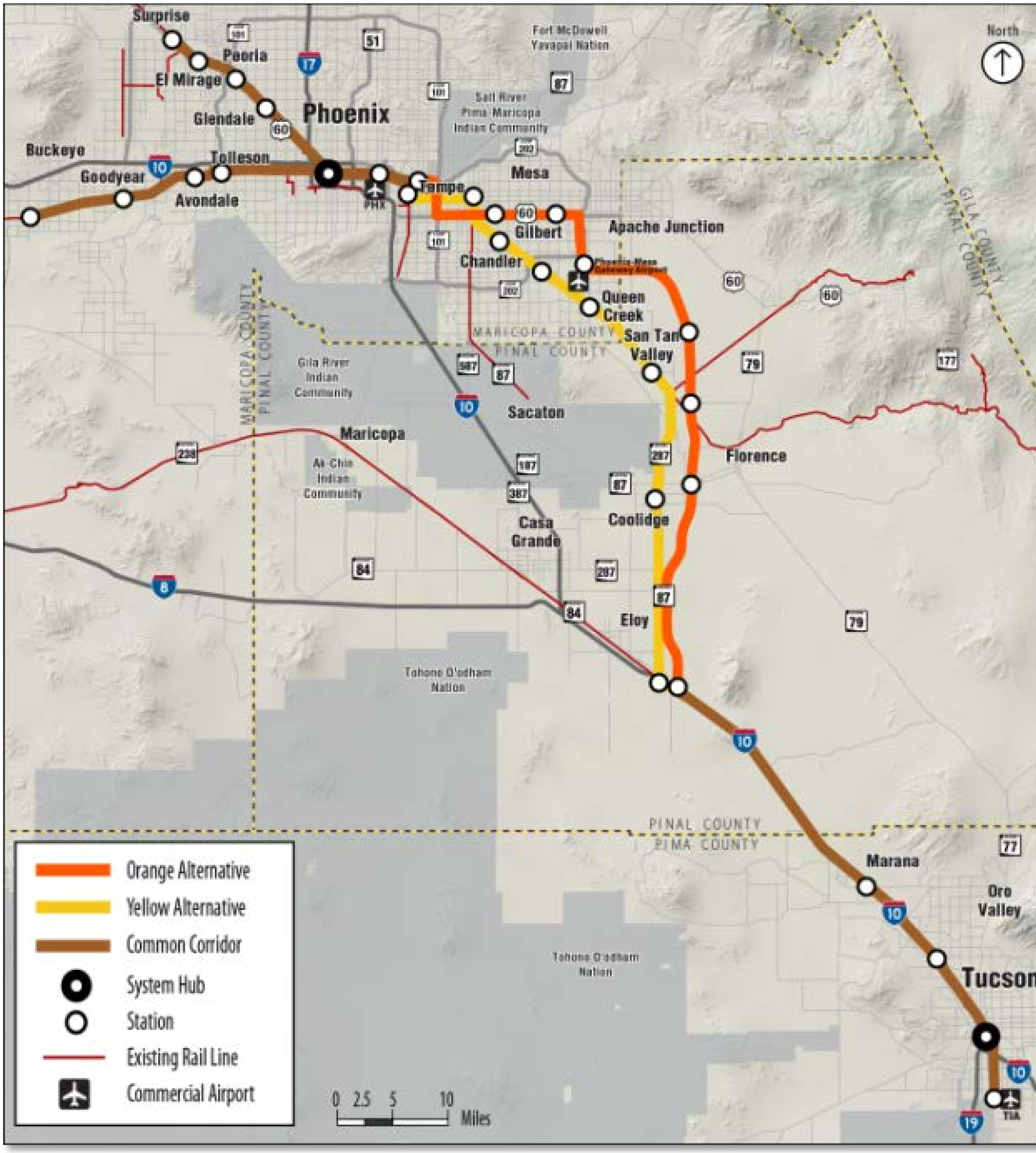
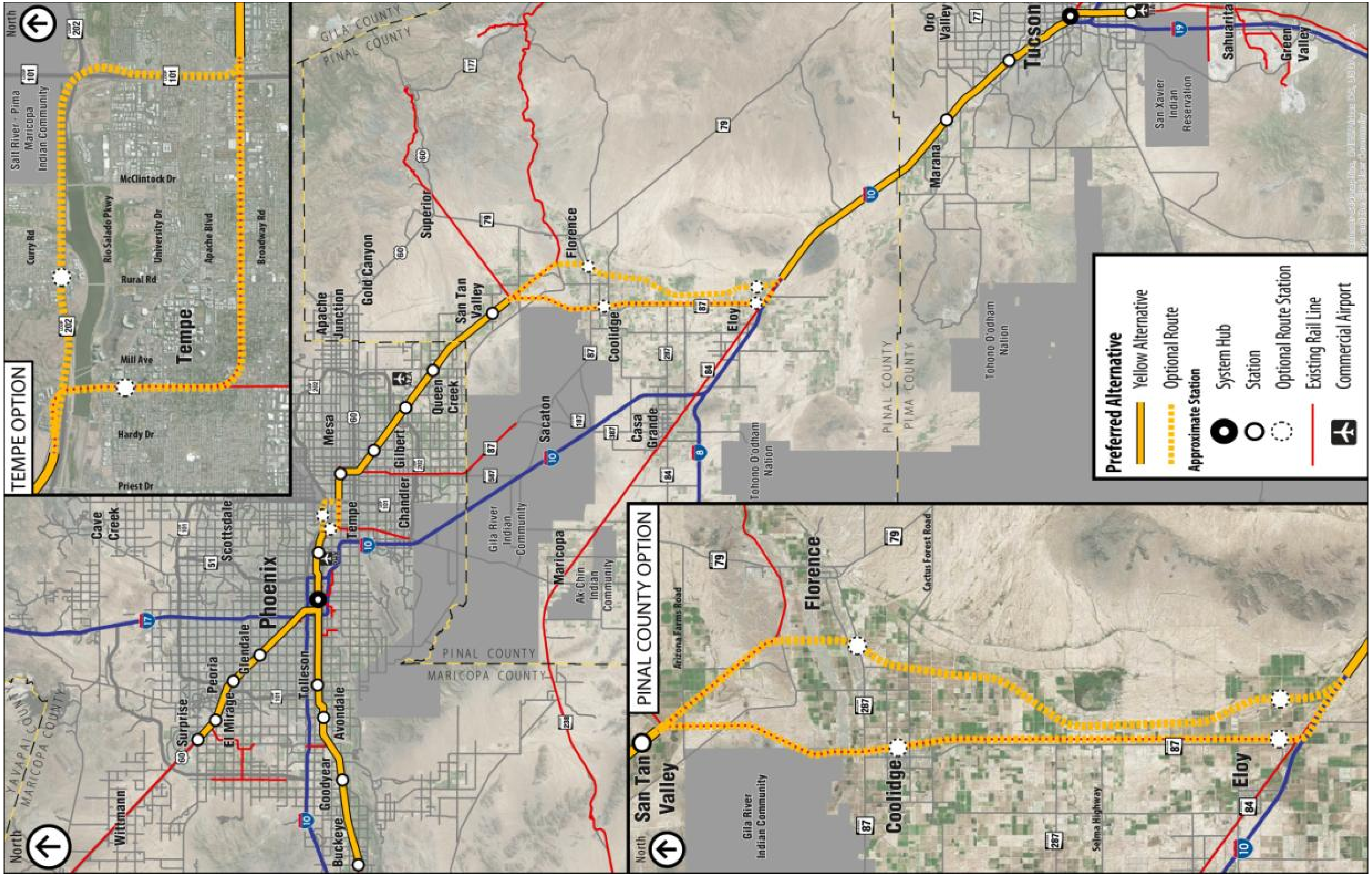


Figure 4-2: Preferred Corridor (AA Yellow Alternative)



4.4 Service Plan Alternatives

Two service concepts are addressed in this SDP and are described in this section:

1 - The Base Service Plan that runs the full length of the corridor for both commuter and intercity rail services and is the basis of the analysis under this Tier 1 study

2 - The Alternative Service Plan limits commuter rail service to the Phoenix and Tucson metro areas and is the preferred option given ridership and costs.

The analysis in this section is conceptual given the stage of the project and the level of the data available for the study. Scheduling assumptions have been made to show potential operational timetables for the BSP and ASP, but there is a recognition that with more detailed and more complete information, a more efficient plan could be developed that would optimize fleet size and cost and maximize user access.

The station locations are approximate and designed to distribute the demand across the corridor given anticipated growth patterns. Some stations may not be included in an implementation plan if they do not show sufficient ridership or have not made the necessary commitment to the new service to warrant a stop. For planning purposes, in this analysis, all potential stations are identified along the route regardless of demand.

The new passenger rail service is proposed to be made compatible with expanding freight operations by avoiding the Sunset Route and, as much as possible, maintaining a 50-foot separation from freight operations throughout the corridor except where such separation is not possible because of physical constraints. The added capacity of passenger track in the corridor will afford a substantial benefit to both passenger service and freight operations by improving much of the trackage in the corridor because freight track would need to be moved in places to accommodate passenger tracks.

Base Service Plan (BSP) – Full Phoenix to Tucson Blended Service

This SDP comprises two proposed passenger service types within the corridor: commuter service and intercity service. The BSP alternative that was investigated to assess the project's long term potential included an operating plan consisting of two (2) commuter trains and one (1) intercity train hourly per direction during the AM peak and similar service during the PM peak for a total of 36 trains a day (12 intercity and 36 commuter in both directions), all of which were assumed to travel the entire length of the corridor. The intercity service is assumed to operate in all alternatives.

Operating assumptions

Two commuter trains and one intercity train per hour in both directions would operate between 5:00 and 6:00 AM and about 8:30 AM and 3:00 PM and 7:00 or 7:30 PM, subject to the best timing of rolling stock and patronage. The conceptual schedule shown in Table 4-1 and the configuration in Figure 4-3 are a preliminary version of a timetable pending improved data and a more refined analysis. The schedule in 4-1 assumes a turnaround time of 20 minutes but no fewer than 10 minutes, but is presented as a time-specific plan to show a predictable relationship among the various runs. As a result, the turnaround time could be extended. The intercity service runs from Peoria in the West Valley to TUS, south of downtown Tucson, shown by the dashed blue line in Figure 4-3. Commuter service is divided between runs from Surprise to TUS and Buckeye to TUS, shown in the green and red lines, respectively.

Depending on demand, trains could be added or removed from service. This is a high level of service where no service currently exists and is used as a basis for travel forecasting. The basis of the numbers is a focus on a high service level during peak periods that could be effectively coordinated with other transit or transportation options and carry substantial ridership in both the commuter and intercity service areas.

Lower numbers at opening would suggest lower frequency of the commuter service and possibly fewer intercity trains as well. Using capacity assumptions of 300 to 400 passengers per train (ppt) for both commuter service and intercity service (four-car consists), travel forecasting results obtained with the current assumptions produce a demand commensurate with the service being tested.

Frequency in 10 years

At the inception of service, frequencies would be adapted to demand. Based on travel forecasting, current demand would be about 11,000 per day for commuter and intercity services combined.

Frequency in 2035

The 2035 service that carries 22,000 passengers is the same as indicated in the operating assumption schedule unless future travel forecasting suggests a different course of action.

Figure 4-3: Base Service Plan Operating Concept

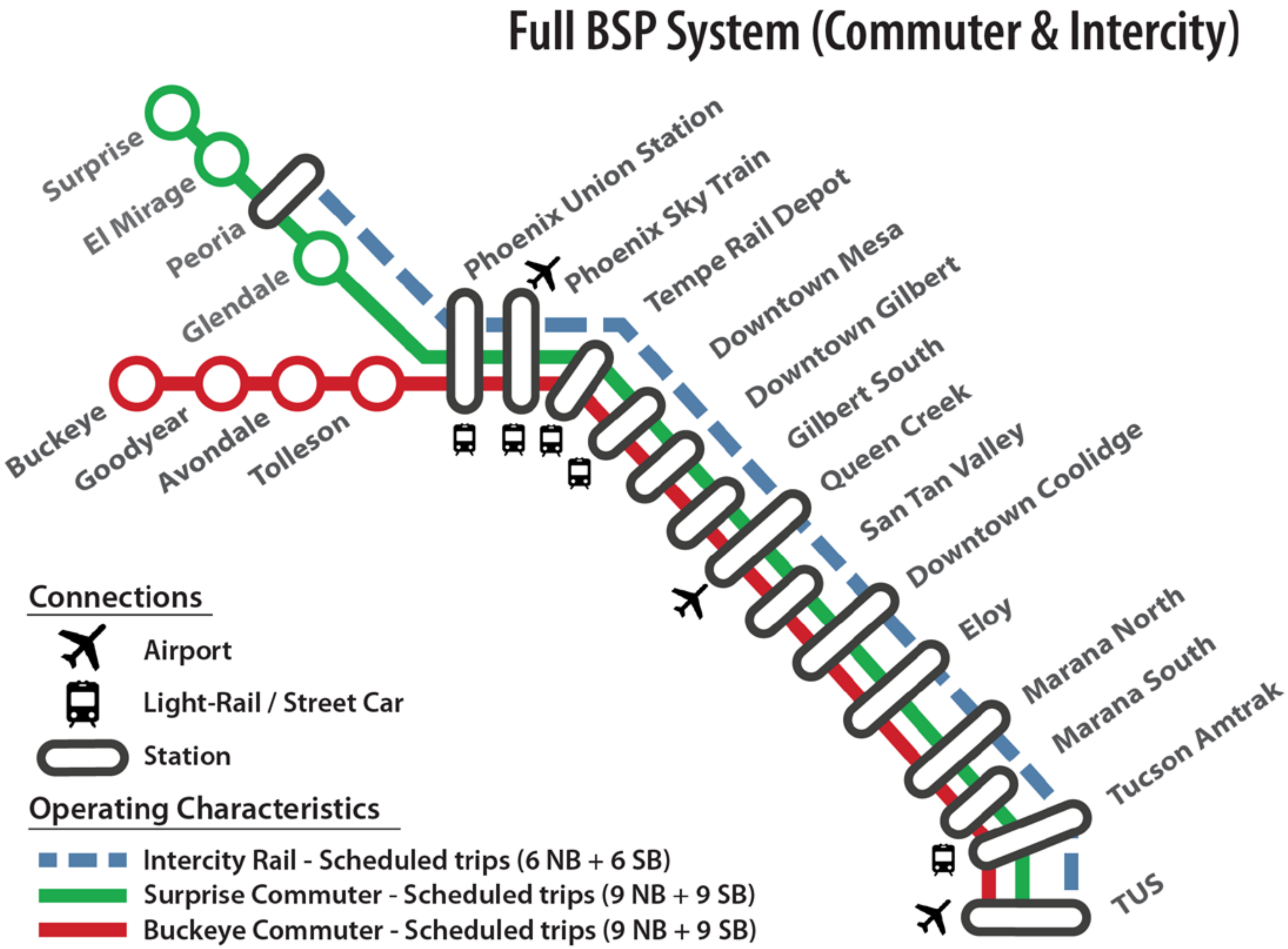


Table 4-1 - BSP Schedule Operating Assumptions[4]

APRCS - BSP - Train Schedule - Southbound Service

	AM PEAK SERVICE									MIDDAY SERVICE						PM PEAK SERVICE								
Train No.	**101**	**201**	**401**	**103**	**203**	**403**	**105**	**205**	**405**	**111**	**211**	**113**	**213**	**115**	**215**	**121**	**221**	**421**	**123**	**223**	**423**	**125**	**225**	**425**
Surprise	5:30	-	-	6:30	-	-	7:30	-	-	9:30	-	11:30	-	13:30	-	15:30	-	-	16:30	-	-	17:30	-	-
El Mirage	5:33	-	-	6:33	-	-	7:33	-	-	9:33	-	11:33	-	13:33	-	15:33	-	-	16:33	-	-	17:33	-	-
Peoria	5:38	-	6:20	6:38	-	7:20	7:38	-	8:20	9:38	-	11:38	-	13:38	-	15:38	-	16:20	16:38	-	17:20	17:38	-	18:20
Glendale	5:42	-	-	6:42	-	-	7:42	-	-	9:42	-	11:42	-	13:42	-	15:42	-	-	16:42	-	-	17:42	-	-
Buckeye	-	5:44	-	-	6:44	-	-	7:44	-	-	10:24	-	12:24	-	14:24	-	15:44	-	-	16:44	-	-	17:44	-
Goodyear	-	5:51	-	-	6:51	-	-	7:51	-	-	10:31	-	12:31	-	14:31	-	15:51	-	-	16:51	-	-	17:51	-
Avondale	-	5:58	-	-	6:58	-	-	7:58	-	-	10:38	-	12:38	-	14:38	-	15:58	-	-	16:58	-	-	17:58	-
Tolleson	-	6:03	-	-	7:03	-	-	8:03	-	-	10:43	-	12:43	-	14:43	-	16:03	-	-	17:03	-	-	18:03	-
Phoenix	**5:53**	**6:13**	**6:33**	**6:53**	**7:13**	**7:33**	**7:53**	**8:13**	**8:33**	**9:53**	**10:53**	**11:53**	**12:53**	**13:53**	**14:53**	**15:53**	**16:13**	**16:33**	**16:53**	**17:13**	**17:33**	**17:53**	**18:13**	**18:33**
Sky Harbor	6:01	6:21	6:41	7:01	7:21	7:41	8:01	8:21	8:41	10:01	11:01	12:01	13:01	14:01	15:01	16:01	16:21	16:41	17:01	17:21	17:41	18:01	18:21	18:41
Tempe	6:07	6:27	|	7:07	7:27	|	8:07	8:27	|	10:07	11:07	12:07	13:07	14:07	15:07	16:07	16:27	|	17:07	17:27	|	18:07	18:27	|
Mesa	6:15	6:35	|	7:15	7:35	|	8:15	8:35	|	10:15	11:15	12:15	13:15	14:15	15:15	16:15	16:35	|	17:15	17:35	|	18:15	18:35	|
Gilbert	6:21	6:41	|	7:21	7:41	|	8:21	8:41	|	10:21	11:21	12:21	13:21	14:21	15:21	16:21	16:41	|	17:21	17:41	|	18:21	18:41	|
Cooley	6:26	6:46	V	7:26	7:46	V	8:26	8:46	V	10:26	11:26	12:26	13:26	14:26	15:26	16:26	16:46	V	17:26	17:46	V	18:26	18:46	V
Queen Creek	6:30	6:50	7:05	7:30	7:50	8:05	8:30	8:50	9:05	10:30	11:30	12:30	13:30	14:30	15:30	16:30	16:50	17:05	17:30	17:50	18:05	18:30	18:50	19:05
SanTan Valley	6:37	6:57	-	7:37	7:57	-	8:37	8:57	-	10:37	11:37	12:37	13:37	14:37	15:37	16:37	16:57	-	17:37	17:57	-	18:37	18:57	-
Coolidge	6:46	7:06	7:19	7:46	8:06	8:19	8:46	9:06	9:19	10:46	11:46	12:46	13:46	14:46	15:46	16:46	17:06	17:19	17:46	18:06	18:19	18:46	19:06	19:19
Eloy	6:56	7:16	-	7:56	8:16	-	8:56	9:16	-	10:56	11:56	12:56	13:56	14:56	15:56	16:56	17:16	-	17:56	18:16	-	18:56	19:16	-
I-10 at Tangerine	7:14	7:34	7:46	8:14	8:34	8:46	9:14	9:34	9:46	11:14	12:14	13:14	14:14	15:14	16:14	17:14	17:34	17:46	18:14	18:34	18:46	19:14	19:34	19:46
I-10 at Orange	7:20	7:40	-	8:20	8:40	-	9:20	9:40	-	11:20	12:20	13:20	14:20	15:20	16:20	17:20	17:40	-	18:20	18:40	-	19:20	19:40	-
Tucson Amtrak	**7:27**	**7:47**	**7:57**	**8:27**	**8:47**	**8:57**	**9:27**	**9:47**	**9:57**	**11:27**	**12:27**	**13:27**	**14:27**	**15:27**	**16:27**	**17:27**	**17:47**	**17:57**	**18:27**	**18:47**	**18:57**	**19:27**	**19:47**	**19:57**
Tucson Airport	7:34	7:54	8:04	8:34	8:54	9:04	9:34	9:54	10:04	11:34	12:34	13:34	14:34	15:34	16:34	17:34	17:54	18:04	18:34	18:54	19:04	19:34	19:54	20:04

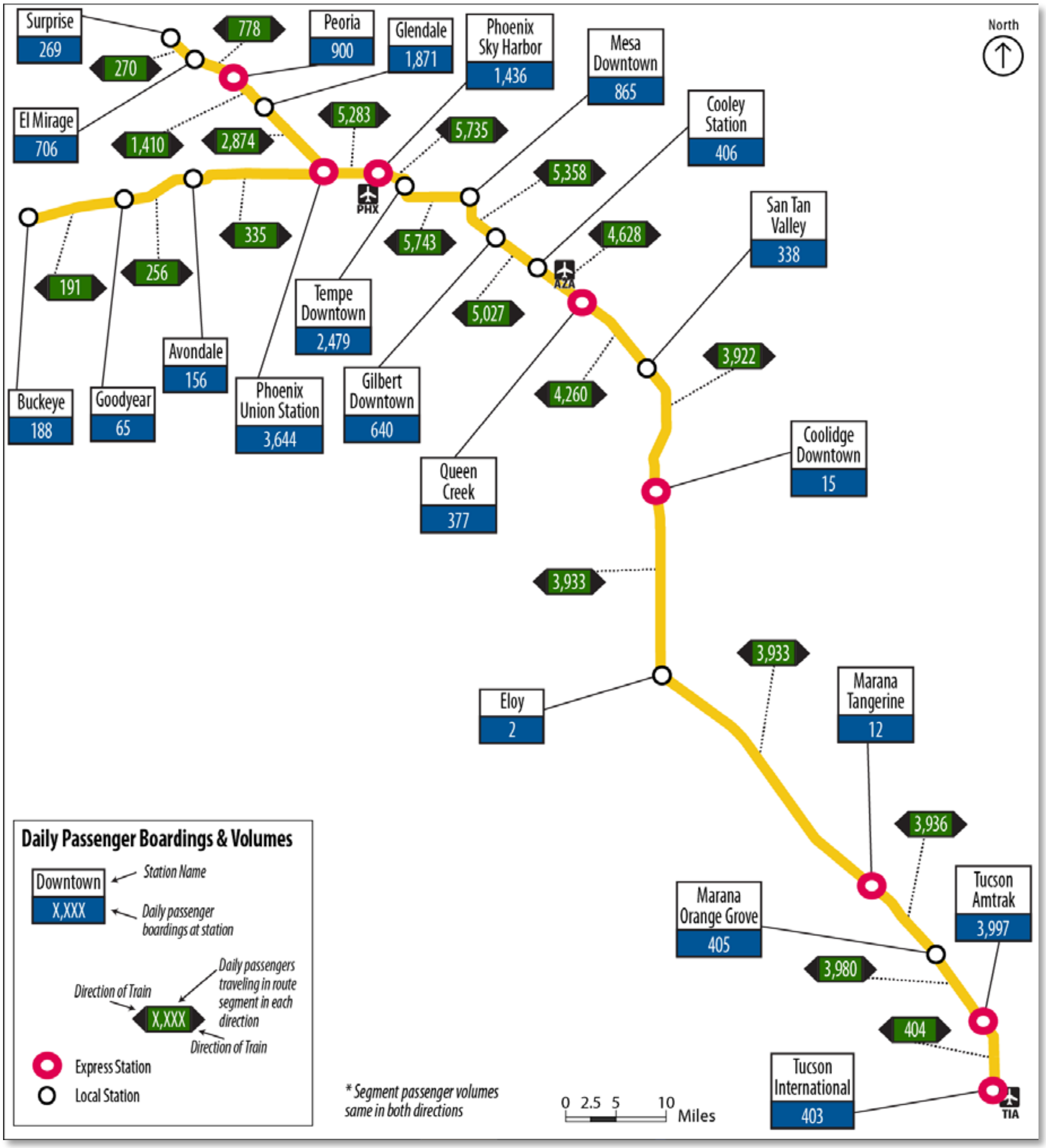
APRCSW - BSP - Train Schedule - Northbound Service

	AM PEAK SERVICE									MIDDAY SERVICE						PM PEAK SERVICE								
Train No.	**102**	**202**	**402**	**104**	**204**	**404**	**106**	**206**	**406**	**112**	**212**	**114**	**214**	**116**	**216**	**122**	**222**	**422**	**124**	**224**	**424**	**126**	**226**	**426**
Tucson Airport	5:22	5:42	6:02	6:22	6:42	7:02	7:22	7:42	8:02	9:22	10:22	11:22	12:22	13:22	14:22	15:22	15:42	16:02	16:22	16:42	17:02	17:22	17:42	18:02
Tucson Amtrak	**5:29**	**5:49**	**6:09**	**6:29**	**6:49**	**7:09**	**7:29**	**7:49**	**8:09**	**9:29**	**10:29**	**11:29**	**12:29**	**13:29**	**14:29**	**15:29**	**15:49**	**16:09**	**16:29**	**16:49**	**17:09**	**17:29**	**17:49**	**18:09**
I-10 at Orange	5:36	5:56	-	6:36	6:56	-	7:36	7:56	-	9:36	10:36	11:36	12:36	13:36	14:36	15:36	15:56	-	16:36	16:56	-	17:36	17:56	-
I-10 at Tangerine	5:42	6:02	6:20	6:42	7:02	7:20	7:42	8:02	8:20	9:42	10:42	11:42	12:42	13:42	14:42	15:42	16:02	16:20	16:42	17:02	17:20	17:42	18:02	18:20
Eloy	6:00	6:20	-	7:00	7:20	-	8:00	8:20	-	10:00	11:00	12:00	13:00	14:00	15:00	16:00	16:20	-	17:00	17:20	-	18:00	18:20	-
Coolidge	6:10	6:30	6:47	7:10	7:30	7:47	8:10	8:30	8:47	10:10	11:10	12:10	13:10	14:10	15:10	16:10	16:30	16:47	17:10	17:30	17:47	18:10	18:30	18:47
SanTan Valley	6:19	6:39	-	7:19	7:39	-	8:19	8:39	-	10:19	11:19	12:19	13:19	14:19	15:19	16:19	16:39	-	17:19	17:39	-	18:19	18:39	-
Queen Creek	6:26	6:46	7:01	7:26	7:46	8:01	8:26	8:46	9:01	10:26	11:26	12:26	13:26	14:26	15:26	16:26	16:46	17:01	17:26	17:46	18:01	18:26	18:46	19:01
Cooley	6:30	6:50	|	7:30	7:50	|	8:30	8:50	|	10:30	11:30	12:30	13:30	14:30	15:30	16:30	16:50	|	17:30	17:50	|	18:30	18:50	|
Gilbert	6:35	6:55	|	7:35	7:55	|	8:35	8:55	|	10:35	11:35	12:35	13:35	14:35	15:35	16:35	16:55	|	17:35	17:55	|	18:35	18:55	|
Mesa	6:41	7:01	|	7:41	8:01	|	8:41	9:01	|	10:41	11:41	12:41	13:41	14:41	15:41	16:41	17:01	|	17:41	18:01	|	18:41	19:01	|
Tempe	6:49	7:09	V	7:49	8:09	V	8:49	9:09	V	10:49	11:49	12:49	13:49	14:49	15:49	16:49	17:09	V	17:49	18:09	V	18:49	19:09	V
Sky Harbor	6:55	7:15	7:25	7:55	8:15	8:25	8:55	9:15	9:25	10:55	11:55	12:55	13:55	14:55	15:55	16:55	17:15	17:25	17:55	18:15	18:25	18:55	19:15	19:25
Phoenix	**7:03**	**7:23**	**7:33**	**8:03**	**8:23**	**8:33**	**9:03**	**9:23**	**9:33**	**11:03**	**12:03**	**13:03**	**14:03**	**15:03**	**16:03**	**17:03**	**17:23**	**17:33**	**18:03**	**18:23**	**18:33**	**19:03**	**19:23**	**19:33**
Tolleson	-	7:33	-	-	8:33	-	-	9:33	-	-	12:13	-	14:13	-	16:13	-	17:33	-	-	18:33	-	-	19:33	-
Avondale	-	7:38	-	-	8:38	-	-	9:38	-	-	12:18	-	14:18	-	16:18	-	17:38	-	-	18:38	-	-	19:38	-
Goodyear	-	7:45	-	-	8:45	-	-	9:45	-	-	12:25	-	14:25	-	16:25	-	17:45	-	-	18:45	-	-	19:45	-
Buckeye	-	7:52	-	-	8:52	-	-	9:52	-	-	12:32	-	14:32	-	16:32	-	17:52	-	-	18:52	-	-	19:52	-
Glendale	7:14	-	-	8:14	-	-	9:14	-	-	11:14	-	13:14	-	15:14	-	17:14	-	-	18:14	-	-	19:14	-	-
Peoria	7:18	-	7:46	8:18	-	8:46	9:18	-	9:46	11:18	-	13:18	-	15:18	-	17:18	-	17:46	18:18	-	18:46	19:18	-	19:46
El Mirage	7:23	-	-	8:23	-	-	9:23	-	-	11:23	-	13:23	-	15:23	-	17:23	-	-	18:23	-	-	19:23	-	-
Surprise	7:26	-	-	8:26	-	-	9:26	-	-	11:26	-	13:26	-	15:26	-	17:26	-	-	18:26	-	-	19:26	-	-

- (green) Surprise to TUS
- (pink) Buckeye to TUS
- (light blue) Peoria to TUS (Intercity)

[4] Timetable analysis is conceptual and subject to refinement as more complete information becomes available

Figure 4-4: 2035 Station Boardings and Link Volumes for the Base Service Alternative



Alternative Service Plan (ASP) – Urban Commuter and Intercity Service

The ASP was based on forecast ridership on the BSP and formulated to take advantage of the highest ridership segments in the corridor by differentiating between intercity and commuter services. Figure 4-4 shows the ridership levels that form the basis for the commuter services proposed in the ASP.

This is a preliminary assessment subject to much more detailed analysis regarding ridership and station locations before a final concept is ready for implementation. Like the BSP, the identified timetable is also conceptual in that a more efficient use of rolling stock may be possible with some adjustments to the input assumptions. However, until there is a better-defined project, such detailed analyses would need to be supported by more comprehensive data.

This section is also an indication of how the project could evolve over time and how it would be phased as funding materializes. One station location from the BSP, Eloy, is not shown in the ASP. Eloy is identified as an emerging station location because of extremely low ridership potential during this study timeframe. It does not yet meet the minimum requirements for dedicated service given the high operating costs it would require, but as the area grows and builds support for passenger service, either commuter service toward the Tucson and Phoenix metro areas or intercity service, a station would be added and operations would be modified to include the new location. Other locations, such as Marana Tangerine and Downtown Coolidge, with low ridership will most likely also be subject to a similar assessment.

Based on this assessment, the following operating configuration was defined and is shown in Figure 4-5.

Santan Valley-Phoenix Commuter Service

Service is assumed to run two times an hour in both directions between Santan Valley and Phoenix during peak service periods. Other northbound trains would travel to Surprise (green line) and Buckeye (red line). Trains from Surprise and Buckeye would interline between Phoenix and Santan Valley.

Marana-Tucson Commuter Service

Service would run two times an hour between Marana and Tucson during peak service periods. All trains would run to Tucson International Airport (TUS) (purple line).

Tucson-Phoenix Intercity Service

Service is assumed to be offered once every two hours in both directions between Phoenix and Tucson. For purposes of estimating ridership, service was conservatively operated between the hours of 6 AM and 9 AM and 4 PM and 7 PM. In future analyses, a more comprehensive schedule that would run throughout the day could be instituted to accommodate midday turnaround trips and evening events which could attract higher ridership. Trains would start in Peoria or Avondale and would run to TUS. Service frequency would be determined by demand, but will likely favor the Grand Avenue extension over the I-10 extension on the basis of anticipated growth (dashed blue line).

Operating Assumptions

As in the BSP option, two commuter trains would operate per hour in both the Phoenix and Tucson metro areas. They would serve both directions between 5:30 AM and 8:30 AM and 3:00 PM and 7:00 PM. One intercity train would operate every two hours per direction consistent with the schedule shown in Table 4-2 and in accordance with the configuration in Figure 4-5. Also, as before, depending on demand, trains could be added or removed from service.

Figure 4-5: Alternative Service Plan Operating Concept

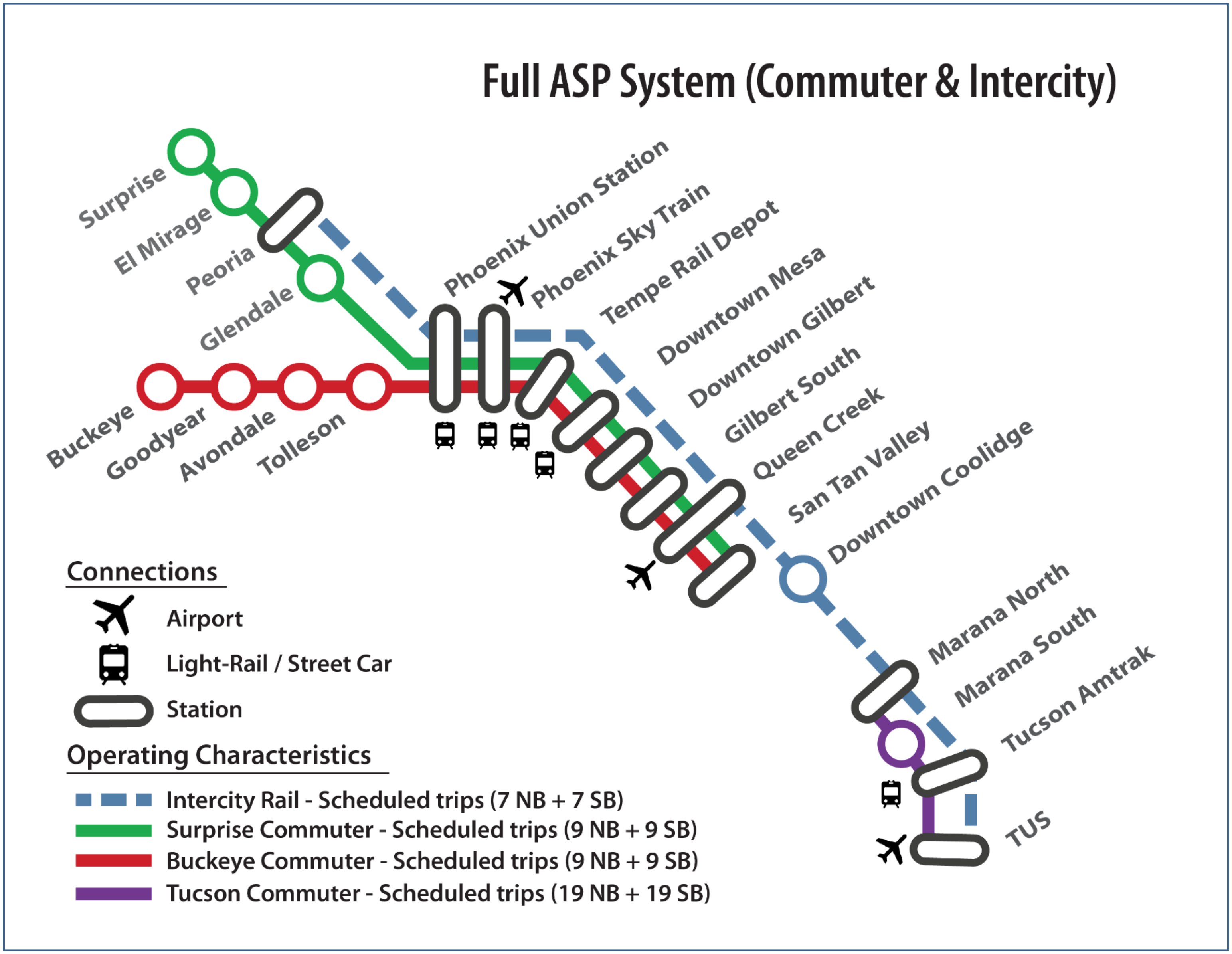


Table 4-2 – ASP Schedule Operating Assumptions[5]

APRCS - ASP - Train Schedule - Southbound Service

AM PEAK SERVICE

Train No.	301	303	305	307	101	309	201	401	311	103	313	203	105	205	405
Surprise	-	-	-	-	5:30	-	-	-	-	6:30	-	-	7:30	-	-
El Mirage	-	-	-	-	5:33	-	-	-	-	6:33	-	-	7:33	-	-
Peoria	-	-	-	-	5:38	-	-	6:20	-	6:38	-	-	7:38	-	8:20
Glendale	-	-	-	-	5:42	-	-	-	-	6:42	-	-	7:42	-	-
Buckeye	-	-	-	-	-	-	5:44	-	-	-	-	6:44	-	7:44	-
Goodyear	-	-	-	-	-	-	5:51	-	-	-	-	6:51	-	7:51	-
Avondale	-	-	-	-	-	-	5:58	-	-	-	-	6:58	-	7:58	-
Tolleson	-	-	-	-	-	-	6:03	-	-	-	-	7:03	-	8:03	-
Phoenix	**-**	**-**	**-**	**-**	**5:53**	**-**	**6:13**	**6:33**	**-**	**6:53**	**-**	**7:13**	**7:53**	**8:13**	**8:33**
Sky Harbor	-	-	-	-	6:01	-	6:21	6:41	-	7:01	-	7:21	8:01	8:21	8:41
Tempe	-	-	-	-	6:07	-	6:27	|	-	7:07	-	7:27	8:07	8:27	|
Mesa	-	-	-	-	6:15	-	6:35	|	-	7:15	-	7:35	8:15	8:35	|
Dwntwn Gilbert	-	-	-	-	6:21	-	6:41	|	-	7:21	-	7:41	8:21	8:41	|
Gilbert South	-	-	-	-	6:26	-	6:46	V	-	7:26	-	7:46	8:26	8:46	V
Queen Creek	-	-	-	-	6:30	-	6:50	7:05	-	7:30	-	7:50	8:30	8:50	9:05
SanTan Valley	-	-	-	-	6:37	-	6:57	-	-	7:37	-	7:57	8:37	8:57	-
Coolidge	-	-	-	-	-	-	-	7:19	-	-	-	-	-	-	9:19
Eloy	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Marana North	5:24	5:54	6:24	6:54	-	7:24	-	7:46	7:54	-	8:24	-	-	-	9:46
Marana South	5:30	6:00	6:30	7:00	-	7:30	-	-	8:00	-	8:30	-	-	-	-
Tucson Amtrak	**5:37**	**6:07**	**6:37**	**7:07**	**-**	**7:37**	**-**	**7:57**	**8:07**	**-**	**8:37**	**-**	**-**	**-**	**9:57**
Tucson Airport	5:44	6:14	6:44	7:14	-	7:44	-	8:04	8:14	-	8:44	-	-	-	10:04

MIDDAY SERVICE

Train No.	323	325	111	411	327	211	329	113	413	331	213	333	115	415	335	215
Surprise	-	-	9:30	-	-	-	-	11:30	-	-	-	-	13:30	-	-	-
El Mirage	-	-	9:33	-	-	-	-	11:33	-	-	-	-	13:33	-	-	-
Peoria	-	-	9:38	10:20	-	-	-	11:38	12:20	-	-	-	13:38	14:20	-	-
Glendale	-	-	9:42	-	-	-	-	11:42	-	-	-	-	13:42	-	-	-
Buckeye	-	-	-	-	-	10:24	-	-	-	-	12:24	-	-	-	-	14:24
Goodyear	-	-	-	-	-	10:31	-	-	-	-	12:31	-	-	-	-	14:31
Avondale	-	-	-	-	-	10:38	-	-	-	-	12:38	-	-	-	-	14:38
Tolleson	-	-	-	-	-	10:43	-	-	-	-	12:43	-	-	-	-	14:43
Phoenix	**-**	**-**	**9:53**	**10:33**	**-**	**10:53**	**-**	**11:53**	**12:33**	**-**	**12:53**	**-**	**13:53**	**14:33**	**-**	**14:53**
Sky Harbor	-	-	10:01	10:41	-	11:01	-	12:01	12:41	-	13:01	-	14:01	14:41	-	15:01
Tempe	-	-	10:07	|	-	11:07	-	12:07	|	-	13:07	-	14:07	|	-	15:07
Mesa	-	-	10:15	|	-	11:15	-	12:15	|	-	13:15	-	14:15	|	-	15:15
Dwntwn Gilbert	-	-	10:21	|	-	11:21	-	12:21	|	-	13:21	-	14:21	|	-	15:21
Gilbert South	-	-	10:26	V	-	11:26	-	12:26	V	-	13:26	-	14:26	V	-	15:26
Queen Creek	-	-	10:30	11:05	-	11:30	-	12:30	13:05	-	13:30	-	14:30	15:05	-	15:30
SanTan Valley	-	-	10:37	-	-	11:37	-	12:37	-	-	13:37	-	14:37	-	-	15:37
Coolidge	-	-	-	11:19	-	-	-	-	13:19	-	-	-	-	15:19	-	-
Eloy	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Marana North	9:45	10:45	-	11:46	11:45	-	12:45	-	13:46	13:45	-	14:45	-	15:46	15:45	-
Marana South	9:51	10:51	-	-	11:51	-	12:51	-	-	13:51	-	14:51	-	-	15:51	-
Tucson Amtrak	**9:58**	**10:58**	**-**	**11:57**	**11:58**	**-**	**12:58**	**-**	**13:57**	**13:58**	**-**	**14:58**	**-**	**15:57**	**15:58**	**-**
Tucson Airport	10:05	11:05	-	12:04	12:05	-	13:05	-	14:04	14:05	-	15:05	-	16:04	16:05	-

PM PEAK SERVICE

Train No.	341	343	121	345	221	421	347	123	349	223	125	225	425
Surprise	-	-	15:30	-	-	-	-	16:30	-	-	17:30	-	-
El Mirage	-	-	15:33	-	-	-	-	16:33	-	-	17:33	-	-
Peoria	-	-	15:38	-	-	16:20	-	16:38	-	-	17:38	-	18:20
Glendale	-	-	15:42	-	-	-	-	16:42	-	-	17:42	-	-
Buckeye	-	-	-	-	15:44	-	-	-	-	16:44	-	17:44	-
Goodyear	-	-	-	-	15:51	-	-	-	-	16:51	-	17:51	-
Avondale	-	-	-	-	15:58	-	-	-	-	16:58	-	17:58	-
Tolleson	-	-	-	-	16:03	-	-	-	-	17:03	-	18:03	-
Phoenix	**-**	**-**	**15:53**	**-**	**16:13**	**16:33**	**-**	**16:53**	**-**	**17:13**	**17:53**	**18:13**	**18:33**
Sky Harbor	-	-	16:01	-	16:21	16:41	-	17:01	-	17:21	18:01	18:21	18:41
Tempe	-	-	16:07	-	16:27	|	-	17:07	-	17:27	18:07	18:27	|
Mesa	-	-	16:15	-	16:35	|	-	17:15	-	17:35	18:15	18:35	|
Dwntwn Gilbert	-	-	16:21	-	16:41	|	-	17:21	-	17:41	18:21	18:41	|
Gilbert South	-	-	16:26	-	16:46	V	-	17:26	-	17:46	18:26	18:46	V
Queen Creek	-	-	16:30	-	16:50	17:05	-	17:30	-	17:50	18:30	18:50	19:05
SanTan Valley	-	-	16:37	-	16:57	-	-	17:37	-	17:57	18:37	18:57	-
Coolidge	-	-	-	-	-	17:19	-	-	-	-	-	-	19:19
Eloy	-	-	-	-	-	-	-	-	-	-	-	-	-
Marana North	16:24	16:54	-	17:24	-	17:46	17:54	-	18:24	-	-	-	19:46
Marana South	16:30	17:00	-	17:30	-	-	18:00	-	18:30	-	-	-	-
Tucson Amtrak	**16:37**	**17:07**	**-**	**17:37**	**-**	**17:57**	**18:07**	**-**	**18:37**	**-**	**-**	**-**	**19:57**
Tucson Airport	16:44	17:14	-	17:44	-	18:04	18:14	-	18:44	-	-	-	20:04

APRCS - ASP - Train Schedule - Northbound Service

AM PEAK SERVICE

Train No.	102	302	202	402	304	104	306	204	308	106	310	206	406	312
Tucson Airport	-	5:35	-	6:02	6:05	-	6:35	-	7:05	-	7:35	-	8:02	8:05
Tucson Amtrak	**-**	**5:42**	**-**	**6:09**	**6:12**	**-**	**6:42**	**-**	**7:12**	**-**	**7:42**	**-**	**8:09**	**8:12**
Marana South	-	5:49	-	-	6:19	-	6:49	-	7:19	-	7:49	-	-	8:19
Marana North	-	5:55	-	6:20	6:25	-	6:55	-	7:25	-	7:55	-	8:20	8:25
Eloy	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coolidge	-	-	-	6:47	-	-	-	-	-	-	-	-	8:47	-
SanTan Valley	6:19	-	6:39	-	-	7:19	-	7:39	-	8:19	-	8:39	-	-
Queen Creek	6:26	-	6:46	7:01	-	7:26	-	7:46	-	8:26	-	8:46	9:01	-
Gilbert South	6:30	-	6:50	|	-	7:30	-	7:50	-	8:30	-	8:50	|	-
Dwntwn Gilbert	6:35	-	6:55	|	-	7:35	-	7:55	-	8:35	-	8:55	|	-
Mesa	6:41	-	7:01	|	-	7:41	-	8:01	-	8:41	-	9:01	|	-
Tempe	6:49	-	7:09	V	-	7:49	-	8:09	-	8:49	-	9:09	V	-
Sky Harbor	6:55	-	7:15	7:25	-	7:55	-	8:15	-	8:55	-	9:15	9:25	-
Phoenix	**7:03**	**-**	**7:23**	**7:33**	**-**	**8:03**	**-**	**8:23**	**-**	**9:03**	**-**	**9:23**	**9:33**	**-**
Tolleson	-	-	7:33	-	-	-	-	8:33	-	-	-	9:33	-	-
Avondale	-	-	7:38	-	-	-	-	8:38	-	-	-	9:38	-	-
Goodyear	-	-	7:45	-	-	-	-	8:45	-	-	-	9:45	-	-
Buckeye	-	-	7:52	-	-	-	-	8:52	-	-	-	9:52	-	-
Glendale	7:14	-	-	-	-	8:14	-	-	-	9:14	-	-	-	-
Peoria	7:18	-	-	7:46	-	8:18	-	-	-	9:18	-	-	9:46	-
El Mirage	7:23	-	-	-	-	8:23	-	-	-	9:23	-	-	-	-
Surprise	7:26	-	-	-	-	8:26	-	-	-	9:26	-	-	-	-

MIDDAY SERVICE

Train No.	322	112	324	412	212	326	114	328	414	214	330	116	332	416	216	334
Tucson Airport	8:35	-	9:33	10:02	-	10:33	-	11:33	12:02	-	12:33	-	13:33	14:02	-	14:33
Tucson Amtrak	**8:41**	**-**	**9:39**	**10:09**	**-**	**10:39**	**-**	**11:39**	**12:09**	**-**	**12:39**	**-**	**13:39**	**14:09**	**-**	**14:39**
Marana South	8:48	-	9:46	-	-	10:46	-	11:46	-	-	12:46	-	13:46	-	-	14:46
Marana North	8:55	-	9:53	10:20	-	10:53	-	11:53	12:20	-	12:53	-	13:53	14:20	-	14:53
Eloy	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-
Coolidge	-	-	-	10:47	-	-	-	-	12:47	-	-	-		14:47	-	-
SanTan Valley	-	10:19	-	-	11:19	-	12:19	-	-	13:19	-	14:19		-	15:19	-
Queen Creek	-	10:26	-	11:01	11:26	-	12:26	-	13:01	13:26	-	14:26		15:01	15:26	-
Gilbert South	-	10:30	-	|	11:30	-	12:30	-	|	13:30	-	14:30		|	15:30	-
Dwntwn Gilbert	-	10:35	-	|	11:35	-	12:35	-	|	13:35	-	14:35		|	15:35	-
Mesa	-	10:41	-	|	11:41	-	12:41	-	|	13:41	-	14:41		|	15:41	-
Tempe	-	10:49	-	V	11:49	-	12:49	-	V	13:49	-	14:49		V	15:49	-
Sky Harbor	-	10:55	-	11:25	11:55	-	12:55	-	13:25	13:55	-	14:55		15:25	15:55	-
Phoenix	**-**	**11:03**	**-**	**11:33**	**12:03**	**-**	**13:03**	**-**	**13:33**	**14:03**	**-**	**15:03**		**15:33**	**16:03**	**-**
Tolleson	-	-	-	-	12:13	-	-	-	-	14:13	-	-		-	16:13	-
Avondale	-	-	-	-	12:18	-	-	-	-	14:18	-	-		-	16:18	-
Goodyear	-	-	-	-	12:25	-	-	-	-	14:25	-	-		-	16:25	-
Buckeye	-	-	-	-	12:32	-	-	-	-	14:32	-	-		-	16:32	-
Glendale	-	11:14	-	-	-	-	13:14	-	-	-	-	15:14		-	-	-
Peoria	-	11:18	-	11:46	-	-	13:18	-	13:46	-	-	15:18		15:46	-	-
El Mirage	-	11:23	-	-	-	-	13:23	-	-	-	-	15:23		-	-	-
Surprise	-	11:26	-	-	-	-	13:26	-	-	-	-	15:26		-	-	-

PM PEAK SERVICE

Train No.	122	342	222	422	344	124	346	224	348	126	350	226	352	426
Tucson Airport	-	15:35	-	16:02	16:05	-	16:35	-	17:05	-	17:35	-	18:05	18:02
Tucson Amtrak	**-**	**15:41**	**-**	**16:09**	**16:11**	**-**	**16:41**	**-**	**17:11**	**-**	**17:41**	**-**	**18:11**	**18:09**
Marana South	-	15:48	-	-	16:18	-	16:48	-	17:18	-	17:48	-	18:18	-
Marana North	-	15:55	-	16:20	16:25	-	16:55	-	17:25	-	17:55	-	18:25	18:20
Eloy	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coolidge	-	-	-	16:47	-	-	-	-	-	-	-	-	-	18:47
SanTan Valley	16:19	-	16:39	-	-	17:19	-	17:39	-	18:19	-	18:39	-	-
Queen Creek	16:26	-	16:46	17:01	-	17:26	-	17:46	-	18:26	-	18:46	-	19:01
Gilbert South	16:30	-	16:50	|	-	17:30	-	17:50	-	18:30	-	18:50	-	|
Dwntwn Gilbert	16:35	-	16:55	|	-	17:35	-	17:55	-	18:35	-	18:55	-	|
Mesa	16:41	-	17:01	|	-	17:41	-	18:01	-	18:41	-	19:01	-	|
Tempe	16:49	-	17:09	V	-	17:49	-	18:09	-	18:49	-	19:09	-	V
Sky Harbor	16:55	-	17:15	17:25	-	17:55	-	18:15	-	18:55	-	19:15	-	19:25
Phoenix	**17:03**	**-**	**17:23**	**17:33**	**-**	**18:03**	**-**	**18:23**	**-**	**19:03**	**-**	**19:23**	**-**	**19:33**
Tolleson	-	-	17:33	-	-	-	-	18:33	-	-	-	19:33	-	-
Avondale	-	-	17:38	-	-	-	-	18:38	-	-	-	19:38	-	-
Goodyear	-	-	17:45	-	-	-	-	18:45	-	-	-	19:45	-	-
Buckeye	-	-	17:52	-	-	-	-	18:52	-	-	-	19:52	-	-
Glendale	17:14	-	-	-	-	18:14	-	-	-	19:14	-	-	-	-
Peoria	17:18	-	-	17:46	-	18:18	-	-	-	19:18	-	-	-	19:46
El Mirage	17:23	-	-	-	-	18:23	-	-	-	19:23	-	-	-	-
Surprise	17:26	-	-	-	-	18:26	-	-	-	19:26	-	-	-	-

Surprise to Santan Valley

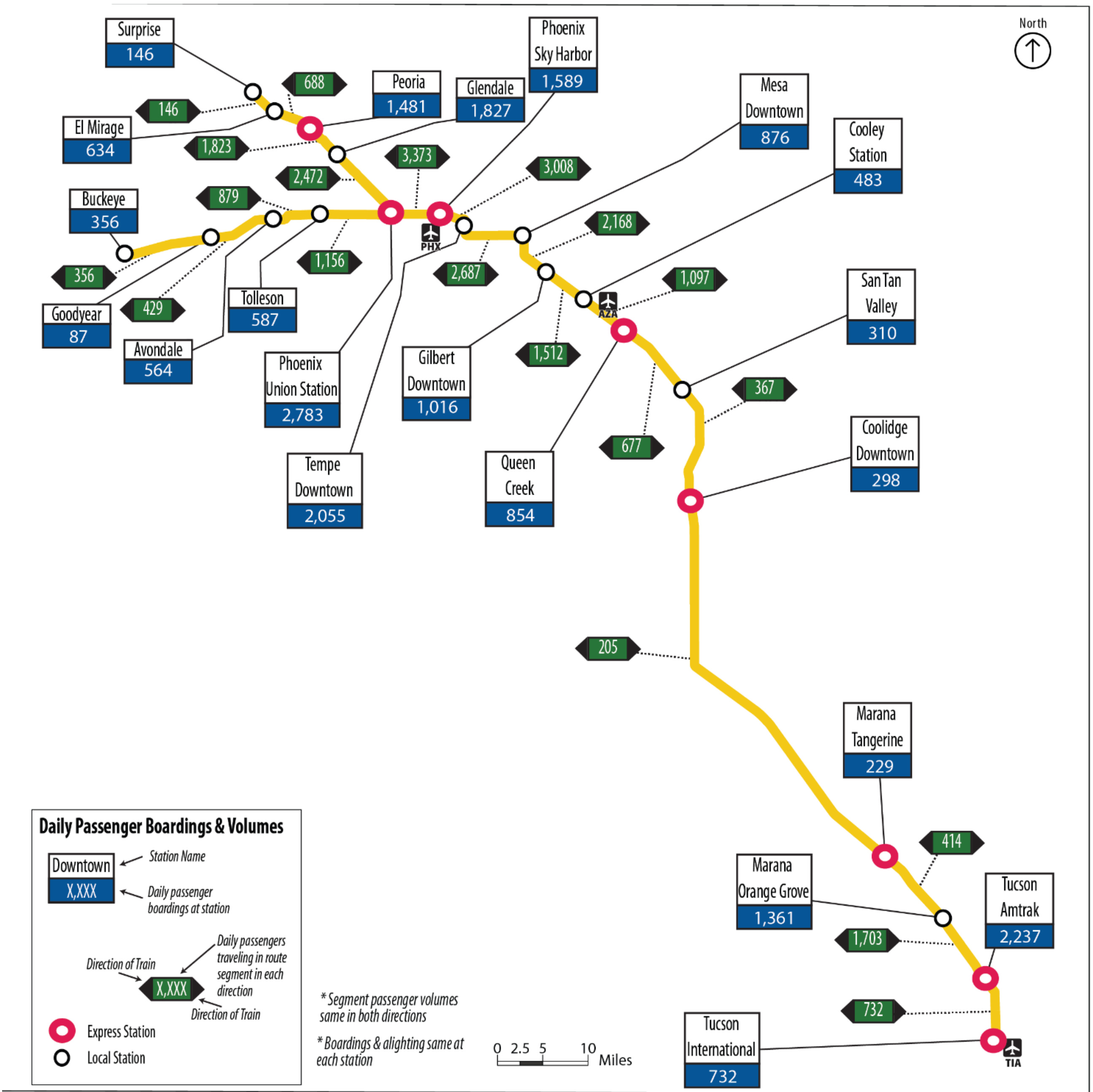
Marana to TIA

Buckeye to Santan Valley

Peoria to TIA (Intercity)

[5] Timetable analysis is conceptual and subject to refinement as more complete information becomes available

Figure 4-6: 2035 Station Boardings and Link Volumes for the Base Service Alternative



5 Planning Methodology

The service planning process included the following:

- Evaluating alternative routes to connect the major population centers within the corridor
- Understanding present freight operations on the Yellow Alternative to determine how to ensure passenger operations do not unduly interfere with freight customers of the current owner of the route, UPRR
- Optimizing operations to minimize infrastructure investment
- Despite primarily separate tracks, coordinating with UP on using the Rail Traffic Controller (RTC) operations simulation model to assess infrastructure needs with different schedule assumptions
- Evaluating general equipment, stations, and maintenance facility requirements based on ridership and schedules
- Estimating infrastructure, equipment, operating and maintenance costs
- Developing and evaluating an implementation strategy including an initial "start-up" service with staged capital investment to permit an early introduction of the new service
- Identifying opportunities for outsourcing some elements of operations and maintenance

5.1 Stakeholder Coordination

Evaluation of Physical Plant

The proposed service uses very little existing track under the assumption that UP would limit joint use of their freight track for passenger service, so existing physical plant cannot be evaluated in the context of passenger operations. On the other hand, new track will allow the service to operate efficiently with tracks built to the requisite tolerances for higher speed rail and, in cases where existing freight track would be relocated to maintain passenger-freight separation, updated freight track could improve UP freight operations.

Amtrak Coordination

ADOT met with Amtrak at the time of the project Kickoff meeting in March 2011. The following assumptions used in its initial analyses were identified with respect to subsequent planning:

- Priority for passenger trains over all freight trains in any location of conflict (incorporated into RTC simulations)
- One hundred percent on-time performance target (assuming that Federal requirements under the Passenger Rail Improvement and Investment Act of 2008 (PRIIA) would be in place)
- Incremental infrastructure improvements including some speed increases on certain route segments
- All at-grade railroad highway crossings upgraded with constant warning times (CWT 22) appropriate for proposed passenger train speeds
- Ridership and revenue forecasts developed using FTA's STOPS model reflecting current population figures, employment forecasts, and recent demographic changes
- Ridership modeling considered service factors including travel times, time of day, frequency of service
- Potential station locations for the proposed services

- Competing modes considered through AZTDM2 congested highway skim travel times

These assumptions are good practice for designing and building a passenger rail service. However, there is currently no section of the preferred alternative used by Amtrak. That could change with the implementation of an improved corridor.

Union Pacific Coordination

Coordination with Union Pacific has been ongoing since the beginning of the project. Because part of the preferred corridor follows the UP Phoenix Subdivision, it was imperative to open a dialogue with the property owner. Multiple meetings have been held since 2011 and the discussions have ranged from sharing track to using UP rights-of-way to applying the UP "Commuter Rail Principles" in defining the characteristics of the corridor. ADOT staff and members of the consultant team have participated in these meetings with UP officials.

UP freight operations have greatly increased along segments of the corridor and UP plans for substantially more growth over the years. In particular, the Sunset Route portion of the proposed line, from Eloy to Tucson, is used for traffic along UP's transcontinental route, which includes high-priority intermodal unit trains daily, typically exceeding 120 cars in length. As a result, the proposed passenger train service has been kept separate from the freight operations with a few exceptions.

The following is a summary of the meetings:

- UP provided the SDP consultant team with data for their lines in the Sunset Route Mainline and the Phoenix Subdivision.
- The detailed track charts included information on locations of double track, passing sidings, type of signal system, year and weight of rail, degree of curves, and the locations of grade crossings and major bridges.
- UP noted its concern with the FRA's latest requirements based on PRIIA-stipulated on-time performance and the consequences on freight operations.
- Freight train interference causing passenger train delay is a key FRA metric, which concerns UP.
- The Sunset Route is UP's most heavily used rail corridor connecting Los Angeles to El Paso. UP plans to further expand the double track to ultimately four tracks. Therefore, the Sunset Route capacity for passenger rail is limited. Other transportation corridors should be considered.
- The UP freight service includes the same route as the potential new passenger services, but the conflicts would be minimized by separating freight and passenger tracks wherever and as much as possible.
- Issues related to liability will need to be resolved. UP prefers not to permit passenger services on its mainline tracks. Should agreement be reached for passenger services, liability compensation and responsibility needs would have to be met. Amtrak would have the right to operate the service under existing agreements.

- Considerable infrastructure improvements will be needed to eliminate potential freight train delays caused by passenger services now and into the future. Separate track, including some upgraded freight track, will help substantially to overcome this concern, but are expensive. Packaging the implementation plan will very likely require a financial partnership in addition to liability concerns.
- If the preferred alternative moves forward and an implementation concept is better defined, schedules will be tested with varying dispatching priorities for the new passenger service given a general UP freight operations freight schedule. For the present alternative, conflict locations have been minimized and schedule matched to minimize delays to passenger services with minimal infringement upon freight operations. The primary potential for conflict is serving UP customers across the passenger rail tracks.
- UP has given the study team input about UP operation, customers and principles for the study team to consider in developing the infrastructure improvements and operating plans.
- Discussion of the potential to use existing freight tracks to introduce basic passenger service that would allow for an earlier implementation step

Based on these factors, along with speed restrictions due to corridor geometry, freight schedules, and travel demand operating concepts can be defined that provide the best service in the corridor.

5.2 Public and Agency Involvement

Public outreach for the APRCS has been extensive and varied. The results have been very positive with a substantial majority of participants strongly favoring the introduction of passenger rail service in the Sun Corridor.

Agencies, nongovernmental groups, and the public were engaged throughout the planning process for the APRCS, as required by federal law and regulation. CEQ's NEPA implementing regulations require agency and public participation in defining and evaluating the impacts of a proposed action and its alternatives (40 CFR §§ 1503.1 and 1506.6). The public involvement, agency and public coordination, the scoping process, public outreach associated with the Alternatives Analysis process, and the public hearings held following the release of the Draft Tier 1 EIS are described in detail in Chapter 3 of the Final Tier 1 EIS and ROD as part of a complementary three-volume study effort (AA, Tier 1 EIS and SDP) developed with FRA and FTA.

6 Demand and Revenue Forecasts

No service exists within the full corridor between Tucson and Phoenix so forecasting reflects ridership potential based on socio-economic, network and service parameters. The preferred alternative demand and revenue projections will be refined prior to a Tier 2 EIS (Project NEPA) being completed. Potential ridership is based on a potential alignment and a proposed level of service. In other words, the number of passengers that can be expected to use the local commuter and express intercity services offered through a rail alternative will be related to their access to the system in terms of population and employment served, where the stations are located to serve that population and employment, how frequently the services run, span of service during the day, how long the trip takes, and the attractiveness of competing modes.

6.1 Potential Ridership

For purposes of this study, potential ridership was forecast using the FTA forecasting tool called Simplified Trips-on-Project Software (STOPS). The tool was designed specifically to estimate ridership on urban fixed guideway systems so its application to an intercity corridor is not within its typical realm of operation and may have an effect on the actual forecasts. The development of STOPS evolved directly from the federal requirement established in the Final Rule on major capital investments, which is to provide a simplified method that project sponsors can use to quantify the measures of “trips-on-project” and changes in VMT that are required as part of AA and EIS documents.

Ridership forecasts were produced using the FTA STOPS tool and socio-economic TAZ data produced by the Arizona statewide AZTDM-2 model. Assumptions included mode of access and catchment areas for station areas (i.e., 3 miles for commuter services and 5 miles for intercity services), as well as maximum speed calculations based on recently developed diesel-electric vehicle technology, route curvature, speed limitations, and segment length between stations. In addition, forecasts utilized revised Arizona State Demographer socio-economic forecasts for the three-county study area.

STOPS model outputs have been prepared for both the Base Alternative and the Alternative Service Plan. They include year 2010 and 2035 estimates for average daily total ridership, local commuter and intercity ridership, ridership breakdown by trip purpose, reduction in automobile VMT and, indirectly, vehicle hours traveled (VHT), greenhouse gas emissions reductions, and safety information including fatality and injury reduction factors. Recognizing the intent of STOPS is for urban fixed guideway systems, the results produced intercity service by STOPS are compared against results generated by CONNECT, which is an FRA tool that produces high level forecasts for intercity travel demand based on connections between metropolitan areas and the ease or complexity of traveling among them. The combination of the two travel forecasts results in a possible range of demand for intercity service. A detailed explanation of the modeled transportation effects of the AA Yellow Alternative, including FTA STOPS documentation, calculation methods, and additional ridership characteristics are included in the Appendix. The travel forecast will continue to be refined over time as the project moves toward implementation.

Daily estimated ridership characteristics of each alternative for 2035 are summarized by route and trip purpose[6] in Table 6-1 and Table 6-2 for the BSP and the ASP (based on the operating plans in Section 4). For purposes of this analysis, trips of less than 50 miles were defined as commuter trips, whereas trips greater than that length were considered intercity trips. The Preferred Alternative has the greater passenger potential for all ridership categories, except for intercity trips of over 50 miles and terminal to terminal trips between the Phoenix and Tucson system hub stations.

Table 6-1— Forecast BSP Ridership – Route Level (2035)

Criteria	*Description*	BSP
Daily Route Level Ridership (FTA STOPS)	**Total ridership of BSP service**	22,000 - 24,000
	Commuter ridership (<50 mile trips)	20,370
	Intercity ridership (>50 mile trips)	2,659
	Home-based-Work ridership	18,015
	Home-based-Other ridership	3,663
	Non-Home-Based ridership	887

Table 6-2 – Forecast ASP Ridership – Route Level (2035)

Criteria	*Description*	ASP
Daily Route Level Ridership (FTA STOPS)	**Total ridership of ASP service**	19,000 - 22,000
	Commuter ridership (<50 mile trips)	17,958
	Intercity ridership (>50 mile trips)	2,520
	Home-based-Work ridership	15,339
	Home-based-Other ridership	3,833
	Non-Home-Based ridership	912

The station to station travel times assumed by the STOPS model for the BSP and ASP are shown in Figures 6.1 and 6.2, respectively.

[6] Trips between home and work or home-based-work (HBW), trips between home and other destinations or home-based-other (HBO), and trips that do not have a tripend at home or non-home-based (NHB)

Figure 6-1: FTA STOPS Stations and Travel Times - Base Service Plan

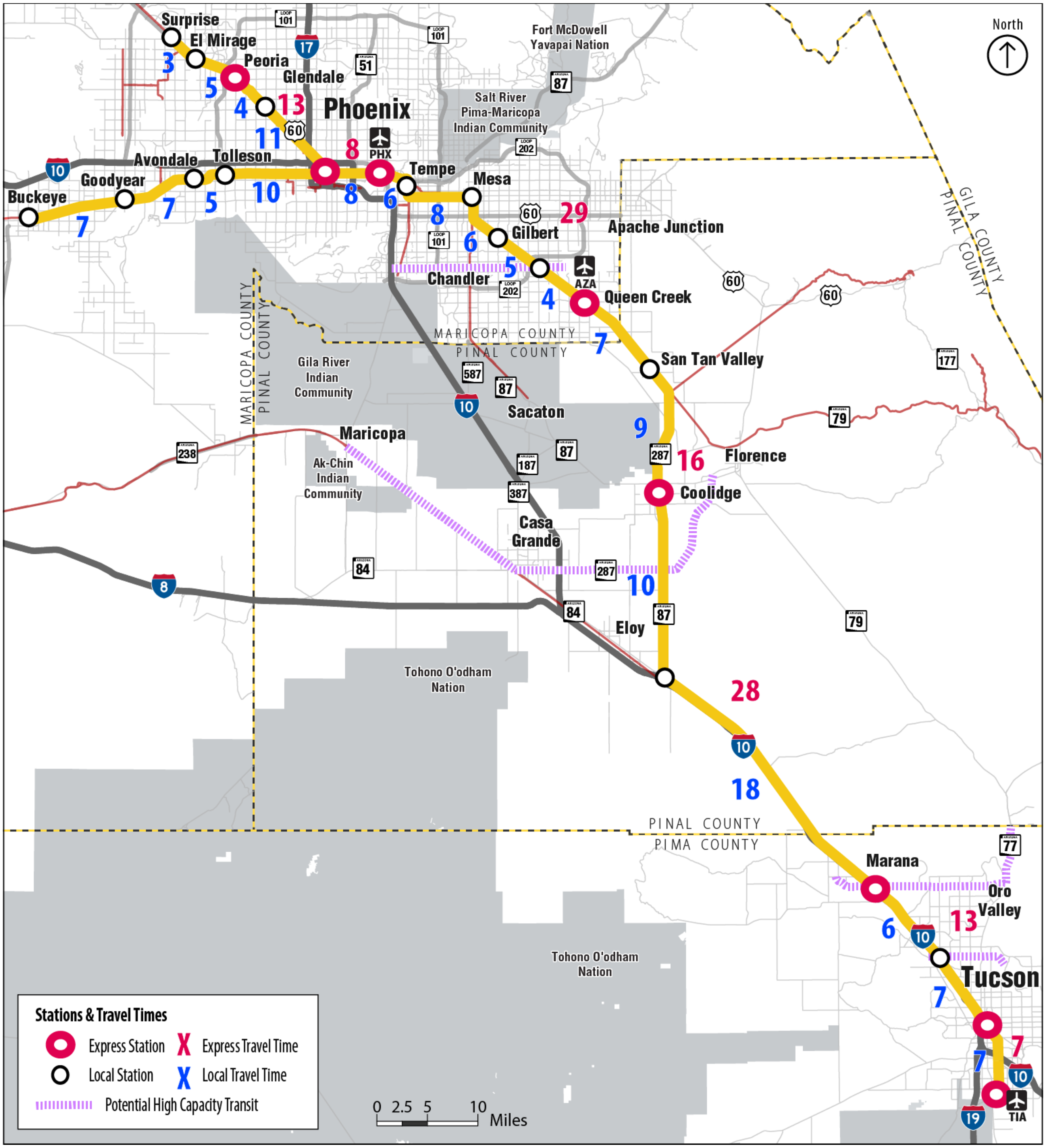
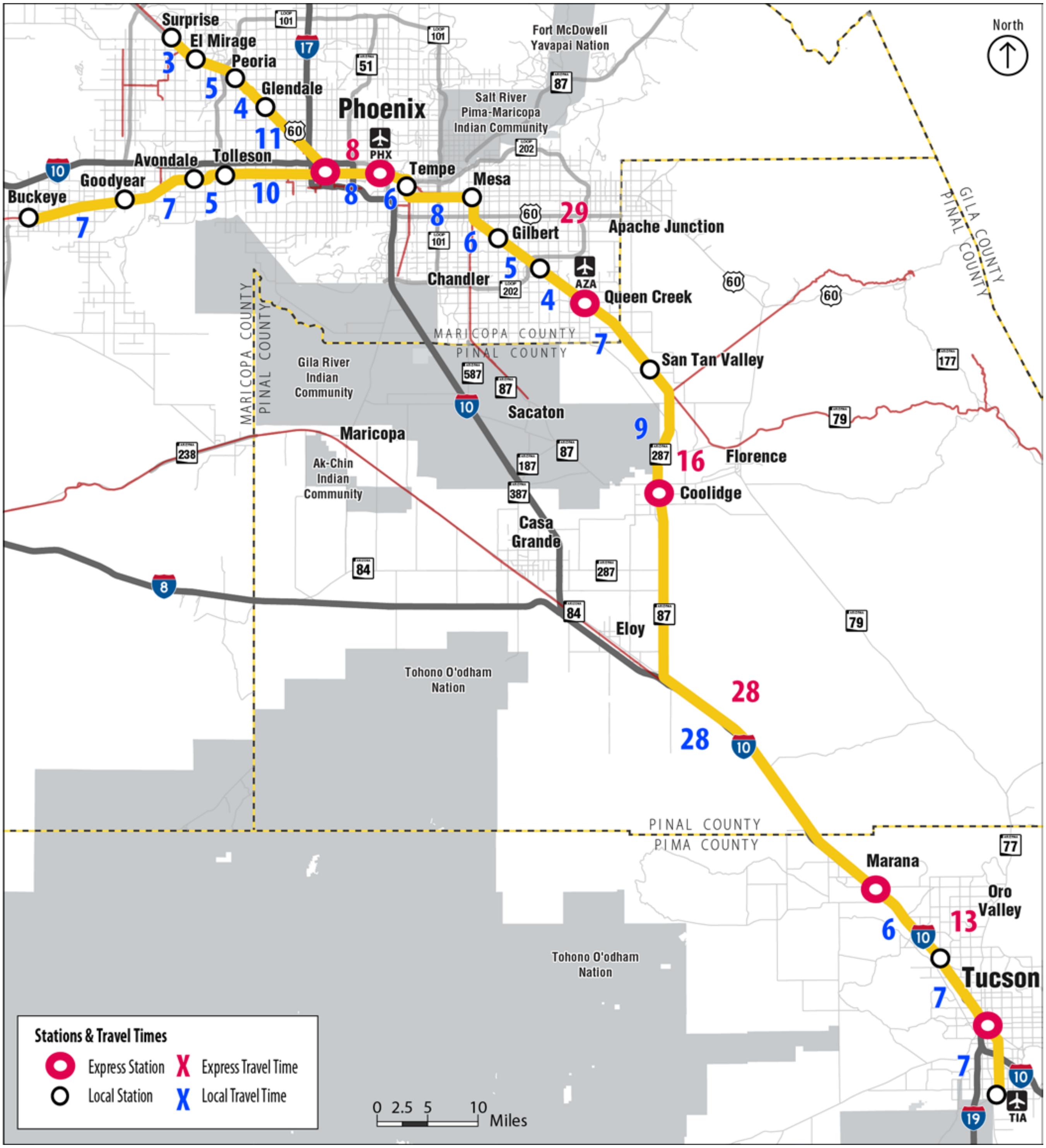


Figure 6-2: FTA STOPS Stations and Travel Times - Alternative Service Plan



6.2 Station Boardings

The demand for service at each of the stations along the proposed route are shown in Table 6-3 for the BSP and Table 6-4 for the ASP.

Table 6-3 – BSP Station 2035 Boardings and Alightings by Station

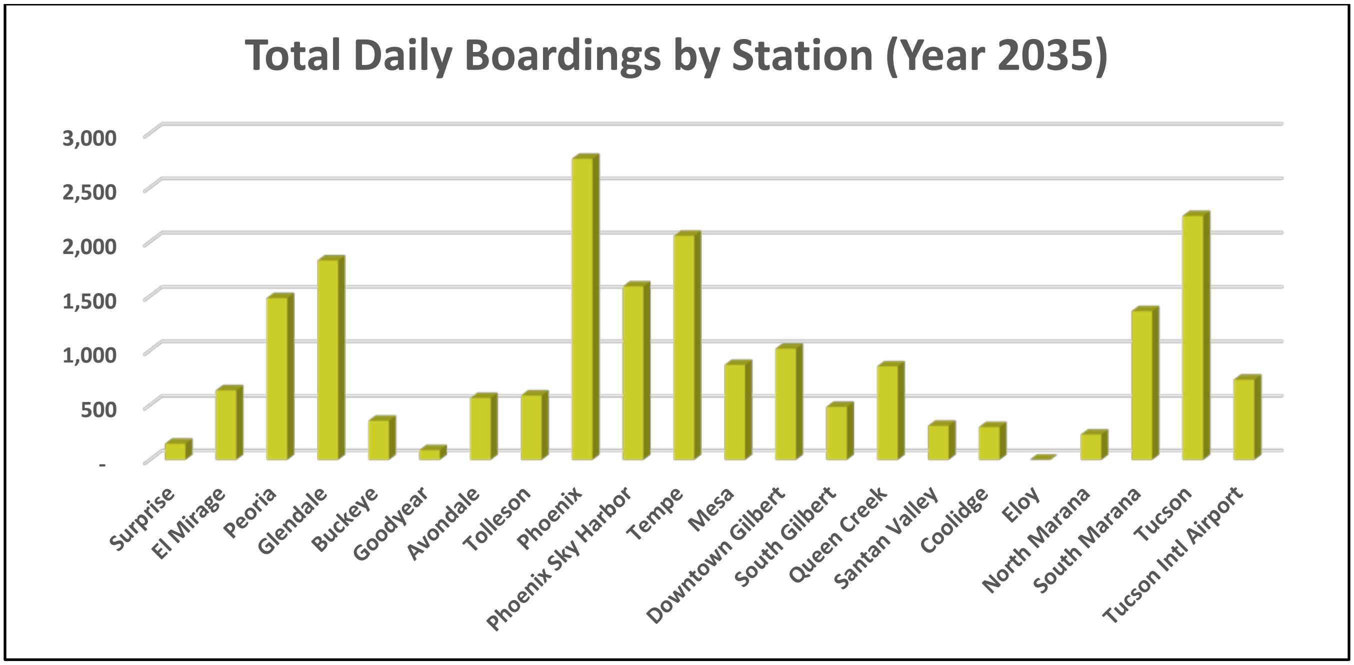
Station	SB Boardings	SB Alightings	SB Volume	NB Boardings	NB Alightings	NB Volume
YUMA WEST BRANCH						
Buckeye	760	0	760	0	760	760
Goodyear	70	0	830	0	70	830
Avondale	160	90	900	90	160	900
GRAND AVE BRANCH						
Surprise	300	0	300	0	300	300
El Mirage	950	10	1,240	10	950	1,240
Peoria	1,070	60	2,250	60	1,070	2,250
Glendale	2,280	880	3,650	880	2,280	3,650
MAINLINE						
Phoenix	1,480	860	5,170	860	1,480	5,170
Phoenix Sky Harbor	870	1,100	4,940	1,100	870	4,940
Tempe	840	1,490	4,290	1,490	840	4,290
Downtown Mesa	220	610	3,900	610	220	3,900
North Gilbert	150	810	3,240	810	150	3,240
South Gilbert	50	530	2,760	530	50	2,760
Queen Creek	0	930	1,830	930	0	1,830
SanTan Valley	10	460	1,380	460	10	1,380
Coolidge	0	10	1,370	10	0	1,370
Eloy	0	10	1,360	10	0	1,360
North Marana	90	20	1,430	20	90	1,430
South Marana	570	190	1,810	190	570	1,810
Downtown Tucson	160	1,650	320	1,650	160	320
TUS	0	320	0	320	0	0

Table 6-4 – ASP Station 2035 Boardings and Alightings by Station

Potential Stations		Surprise	El Mirage	Peoria	Glendale	Buckeye	Goodyear	Avondale	Tolleson	Phoenix	Phoenix Sky Harbor	Tempe	Mesa	Downtwn Gilbert	South Gilbert	Queen Creek	Santan Valley	Coolidge	Eloy (Future)	North Marana	South Marana	Tucson	Tucson Intl Airport	Total	SB/EB Boardings	NB/WB Boardings
Surprise Branch	Surprise	0	46	6	29	0	0	0	0	24	11	27	2	1	0	0	0	0	0	0	0	0	0	146	146	0
	El Mirage	46	0	167	272	0	0	0	0	72	15	35	14	12	1	0	0	0	0	0	0	0	0	634	588	0
	Peoria	6	167	0	288	0	0	0	0	526	215	126	50	16	17	28	15	0	0	5	0	21	1	1481	1307	6
	Glendale	29	272	288	0	0	0	0	0	385	270	331	130	71	24	14	13	0	0	0	0	0	0	1827	1238	301
Buckeye Branch	Buckeye	0	0	0	0	0	7	51	76	103	39	54	4	3	17	1	1	0	0	0	0	0	0	356	356	0
	Goodyear	0	0	0	0	7	0	6	8	39	11	12	2	2	0	0	0	0	0	0	0	0	0	87	80	0
	Avondale	0	0	0	0	51	6	0	71	227	82	50	30	10	7	30	0	0	0	0	0	0	0	564	507	51
	Tolleson	0	0	0	0	76	8	71	0	133	101	132	31	23	2	9	1	0	0	0	0	0	0	587	432	84
Phoenix		24	72	526	385	103	39	227	133	0	233	349	179	190	70	98	37	57	0	2	0	37	2	2763	1252	1376
PHX		11	15	215	270	39	11	82	101	233	0	72	116	163	56	97	32	35	0	1	0	37	3	1589	609	744
Tempe		27	35	126	331	54	12	50	132	349	72	0	135	305	202	139	86	0	0	0	0	0	0	2055	867	1116
Mesa		2	14	50	130	4	2	30	31	179	116	135	0	40	24	78	32	0	0	0	0	0	0	867	174	558
Downtown Gilbert		1	12	16	71	3	2	10	23	190	163	305	40	0	29	120	31	0	0	0	0	0	0	1016	180	796
South Gilbert		0	1	17	24	17	0	7	2	70	56	202	24	29	0	23	11	0	0	0	0	0	0	483	34	420
Queen Creek		0	0	28	14	1	0	30	9	98	97	139	78	120	23	0	51	138	0	0	0	28	0	854	217	614
Santan Valley		0	0	15	13	1	0	0	1	37	32	86	32	31	11	51	0	0	0	0	0	0	0	310	0	259
Coolidge		0	0	0	0	0	0	0	0	57	35	0	0	0	0	138	0	0	0	2	0	61	5	298	63	230
Eloy (Future)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North Marana		0	0	5	0	0	0	0	0	2	1	0	0	0	0	0	0	2	0	0	36	175	8	229	211	10
South Marana		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	1245	80	1361	1245	0
Tucson		0	0	21	0	0	0	0	0	37	37	0	0	0	0	28	0	61	0	175	1245	0	633	2237	0	359
TIA		0	0	1	0	0	0	0	0	2	3	0	0	0	0	0	0	5	0	8	80	633	0	732	633	99
Total		146	634	1481	1827	356	87	564	587	2763	1589	2055	867	1016	483	854	310	298	0	229	1361	2237	732	**20476**	10139	7023
SB/EB Alightings		0	46	173	589	0	7	57	155	1509	977	1188	693	836	449	637	310	230	0	10	36	1604	732	10238		
NB/WB Alightings		100	421	1020	1238	349	74	436	299	1021	540	732	134	151	11	166	0	68	0	183	80	2870	0	9893		

Origin Station to Destination Station MODEL Summary for Scenario 3: Y2035 BUILD
All Purposes All Transit All Access All car HH

Figure 6-3: Total Daily Boardings



6.3 Potential Revenue

Because there is no existing passenger rail service within the corridor, there is no fare history and data to define fare elasticity for service within the corridor. The travel forecasting model used in projecting demand on the proposed service does not afford the opportunity to test the effects of fare levels on ridership except implicitly to the extent they are included in the empirical data upon which the model is formulated. The figures in Table 6-5 are based on information collected for all commuter services that report annual data to the National Transit Data (NTD) that averages to about $7.90 per vehicle revenue mile. This estimate is conservative in that it does not differentiate between types of service (commuter vs. intercity) or trip length. In more detailed analysis, revenue can be modified to represent different fares for intercity and commuter services or distances, which will affect the revenue totals and the fare box recovery.

Table 6-5 – Revenue Forecast for BSP and ASP in 2035

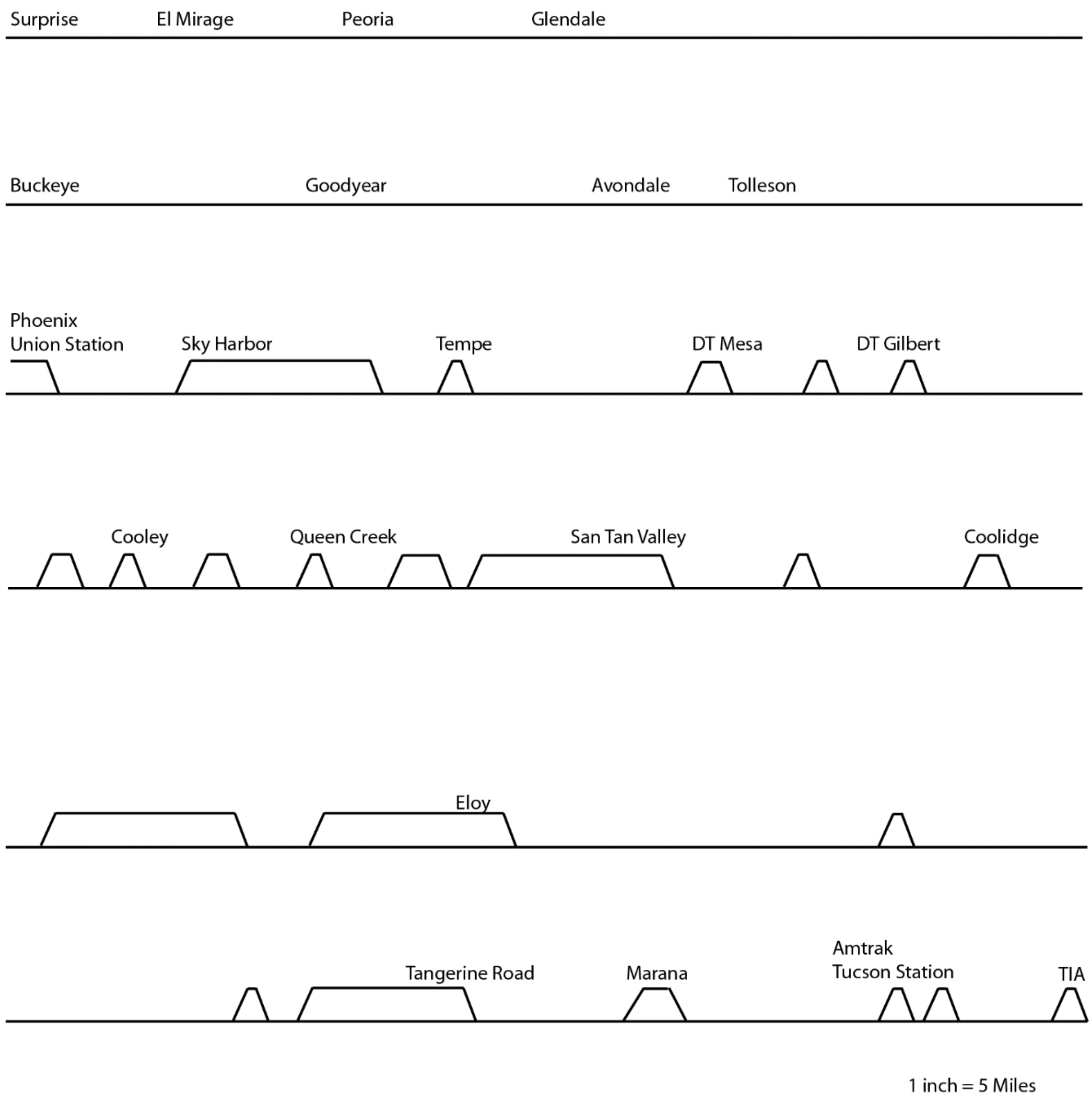
Potential Annual Fare Revenue	Annual Revenue Miles	Annual Revenue	Estimated Fare Box Return
BSP	2,242,656	$15,900,000	24%
ASP	1,794,208	$12,721,000	24%

Note: based on NTD data for all US commuter rail services

7 Infrastructure and Operations Analysis

ADOT conducted operations simulations of alternative new passenger services in the Tucson-Phoenix corridor in cooperation with FRA and UP to evaluate the infrastructure improvements needed to accommodate new passenger rail services. The modeling extended from west of Phoenix in Surprise and Buckeye to Tucson International Airport (TUS) on a primarily independent new passenger track with occasional freight crossovers. The analysis was performed to assess the operation of the proposed passenger service and any potential impacts on UP freight operations. A schematic representation of the model network is shown in Figure 7-1, showing the configuration of the rail network that was evaluated. A series of string line charts were also produced using the Rail Traffic Controller (RTC) simulation model showing the proposed passenger operations under different scheduling scenarios.

Figure 7-1: RTC Rail Operations Simulation Network



7.1 Infrastructure Characteristics

As identified in the operations simulation, several infrastructure and operations issues will need to be addressed in order to establish a reliable passenger rail service within the corridor while avoiding conflicts with UP freight operations at select locations. Federal regulations now require installation of Positive Train Control (PTC) on tracks used for passenger service or carrying certain hazardous materials. UPRR is currently installing PTC on much of the route that would parallel the proposed passenger service.

The following sections summarize the general characteristics of the Preferred Alternative in segments, beginning in Phoenix and moving southward to Tucson. (The segment references are not necessarily sequential because they were developed to cover various routing alternatives.) A segment map is shown in Figure 7-2.

Figure 7-2: Infrastructure Segments

Segment 1: Phoenix Union Station to West of Center Parkway (Tempe)

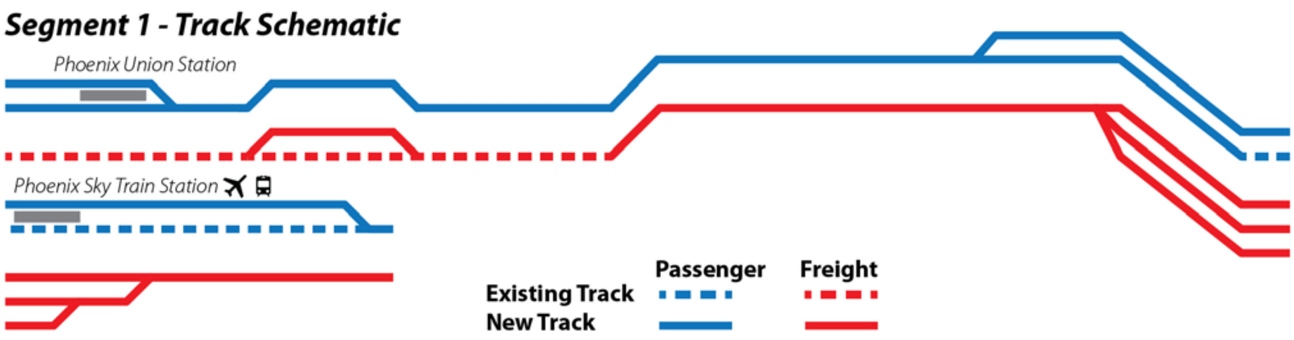
The single track alignment begins at Phoenix Union Station (system hub station)[7] to the east and travel at-grade offset 50 feet north of the existing UP freight track following UP commuter principles. The alignment will continue at-grade for approximately 2.7 miles before crossing 24th Street and turning north, generally following Jefferson and Washington streets in anticipation of the relocation of existing UP track north of PHX Sky Harbor Airport. The alignment will continue parallel to Washington Street for 1.8 miles before arriving at a regional station facility north of the PHX Sky Harbor Airport at the intersection of 38th and Washington Streets. Continuing east from the PHX Sky Harbor Station, the alignment segment will turn south, return to a position offset 50 feet north of existing UP track, and continue at-grade for 2.4 miles.

Within the segment, there are several locations where it is necessary to deviate within the 50 foot offset in order to utilize existing rail underpasses or to avoid impacts to a major landmark property. It will also be necessary to acquire several properties either partially or entirely.

- Alignment: Following UP right-of-way
- Construction: At-grade single track, offset 50 feet from existing track
- Length: 7.4 miles
- Major Structures or Issues:
  - Construction of two station facilities (System Hub and Regional station), with sidings for passing trains
  - Deviations inside of 50 ft offset
    - Chase Field
    - 7th Street underpass
    - 16th Street underpass
    - I-10 underpass
    - SR-143 underpass
    - SR-202L underpass
    - Priest Drive underpass
    - Center Parkway underpass
  - Bridge over 44th Street (200 ft)
  - Twelve (12) at-grade crossings
- Estimated Property Impacts: 5,563,000 square feet

[7] Station typology/hierarchy are discussed in Section 8.1

Figure 7-3: Segment 1 Schematic



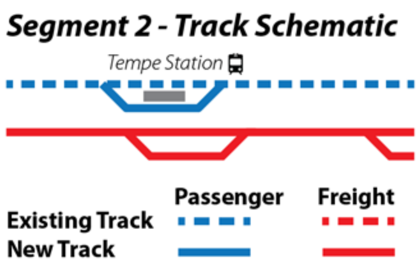
Segment 2: West of Center Parkway to UP Tempe Branch

Beginning to the east of Priest Drive, the alignment will continue east offset 50 feet north of existing UP track. Roughly 1150 feet after passing under Center Parkway, the alignment will turn south, cross existing UP freight track and come to a position west of the existing track prior to crossing under SR-202L. Once south of SR-202L, the alignment will bridge over Tempe Town Lake and Rio Salado Parkway on a new passenger rail bridge before returning to grade, offset 50 feet to the west of existing UP track before 1st Street. From that point, the alignment continues south at-grade for 800 feet before arriving at a local station at 3rd Street (historic rail depot). The alignment segment will then continue south at-grade for another 800 feet until just north of 13th Street.

In addition to several property impacts and deviations within the 50 foot offset from existing track listed below, this segment will require the relocation of roughly 1600 feet of high tension power line within the UP right-of-way between Rio Salado Drive and 13th Street.

- Alignment: Following UP right-of-way
- Construction: At-grade single track, offset 50 ft west of existing track
- Length: 2.1 miles
- Major Structures or Issues:
    - Construction of one station facility (Local Station), with siding for passing trains
    - Bridge over Tempe Town Lake and Rio Salado Parkway (Roughly 1500 ft)
    - Relocation of 1600 feet of high tension power line
    - Deviations inside 50 foot offset
        - Center Parkway underpass
        - SR-202L underpass
        - Track crossing from north of existing track to south (west of Mill Ave)
    - Four (4) at-grade crossings
- Estimated Property Impacts: 545,000 square feet

Figure 7-4: Segment 2 Schematic



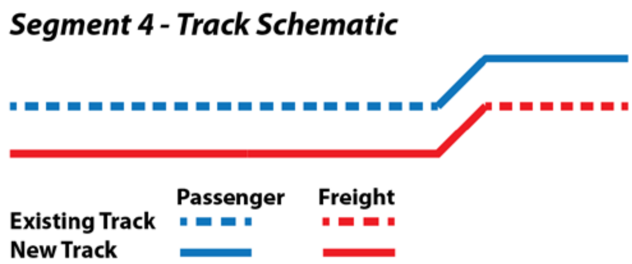
Segment 4: UP Tempe Branch to UP right-of-way and State Route 101L

Just north of 13th Street, the at-grade alignment will turn left and follow a 0.4 mile curve, remaining offset 50 feet from existing track. After crossing Mill Avenue, the alignment segment continues eastward offset 50 feet south of existing UP track for 2.9 miles until crossing SR-101L.

Along this segment of the alignment, new rail bridges will be required over Mill Avenue, McClintock Drive, and SR-101L. There is also one industrial rail spur connecting to a property south of existing track that must be removed, in addition to several property impacts. Of particular note are the potential impacts to historical home properties between Mill Avenue and College Avenue.

- Alignment: Following UP right-of-way
- Construction: At-grade single track, offset 50 feet south of existing track
- Length: 3.2 miles
- Major Structures or Issues:
  - Track crossing UP Tempe Branch (north of 13th Street)
  - New bridge crossing Mill Ave (Roughly 100 ft)
  - New bridge crossing McClintock Dr (Roughly 115 ft)
  - New bridge crossing State Route 101L (Roughly 350 ft)
  - One (1) industrial spur to remove
  - Four (4) at-grade crossings
- Estimated Property Impacts: 1,355,000 square feet

Figure 7-5: Segment 4 Schematic



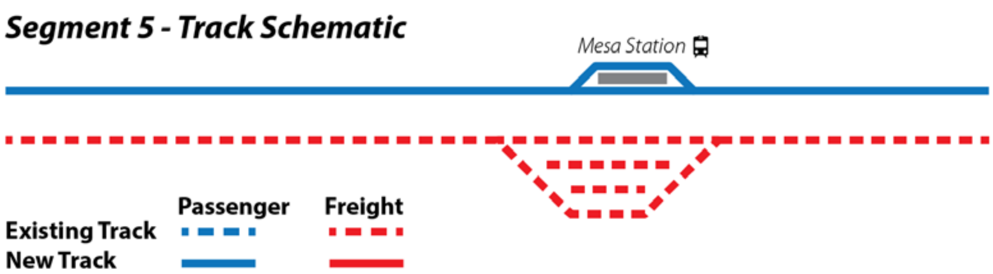
Segment 5: UP right-of-way and State Route 101L to UP right-of-way and US 60

Beginning just east of SR-101L, the alignment continues at-grade for 3 miles, offset 50 feet south of existing UP track, until arriving at a station after bridging over Country Club Drive. The alignment will depart the station and continue east offset south of existing track for 0.25 miles until crossing McDonald Road. After crossing McDonald Road, the alignment will curve south, crossing Broadway Road, offset 50 feet to the west of existing track and west of Center Street, for 1.6 miles. This alignment segment terminates just north of the US 60 rail tunnel.

Within this segment, new rail bridges will be required over the Tempe Canal and Country Club Road. There is also one industrial spur to be removed and an existing four-track freight switching and storage area between Extension Road and McDonald Street that may need to be reconfigured in order to accommodate a station siding to allow passing trains. Property impact totals are listed below.

- Alignment: Following UP right-of-way
- Construction: At-grade single track, offset 50 feet south and west of existing track
- Length: At-Grade: 4.9 miles
- Major Structures or Issues:
    - Construction of one station facility (Local Station), with siding for passing trains
    - New bridge crossing Tempe Canal (Roughly 60 ft)
    - New bridge crossing Country Club Drive (Roughly 100 ft)
    - Four track switching yard (between Extension Road and McDonald Street)
    - One (1) industrial spur to remove
    - Eight (8) at-grade crossings
- Estimated Property Impacts: 2,576,000 square feet

Figure 7-6: Segment 5 Schematic



Segment 7: UP right-of-way and US 60 to Superior Rail Road Spur

Beginning just north of US 60, the alignment passes under the freeway and continues for 0.25 miles before the existing UP track splits, separating the UP Chandler Branch from the UP Southeast Branch. The alignment will turn southeastward, cross the UP Chandler Branch, and continue offset 50 feet to the southwest of existing UP track for 3.2 miles before arriving at a local station facility northwest of Gilbert Road. Leaving the station, the alignment will continue offset from existing track for 3.5 miles, bridging over two canals, Santan Village Parkway, and SR-202L. After crossing the freeway, the alignment continues offset from existing track for 1.25 miles before crossing Higley Road and arriving at another local station. Departing the station, the alignment crosses Williams Field Road and continues offset from existing track for 5.9 miles, bridging over a canal and South Ellsworth Loop before arriving at a regional station between South Ellsworth Loop and Ellsworth Road. The alignment continues southeastwardly from the station at grade for 3.0 miles before bridging the Queen Creek Wash. Once spanning the wash, the alignment will continue for 6 miles and arrive at another local station facility at Bella Vista Road. From that point, the alignment will continue for 2.6 miles before meeting the Superior rail spur.

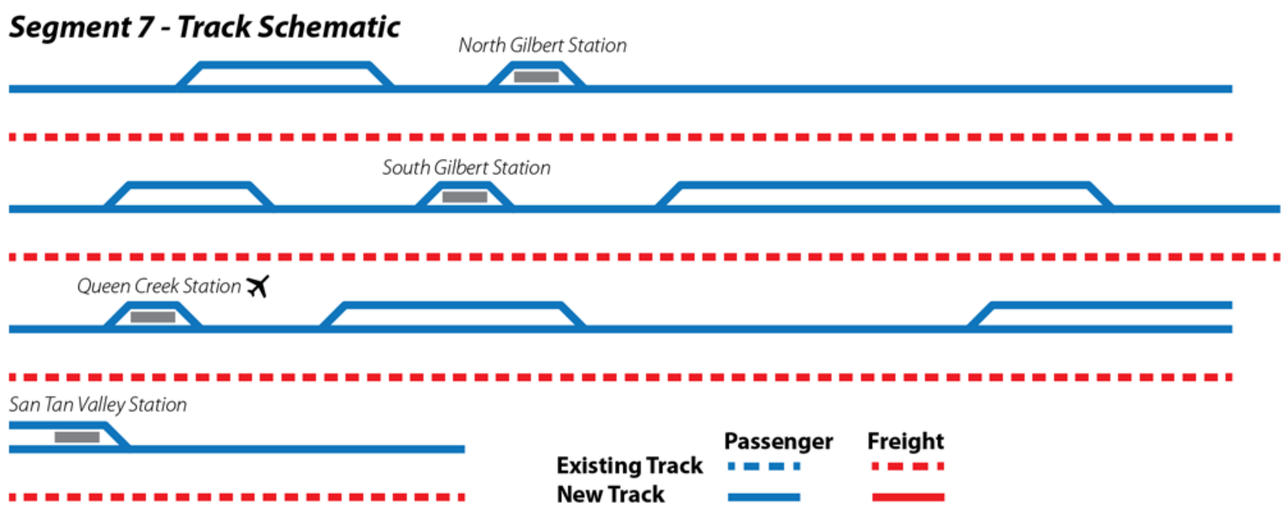
This alignment segment requires deviations within the 50 foot offset from existing track at the US 60 underpass, crossing of the UP Chandler Branch, and in avoidance of the water treatment plant west of Nealy Street. Property impact totals are listed below. However, it should be noted that all impacts to property within the segment are northwest of SR-202L within the Town of Gilbert.

- Alignment: Following UP right-of-way
- Construction: At-grade single track, offset 50 feet southwest of existing track
- Length: At-Grade: 26.1 miles
- Major Structures or Issues:
    - Construction of four station facilities (1 Regional, 3 Local) , with sidings for passing trains
    - Deviations inside of 50 foot offset
        - US 60 underpass
        - Track crossing UP Chandler Branch (north of Baseline Rd)
        - Water treatment plant west of Nealy St
    - New Bridge over Santan Village Pkwy

- o New Bridge over SR-202L
- o New Bridge over Ellsworth Loop
- o New Bridge over Queen Creek Wash
- o Three (3) canal bridges
- o Two (2) industrial spurs
- o Nineteen (19) at-grade crossings

- Estimated Property Impacts: 1,281,000 square feet

Figure 7-7: Segment 7 Schematic



Segment 9: Superior Rail Road Spur to I-10 West Bound Frontage Road

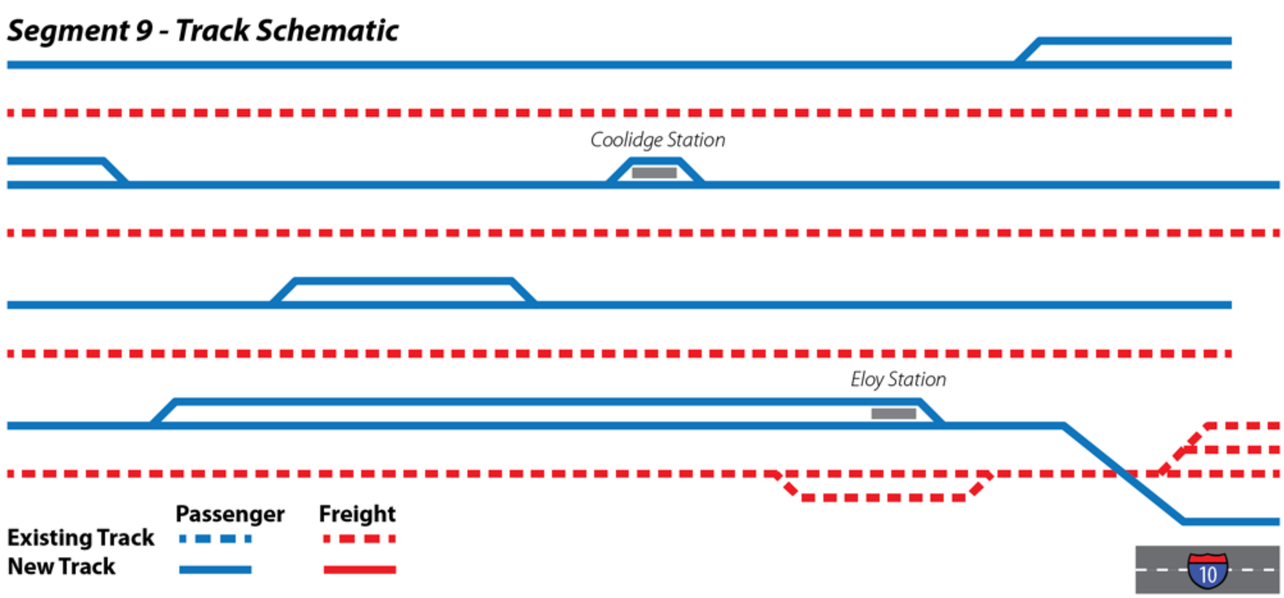
From the rail intersection with the UP Southeast Branch and Superior rail spur, the alignment will travel south; offset 50 feet to the west of existing UP track. The alignment will continue south for 11.1 miles, bridging over the Gila River and a canal before crossing Central Avenue and arriving at a regional station in the City of Coolidge. Departing the station, the alignment continues south offset to the west of existing track for 16 miles, crossing four (4) additional canals and Milligan Road before arriving at another station facility at Milligan Road southeast of central Eloy. After leaving the station, the alignment will enter a roughly 1.0 mile long curve, including an approximately 1,700 foot viaduct, to transition the passenger rail alignment from the west of the UP Phoenix Subdivision, over UP Sunset Route tracks, and return to at-grade construction aligned with the I-10 westbound frontage road southeast of the I-10 and SR-87 interchange.

Within the segment, the passenger rail alignment will require six rail bridges to span the Gila River and canals, the widening of the SR-287 underpass north of downtown Coolidge, the viaduct structure to transition the alignment to the westbound I-10 frontage road, and six impacts to property.

- Alignment: Following UP right-of-way

- Construction: At-grade single track, offset 50 feet west of existing track
- Length: At-Grade: 28.9 miles
- Major Structures or Issues:
    - Construction of two (2) station facilities(one Local Station, one Regional Station), with sidings for passing trains
    - Gila River Crossing (3,300 ft long x 60 ft wide)
    - Widening of SR-287 underpass
    - Bridge over UP Sunset Route Mainline tracks (1,700 ft)
    - Five (5) canal bridges (50 ft each)
    - One (1) industrial rail spur to remove
    - Twenty one (21) at-grade crossings
- Estimated Property Impacts: 809,000 square feet

Figure 7-8: Segment 9 Schematic



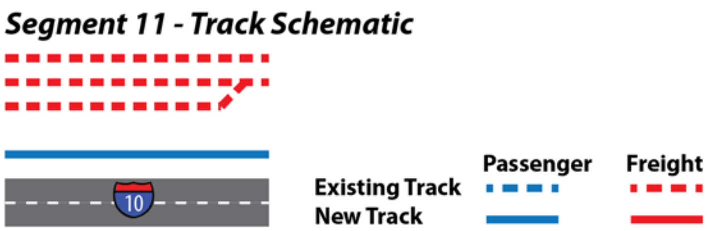
Segment 11: I-10 West Bound Frontage Road to North-South Freeway Corridor

Beginning along the I-10 westbound frontage road southeast of the I-10 and SR-87 interchange, the alignment continues along the westbound frontage road for 3.2 miles. At that point the segment terminates at a location where the frontage road intersects with the most likely recommended alternative of the North-South Freeway Study. The segment will require one bridge over the Picacho westbound exit ramp.

- Alignment: Aligned with I-10 westbound frontage road
- Construction: At-grade single track

- Length: At-Grade: 3.2 miles
- Major Structures or Issues:
    - Bridge over Picacho westbound I-10 exit ramp

Figure 7-9: Segment 11 Schematic



Segment 12: North-South Corridor to Tucson Historic Depot

From the intersection of the I-10 westbound frontage road and the most likely recommended alternative of the North-South Corridor Study, the alignment remains at-grade generally aligned with the westbound frontage road for approximately 42.1 miles until just after Grant Road in Tucson. Along this section, the alignment will arrive and depart from two local stations at Tangerine Road and Orange Grove Road. After crossing Grant Road, the alignment follows the UP right-of-way southeastward, but remains offset 50 feet to the west of existing freight track for 1.9 miles until reaching a system hub station at the existing Tucson Historic Depot building.

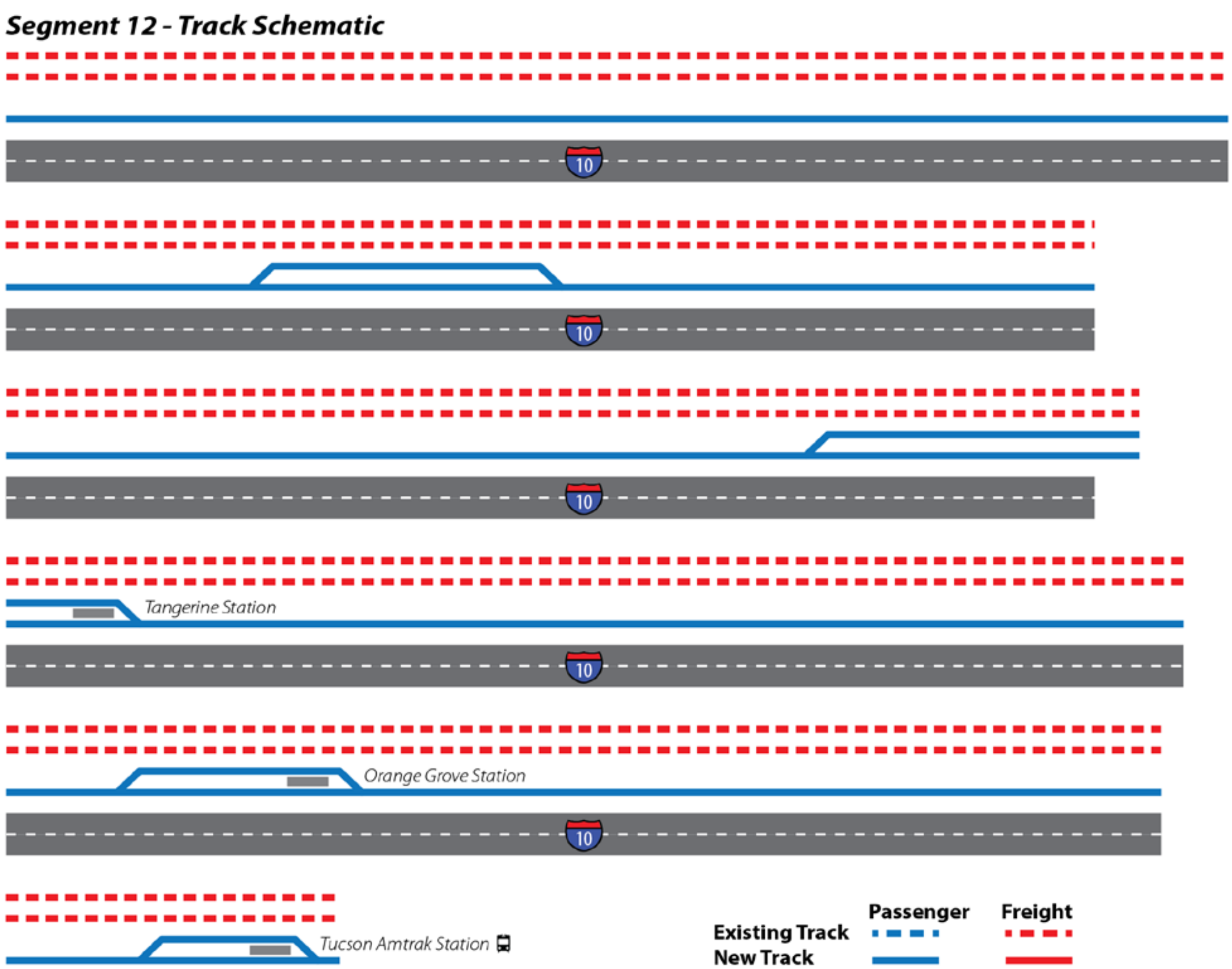
Within the alignment segment, there are ten existing or proposed interchanges (part of planned Interstate 10 improvements). The complicated configuration of freeway through lanes, adjacent frontage roads and freight rail tracks, as well as right-of-way limitations; requires structures to negotiate each of the ten intersection crossings. The proposed structures allow for specific passenger rail design specifications, while accommodating existing UP rail tracks and frontage roads, and not overly infringing on the Interstate 10 freeway. Each structure will need to be approximately 2000 feet long to carry crossroads over the freeway and railroad tracks, include 15 foot high retaining walls, and include the reconstruction of all westbound ramps. The North-South Corridor Study improvements would partly accommodate a future passenger rail track by incorporating the requisite space within the bridge structure for its construction.

This specific segment of the alignment will also require the construction of six new rail bridges for the passenger rail to span two washes and four crossroads, the widening of existing grade separations at Speedway Boulevard and Stone Avenue, five new roadway bridges for property access drives, and several impacts to property.

- Alignment: Aligned with I-10 westbound frontage road, following UP right-of-way after Grant Road.
- Construction: At-grade single track
- Length: 44 miles
- Major Structures or Issues:
    - Construction of (3) station facilities (2 local, 1 system hub), with sidings for passing trains
    - Ten (10) 2000 Foot “tunnel” structures spanning I-10 interchanges

    - 15 foot high retaining walls
    - Reconstructing westbound I-10 on and off ramps
  - Widening of grade separation over Speedway Blvd.
  - Widening of grade separation over Stone Ave.
  - Two (2) bridges over washes (350 ft each)
  - Four (4) bridges over crossroads (200 ft each)
  - Five (5) bridges for property access drives (100 ft each)
  - Four (4) at-grade crossings
- Estimated Property Impacts: 68,000 square feet

Figure 7-10: Segment 12 Schematic



Segment 13: Tucson Historic Depot Station to Tucson International Airport

Beginning at the Tucson Historic Depot Station system hub station, the alignment will continue southeastward offset 50 feet southwest from the UP Sunset Route for 2200 feet. At that point the alignment will turn south, bridge over Toole Avenue, and continue south for 6.4 miles, offset 50 feet to the west of the existing UP Nogales branch, before arriving at an end of line station west of the Tucson International Airport.

The segment will require a deviation inside the 50 foot offset at the existing grade separation over Broadway Boulevard, a bridge over Toole Avenue, one canal bridge, two bridges over washes, and 60 impacts to property.

- Alignment: Following UP right-of-way
- Construction: At-grade single track
- Length: 6.9 miles
- Major Structures or Issues:
    - Construction of one (1) station facility (end of line)
    - Deviation inside of 50 foot offset
        - Grade separation over Broadway Blvd.
    - One (1) industrial rail spur to remove
    - Six (6) at-grade crossings
    - Bridge over Toole Ave (200 ft)
    - (1) canal bridges (50 ft each)
    - (2) bridge over wash (100 ft)
- Estimated Property Impacts: 1,022,000 square feet

Figure 7-11: Segment 13 Schematic

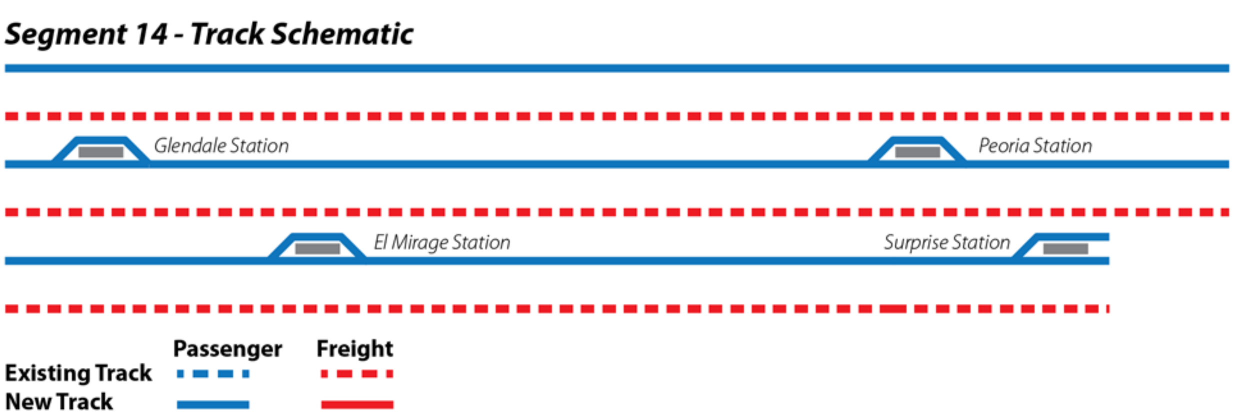
Segment 14: Phoenix Union Station to Surprise

The single track alignment begins at Phoenix Union Station (system hub station) and travels to the west at-grade offset 50 feet north of the existing UP freight track following UP commuter principles. The alignment will continue west, passing under 7th Avenue, for roughly one mile. In the vicinity of 18th Avenue, the alignment will curve northward following BNSF track, crossing 19th Avenue and continue northward for 1.43 miles, situated 50 feet east of existing BNSF track and west of 19th Avenue. After crossing McDowell Road, the route will curve to the northwest and continue in an alignment northeast of existing BNSF track and southwest of US 60. The route continues in this alignment for roughly 6.9 miles before arriving at a local station just east of 59th Avenue in Glendale. After leaving the station, the route will continue for roughly 2.5 miles before passing under eastbound US 60 and bridging over westbound US 60, to transition to an alignment northeast and parallel to US 60. The route then continues in this position for another 9.4 miles, arriving and departing from two local stations near Peoria Avenue and Thunderbird Road, before arriving at an end-of-line station near Bell Road in Surprise.

This specific segment of the alignment will also require the construction of six new rail bridges for the passenger rail to span one wash and one canal, the New and Aqua Fria Rivers, 7th Avenue, and the SR-101L freeway. This segment will also require deviations inside of the 50 foot offset within the I-17 overpass, near the Northern Avenue interchange, and within the US 60 overpass.

- Alignment: Following BNSF right-of-way
- Construction: At-grade single track
- Length: 21.6 miles
- Major Structures or Issues:
    - Construction of four (4) station facilities (3 local, 1 end of line), with sidings for passing trains
    - Deviation inside of 50 foot offset
        - I-17 overpass
        - Northern Ave interchange
        - US 60 overpass
    - Ten (10) industrial rail spurs to be reconfigured
    - Thirty seven (37) at-grade crossings
    - Bridge over 7th Ave (50 ft)
    - Bridge over SR-101L Aqua Fria (350 ft)
    - One (1) canal bridge (50 ft)
    - Bridge over New River (400 ft)
    - Bridge over Aqua Fria River (500 ft)
    - One (1) bridge over wash (150 ft)

Figure 7-12: Segment 14 Schematic



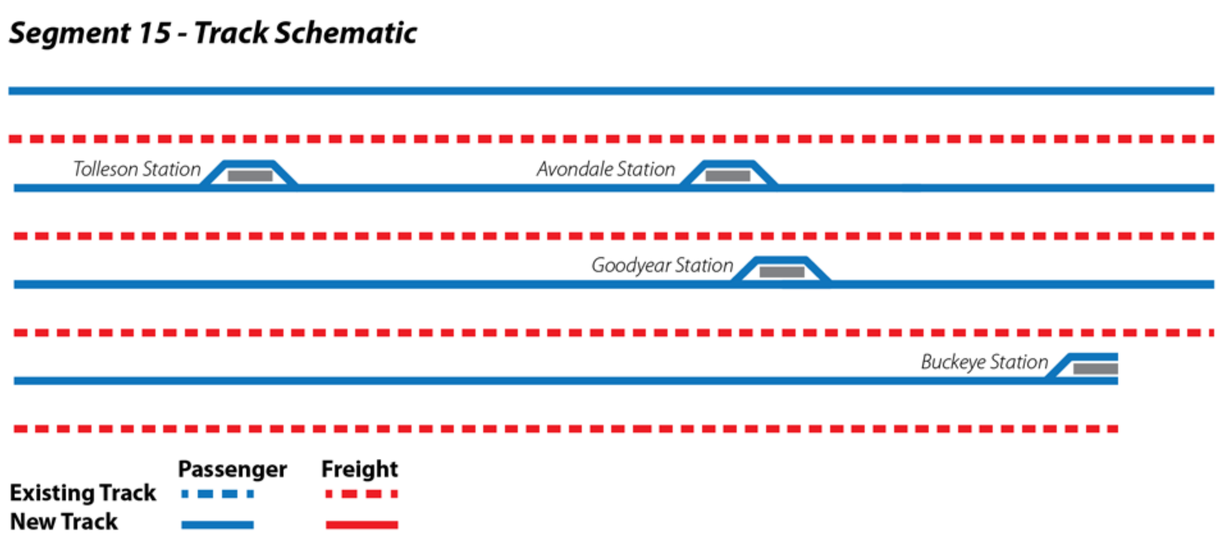
Segment 15: Phoenix Union Station to Buckeye

The single track alignment begins at Phoenix Union Station (system hub station) and travels to the west at-grade offset 50 feet north of the existing UP freight track following UP commuter principles. The alignment will continue west, passing under 7th Avenue, bridging over 17th Avenue and I-17, and continuing for roughly 10.1 miles before arriving at a local station in Tolleson. The route then continues, offset 50 feet north of existing UP track, for 20.4 miles, arriving and departing from two additional local stations before arriving at an end-of-line station in Buckeye.

This specific extension will also require the construction of six additional new rail bridges for the passenger rail to span one wash and four canals, and the Aqua Fria River. This segment will also create 35 new at-grade crossings, and impact 24 individual industrial rail spurs, which will be reconfigured.

- Alignment: Following UP right-of-way
- Construction: At-grade single track
- Length: 30.5 miles
- Major Structures or Issues:
    - Construction of four (4) station facilities (3 local, 1 end of line), with sidings for passing trains
    - Twenty-four (24) industrial rail spurs to be reconfigured
    - Thirty-five (35) at-grade crossings
    - Four (4) canal bridge (50 ft)
    - Bridge over I-17
    - Bridge over 17th Avenue
    - Bridge over Aqua Fria River (1,000 ft)
    - One (1) bridge over wash (100 ft)

Figure 7-13: Segment 15 Schematic



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7.2 Operations Analysis

Along with the operating plan, using the Rail Traffic Controller (RTC) simulation model with a detailed representation of the UP subdivision configurations including permitted speeds, speeds through turnouts, grades, and curves, passing siding locations and lengths, signal spacing, and yard layout, the model produced an anticipated operations performance for each of the operating plans tested. The most efficient alternative in terms of cost and service level is recommended as the basis for long term planning and analysis. This option will also serve as the basis for implementation phasing according to demand for service and funding availability.

Network Improvements

Using the RTC model, the project team examined several track arrangements to determine the best passenger operation with the least impact on freight train operations. This iterative approach eventually produced a track configuration that included infrastructure improvements that maximize passenger train service levels while minimizing the effect on freight rail schedules. No adjustments to the freight operations were considered such as minor changes in train departure times to minimize freight/passenger conflicts. A governing assumption, imposed by UP, was that the present freight operation must be operated with no added delays.

Base Operating Plan

The RTC operations simulation model results developed by the project team were provided to ADOT. The material included “stringline” charts graphically describing passenger operations for both commuter and intercity services in the Tucson-Phoenix corridor. Figure 7-14 shows the base operating alternative that is taken from the AA as discussed in Section 4. All BSP service has access to all station locations along the corridor. Commuter trains stop at all stations and intercity trains only at designated express stations.

Figure 7-14: Base Service Plan (BSP)

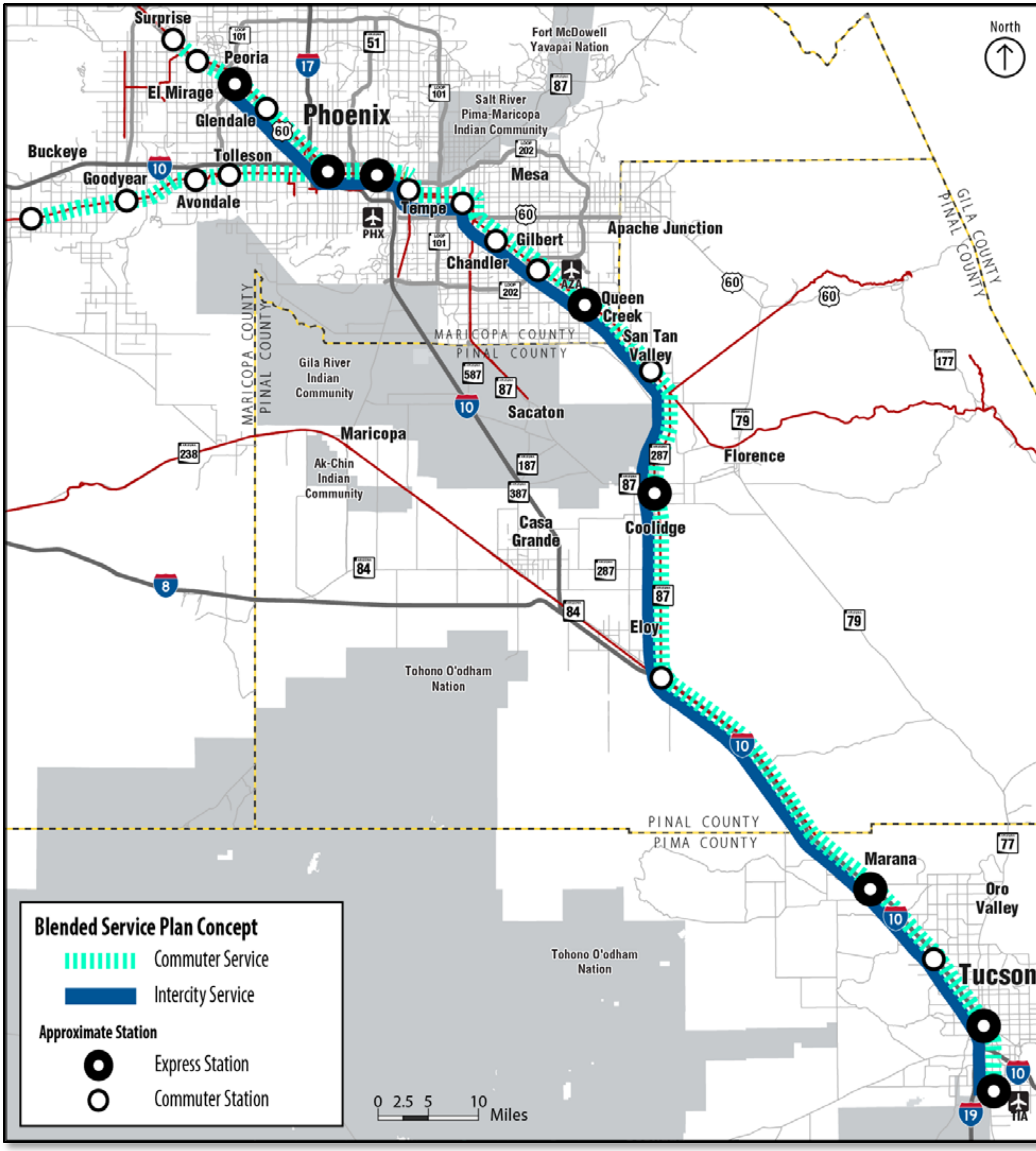


Figure 7-15 is the associated stringline chart that reflects rail operations for a typical day using a ratio of two commuter trains (red lines) to one intercity train (blue lines) hourly per direction during peak periods. (Note that the times shown along the bottom of the chart are on a 24 hour clock.)

A total of 221 miles of new track, including 29.24 miles of added double/passing tracks, are proposed at an estimated construction cost of $1,426 million (in 2015 dollars) including all earthwork, structures and turnouts.

The double track improvements outlined above were developed by analyzing the operational conflicts identified by the stringline diagram (indicated where lines cross) and reflect passenger trains conflicting with each other. Because the passenger track operates separately from the freight track, conflicts with freight trains only exist at a handful of UP customer cross-over locations and are not shown in the stringline diagrams.

Alternative Operating Plan

As described in Section 4, the ASP provides commuter service only within the two major urban areas of Tucson and Phoenix. Intercity service spans the entire length of the corridor. Using the results of ridership forecasting, a revised operating plan was developed that takes advantage of anticipated ridership loads within the corridor. High ridership stations such as the Phoenix and Tucson hubs, major airport access locations and well-defined urban centers such as Tempe and Mesa, provided the strongest rationale for service. Other stations used in the analysis were included within the commuter sheds based on a minimum ridership or geographic coverage. Stations such as Gilbert and Santan Valley attract relatively high ridership, while Coolidge ridership is lower but located in the critical middle of the corridor and a likely location of a future maintenance and storage facility. Low ridership locations were addressed as emerging stations with limited or no service or served only to establish access and connectivity within key corridor segments that would otherwise not be served.

The alternative operating plan tested based on ridership results included commuter service between the West Valley (Buckeye and Surprise) and Santan Valley and between Tucson and TUS, both operating two times hourly per direction during the peak periods, with intercity service operating six times a day per direction between Peoria and TUS. The operating configuration is as shown in Figure 7-16.

Figure 7-15: Stringline Chart for BSP (AA Yellow Alternative)

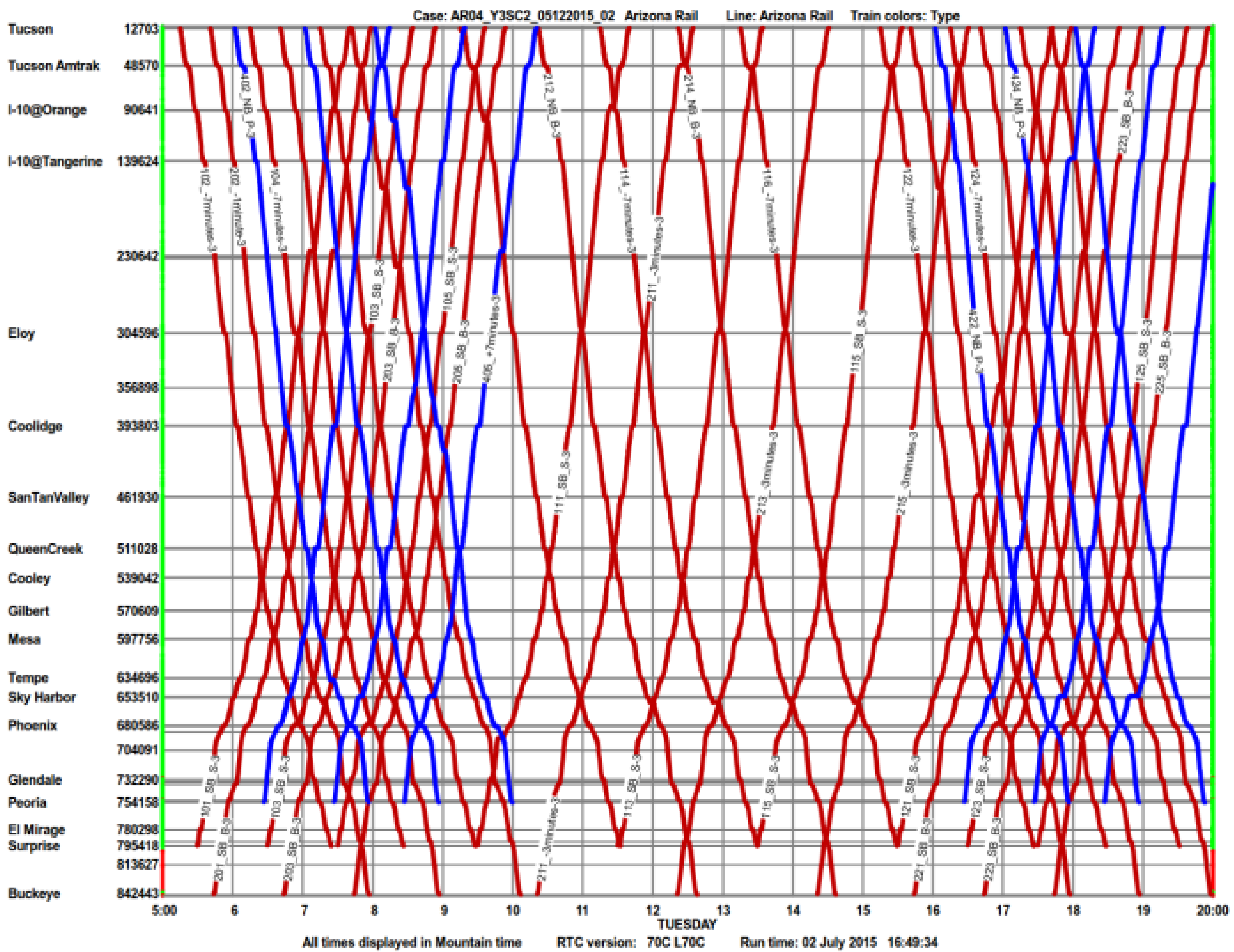
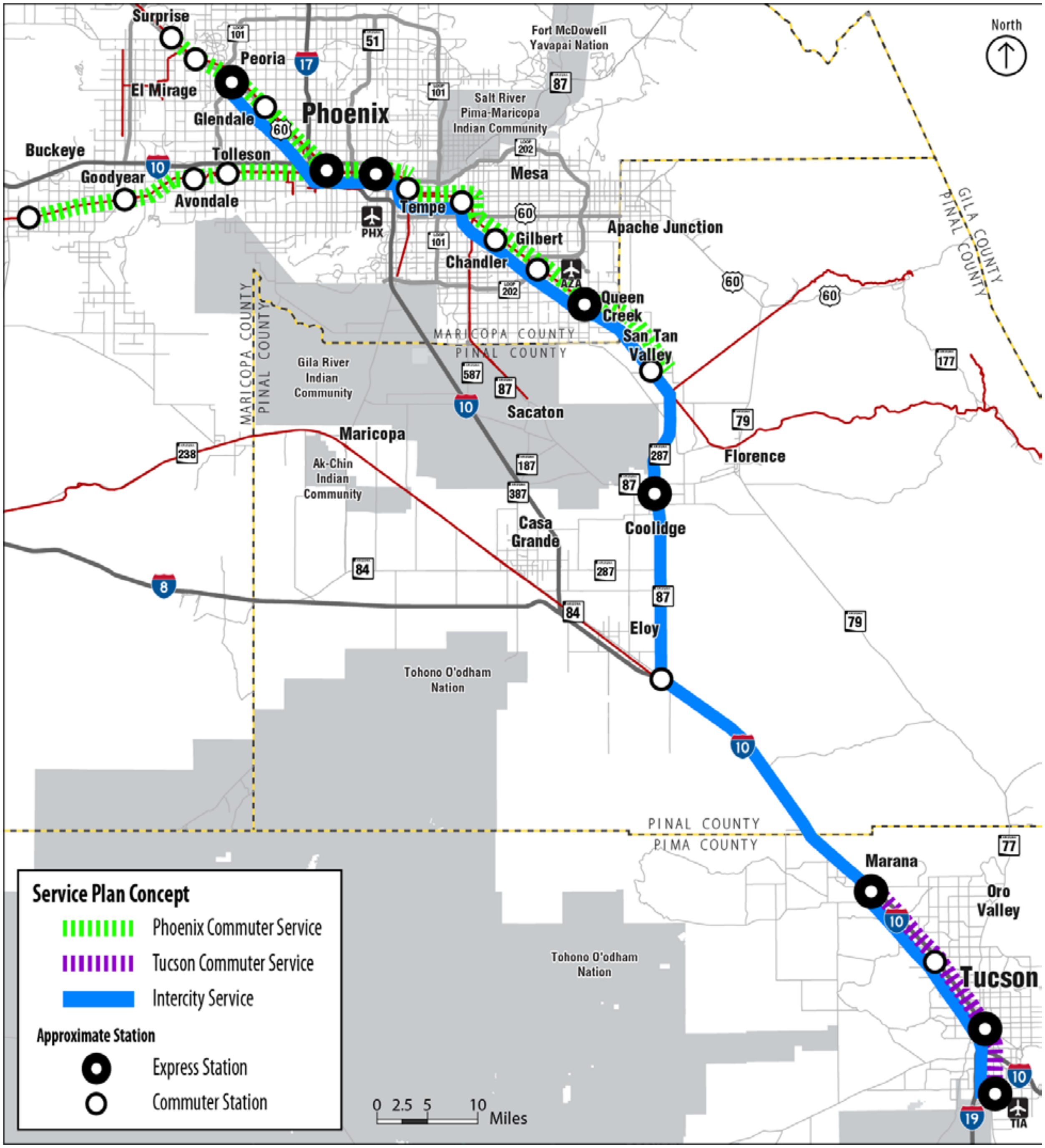


Figure 7-16: ASP Operating Concept



The operational performance for the alternative operating plan is shown in the stringline graphs of Figure 7-17, Figure 7-18, and Figure 7-19.

Figure 7-17: Stringline Chart for ASP Operating Plan (Tucson to Phoenix)

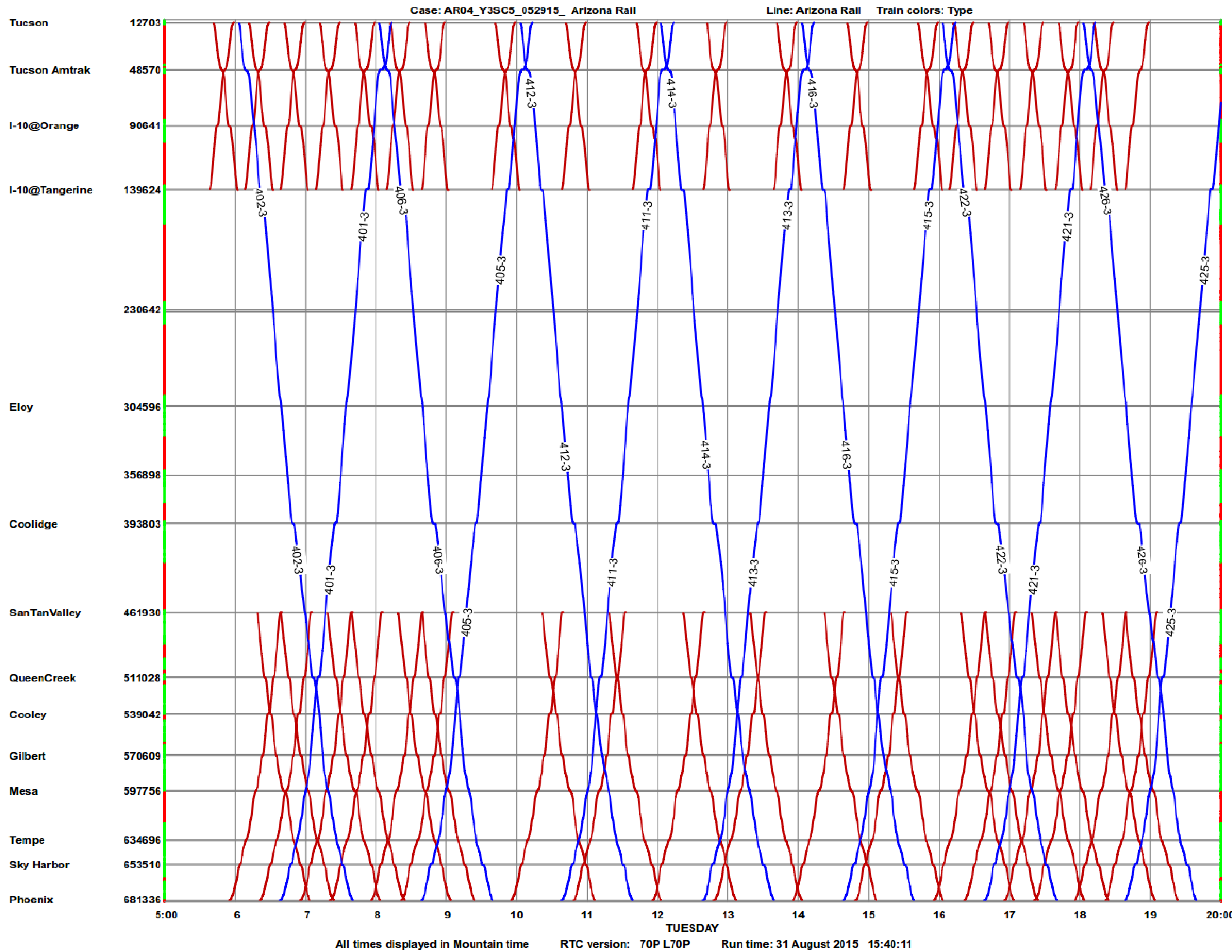


Figure 7-18: Stringline Chart for ASP Extension from Phoenix to Surprise

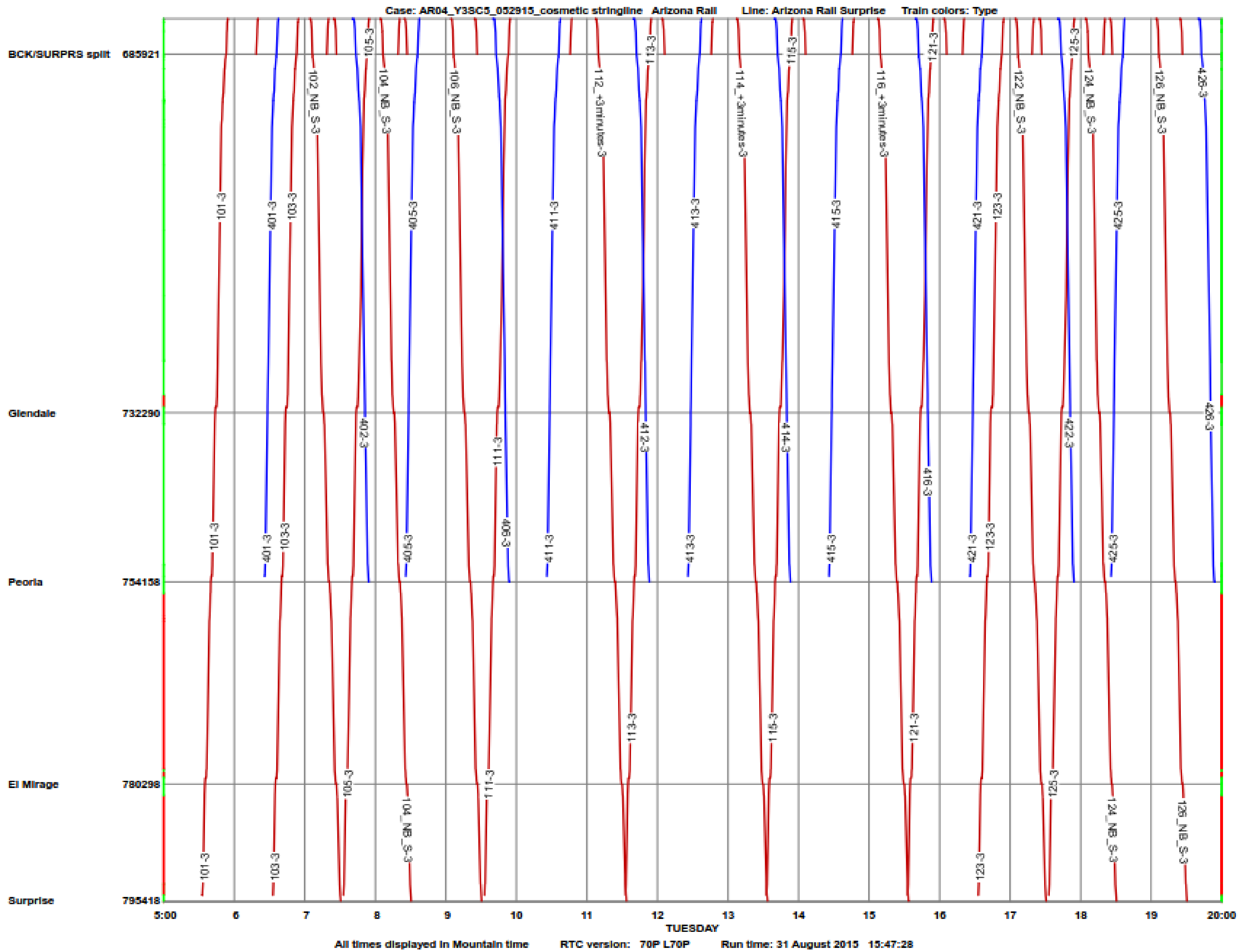
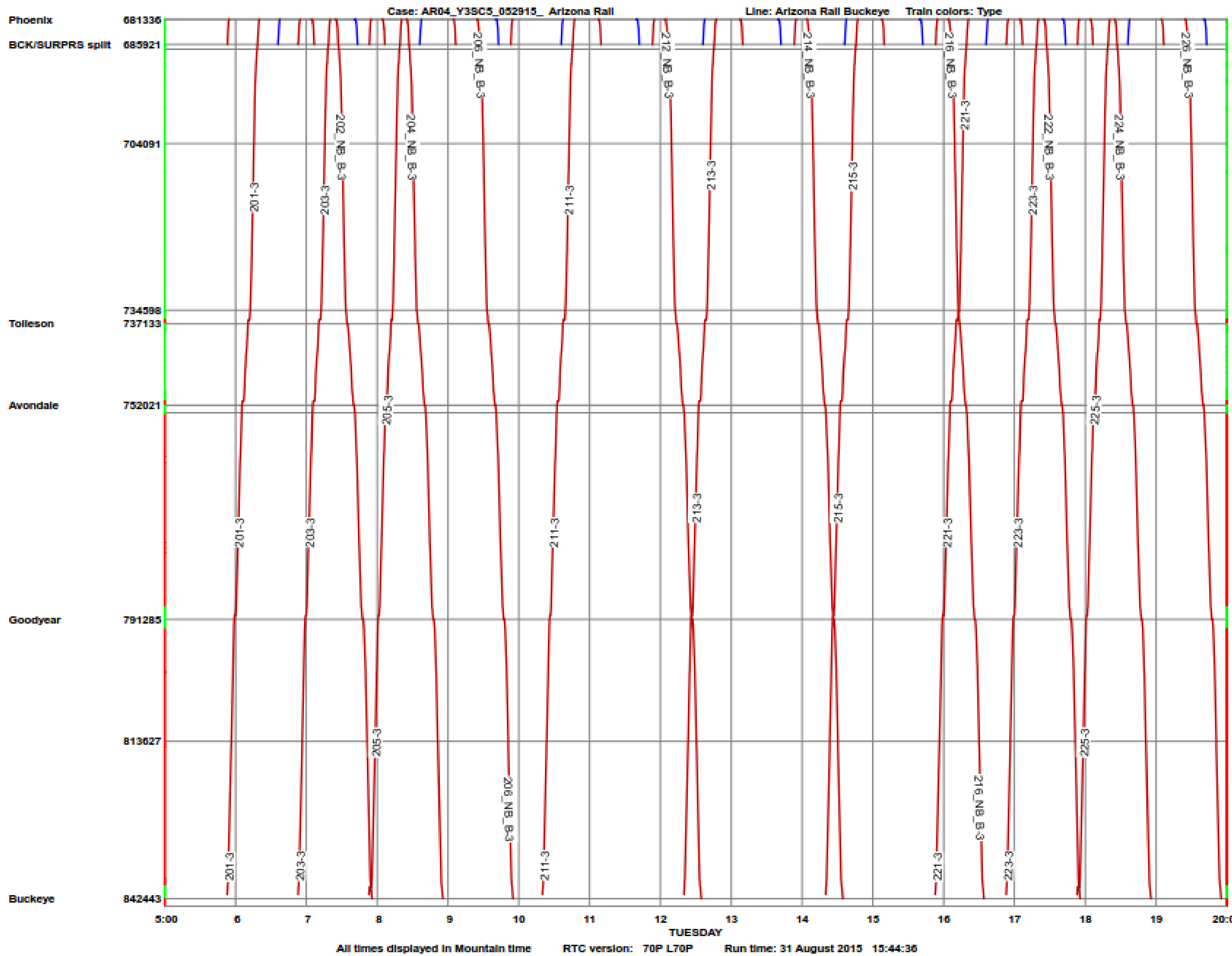


Figure 7-19: Stringline Chart for ASP Extension from Phoenix to Buckeye



7.3 Equipment Consists

Equipment

Under Section 305 of PRIIA, the American Association of State Highway and Transportation Officials (AASHTO) assembled a committee to develop specifications for a new generation of American style conventional (79 MPH) and intermediate high-speed (125 MPH) rail cars and locomotives. FRA requires new equipment purchases that utilize federal assistance to meet the "305" specifications, which have been published for both single and double deck cars and for diesel locomotives. Double deck cars offer some advantages and may be applicable in the Phoenix-Tucson Corridor, but for purposes of this analysis and based on preliminary ridership forecasts, a conservative single deck locomotive pulled train able to operate at 125 mph has been assumed pending more detailed ridership and constraints analyses of a Tier 2 evaluation. In all cases, the assumption is for each train (commuter and intercity) to include 4 cars, which provides a high level of interchangeability in the operating plan pending the needs and preferences of the ultimate operating agency or agencies.

An issue with shorter length, regional passenger rail projects is that small-quantity train acquisitions are more expensive, regardless of whether the equipment is ultimately owned or leased. This proposed Tucson-Phoenix service would benefit by "piggybacking" on other, larger vehicle procurements. FRA grants to other states for the acquisition of passenger cars and locomotives is an opportunity to obtain better pricing and delivery schedules. In the implementation stage, it may be possible to join with other passenger service sponsors in coordinated equipment procurement to obtain lower unit prices. Purchase of replacement equipment is a possibility if such an option is cost-effective and equipment meets expectations.

The most suitable type of equipment for this service has not been determined, but because of necessity much of the corridor will require new track, the expectation is that it will be designed to modern standards and accommodate modern equipment. The following considerations apply:

- Track would be constructed for passenger service capable of meeting freight train loadings
- Dynamic characteristics and durability of equipment will be an essential element in the decision about train types. Existing equipment available has been tuned for freight track alignment and maintenance practices. Equipment procurement can also be made using a number of financial vehicles. The vehicles selected should be delayed until both the equipment and financial market conditions can be determined at the time of acquisition.

Under the assumption that new equipment is purchased for the Tucson-Phoenix service, the intent is to use the same equipment for both intercity and commuter trains, which could offer flexibility in scheduling. The estimated cost would be estimated as $405 million in 2014 dollars for the BSP service configuration. The equipment for this proposed service will be rated at 125 MPH top-speed and can be expected to achieve those speeds over lengthy sections of the corridor. Questions that will need to be addressed include:

- What is the probability of piggybacking on an equipment order from other purchasers?

- Can the performance requirement of up to 125 MPH operations be met?
- Will the service need to meet or interact with Amtrak standards?
- Is there a secondary market for this equipment if terminating the service proves necessary? (In the current market, used equipment of high quality is not likely available.)
- Are there restrictions on height within the corridor at underpasses or other locations that limit the equipment choice?

Designs are required to account for ADA requirements. Station platform designs must be made to match the chosen passenger equipment to take full advantage of ADA features. Amtrak is currently upgrading station platforms throughout its system as funding becomes available.

Rolling stock requirements have been estimated based on ridership forecasts and the round trip travel times for each proposed service. Diesel-electric propulsion has been identified as the preliminary preferred technology for purposes of establishing travel demand and operations planning because of its favorable operating characteristics and ability to readily adapt to passenger demand without significantly affecting performance. However, a specific technology has not been selected as part of this project and other power delivery systems such as electrification will be part of future phases of project development.

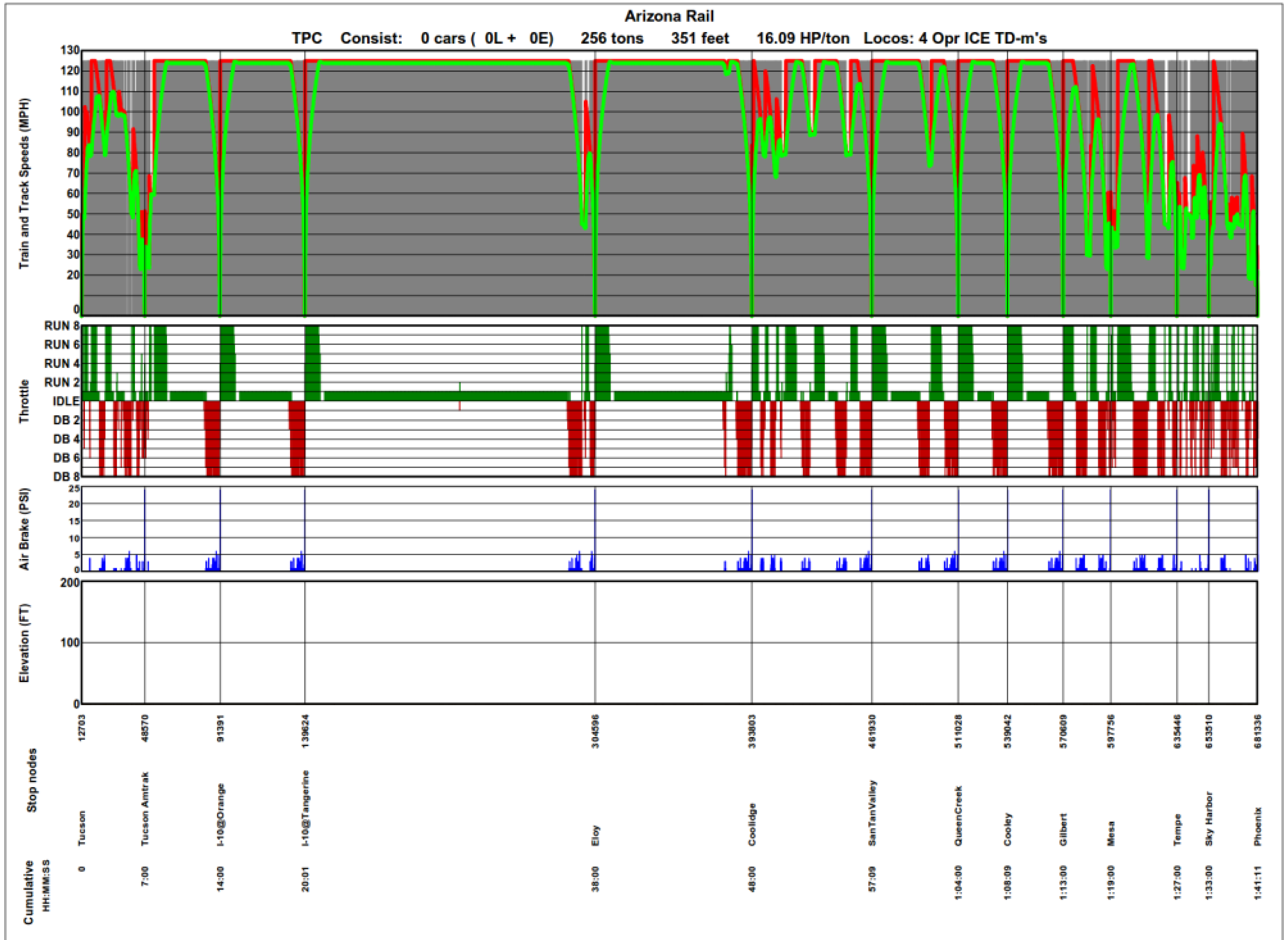
Capital equipment costs are discussed in Section 9.

Performance Characteristics

For purposes of estimating costs and performance, the assumptions made in this analysis include the performance characteristics of the new Siemens Charger locomotive, which has a maximum speed of 125 mph, and a power rating of 4,400 horsepower operating between 600 and 1,800 rpm. The locomotive uses a 16-cylinder fuel-efficient diesel engine and boasts a maximum tractive effort of 65,000 lbs. and can carry 1,800 gallons of fuel. The Charger has other attractive features such as a pneumatically-controlled braking system that feeds the auxiliary and HEP System to minimize fuel consumption.

The assumption of the Siemens Charger as a basis for performance results in a speed profile for a proposed intercity passenger service shown in Figure 7-20. This profile accounts for geometrics and stations and assumes new passenger track. Average operating speeds for the intercity and commuter services are forecast to be 52 mph and 82 mph, respectively. These compare favorably with high performing systems elsewhere in the country.

Figure 7-20: Speed Profile for Northbound Intercity Service (Phoenix-Tucson)



Equipment and Train Crew Scheduling

Train staffing depends on the number of passengers and location within the corridor, but for a relatively short run such as the APRCS, the requirements will generally consist of four people: two engineers, a conductor and an assistant conductor. The staffing levels would increase if the trains included additional features such as café cars or business class service.

Employee shift scheduling is dependent on a number of factors, including employee seniority, length of the train's route, and type of employee (i.e., whether they are an operating employee or train attendant). Operating employees (engineers, conductors, and assistant conductors) have shift lengths determined by crew base locations and Federal Hours of Service requirements such as a maximum of 12 work hours per day. For the APRCS, operating crews and on-board employees (primarily train attendants) would typically remain with a train for the entire run.

Other Key Issues

Electrification

No technology is proposed as part of this SDP. Ideally, the corridor would provide electrified train operations that allow a higher range of speeds and be more environmentally sustainable. For purposes of establishing the corridor in terms of ridership, the use of a diesel-electric unit as an operating assumption was appropriate given costs and the current freight operating environment on the preferred corridor. The advent of future connections beyond the Phoenix-Tucson Corridor such as a Core Express connection between Phoenix and Los Angeles would enhance the benefit of electrification between Phoenix and Tucson in the context of compatibility within a multistate system.

Positive Train Control (PTC)

FRA has issued regulations in response to Federal legislation that requires PTC on virtually all rail lines over which scheduled passenger trains operate by 2015. At this time, the scope, costs, and funding requirements for PTC are still to be determined. However, UP is currently installing PTC on a portion of this route since it also carries freight categories for which FRA also requires PTC.

Branding

The creation of a recognizable brand for a passenger service can prove the key to keeping its availability and the quality of the service in the public's mind. Arizona will need to consider creating an identity for this proposed service. If a positive reputation is earned, the recognition factor will be of great benefit to the continuing success of the service. This is an area of discussion that will include coordination with Amtrak, and other affected agencies to develop an identity that would encourage increased use.

Branding could include a distinctive color scheme such as used on the successful Cascade Services in Washington State or the Rail Runner in New Mexico.

On-board services

A variety of on-board services, including Wi-Fi, would make the train travel experience more pleasant and potentially productive for both the leisure and business traveler.

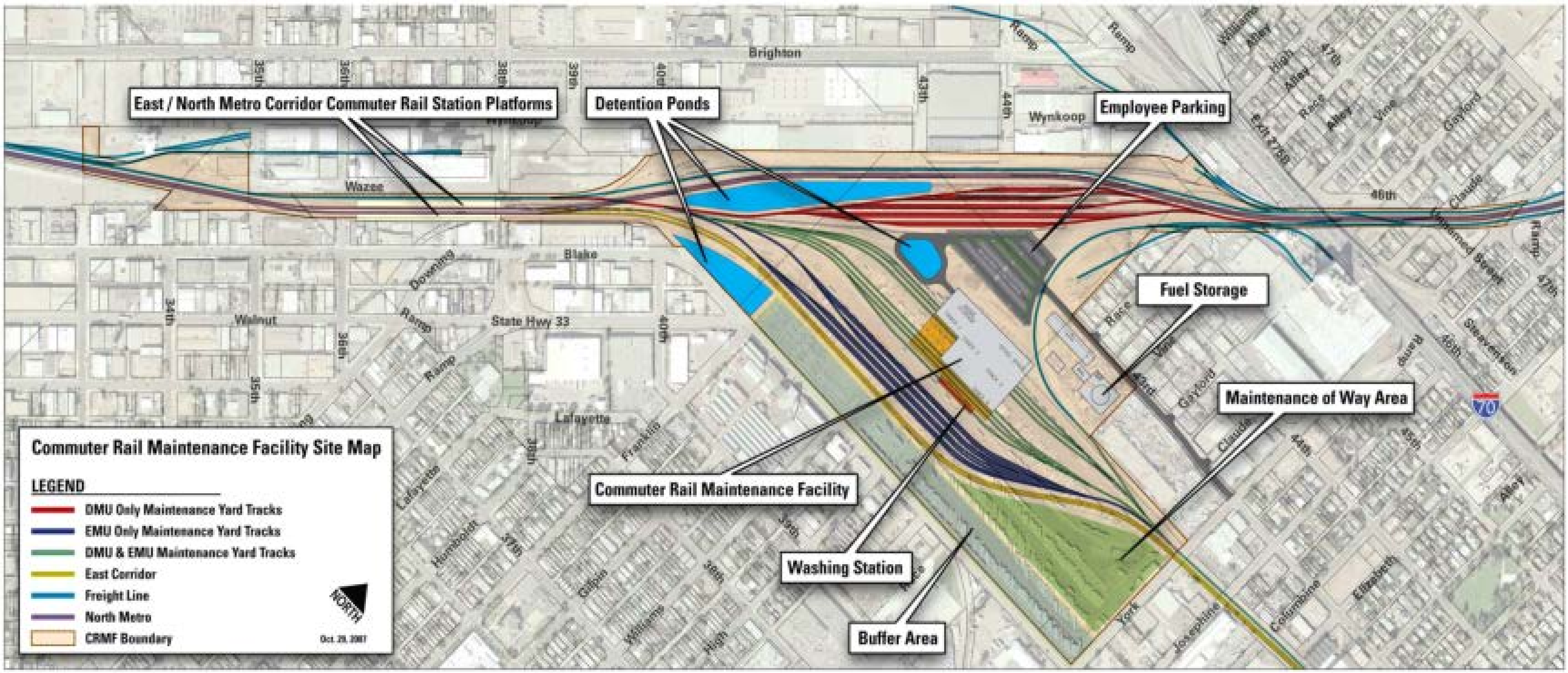
While the length of the journey does not require a full-service sit down dining car, delicatessen quality and type of fare would be suitable for this trip duration. The Tucson-Phoenix connections would require availability of breakfast in the morning hours and light dinner in evening hours.

7.4 Terminal Yard and Support Operations

Terminal facilities, yards and support operations would have to be built to support the proposed operations. There are no available passenger service yards within the corridor. Facilities would need to include crew quarters, train servicing and fueling, and car cleaning. Added crew costs and maintenance costs are developed in Section 10. In the case of the Tucson-Phoenix connection, new facilities would most likely be located at in the vicinity of Coolidge or Eloy for storage and turn-around of the equipment. The existing UP fueling facilities in Tucson or Phoenix could potentially be utilized if allowed. Standby power would be installed. A sample maintenance yard layout is shown in Figure 7-21.

In full development, the ASP operation would require excessive deadhead operation with a storage and maintenance yard located in or near Coolidge to support both commuter and intercity services. However, while that can work in the long run, there would need to be provisions for minor repairs and storage within a more accessible location for commuter operations. Locating these services within the metro areas would be essential if the passenger rail program were phased over time and began as a commuter service in one or both metropolitan locations. A few locations are available near the downtowns in Phoenix and Tucson, but there may be opportunities to accommodate storage and repair near the outer end of the commuter lines or by agreement with the host railroad for use of existing facilities. Analysis of potential locations for yard services will be completed for specific equipment and service needs if the service is phased over time.

Figure 7-21: Sample Maintenance and Operations Layout with Key Elements (FasTracks - Denver)



Source: USGS Base Map, URS 2007

8 Station and Access Analysis

In addition to the rail infrastructure and train operations issues along the corridor, there are additional elements necessary to implement passenger service. These are associated with accommodating passengers' access to the service and are focused in and around stations.

These issues are summarized below around two general areas:

- Access to and from the station and circulation options available in the communities served.
- Issues related to the development of stations and customer accessibility to the service.

With the exception of the Tucson hub which has Amtrak service now, nearly all locations would require new stations to be built, remodeled or updated. Depending on the demand and the local support, additional stations are proposed at Sky Harbor Airport, Tempe, Mesa, Gilbert, Queen Creek, Santan Valley, Coolidge, and Marana. The proposed rail line (existing UP freight) travels through most of the downtowns of all the communities mentioned above. Each community would be determined to be commuter-focused or both intercity and commuter focused and that would determine the appropriate facilities to be built. Eloy has no identified ridership based on current forecasts, so it is identified as a transit emergent station pending growth that would lead to a more productive result. Other locations that have very low ridership potential (e.g., Downtown Coolidge and Marana Tangerine) could also be considered transit emergent upon more detailed analysis and a balancing of operating costs versus system benefits.

New stations will require basic facilities including waiting areas, parking and basic information services. Basic passenger amenities to be provided, at a minimum, will be consistent with services provided at similar size/type of national Amtrak stations. However, ADOT developed the concept of the proposed passenger service with a substantially more aggressive perspective which includes setting the stage for local economic development opportunities within the station areas in the corridor. The project team has met with local officials outlining the local commitments needed and responsibilities for station improvements and the appropriate level of station (i.e., emerging, local, regional or hub) for each location along with the future operations and maintenance of stations and facilities. The level of support staff needed at each location will depend on the extent of the activities at the station. Off-vehicle ticketing, for example, could obviate the need for some stations to employ agency personnel though some communities may prefer an active presence for security and/or passenger support.

Costs to be shouldered by local entities are yet to be determined, but may include building of a minimum station and parking facilities and the on-going maintenance, operations, insurance and utilities for those facilities, provisions for ticketing, either by agent or machine, and provision of any personnel to attend the station prior to train time. In other areas, some localities have used volunteer help to staff their stations.

All stations would include customer services such as ticketing, information and other amenities associated with a commuter or intercity location.

A critical component of successful implementation of new service is circulation to and from stations at each location. This provides passengers the ability to reach their final destinations. As is noted below, there are varying levels of transportation options available in each community. The right mix of parking versus other options will need to be assessed on a station by station basis. This would require extensive coordination with local cities and transportation providers.

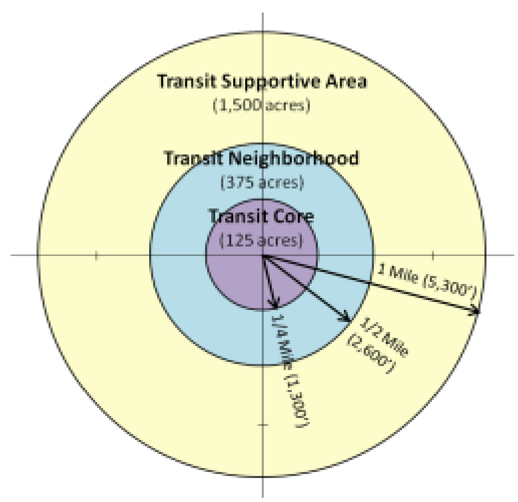
8.1 Station Location Analysis

Station locations in this analysis are preliminary. The possibility of locations has been discussed with each affected community in the preferred corridor, but no final decisions have been made with respect to the exact sites to be used. These decisions will not be made until substantially more detail is known about the service and the best places to attract users.

Station Influence Area Components

Station area planning involves designating the area within a five- to twenty-minute walk, or one-mile, of a transit station as a distinct type of place. The area within this one-mile threshold is known as the station influence area." Actual boundaries will vary based upon the unique physical characteristics of each station area. Stations will be generally located at the centers of significant higher-density economic and cultural activity. In addition, each station area should have a well-established network of pedestrian pathways connecting the station to nearby high-density residential and employment areas. Such pedestrian pathways should include supportive infrastructure, such as sheltered waiting areas, street furniture, low-scale lighting, shade, bike racks, and retail/service uses tailored towards pedestrian traffic. It is understood that for this corridor, the highest density station areas will primarily occur in the core of the Tucson and Phoenix metropolitan areas, however the intent is to stimulate mixed-use, medium- to high-density development within station areas along the entire corridor, including suburban and rural areas.

Figure 8-1: Station Influence Area



The station area consists of (approximately) the 500 acres within the one-half mile surrounding a transit station, composed of the transit core and transit neighborhood. These areas are further surrounded by the transit-supportive area (not part of the station area). Transit geography is illustrated in Figure 8-1 and further defined below:

- ***Transit Core***: First one-quarter mile, or approximately 125 acres, of the station area centered at the transit station; generally a five-minute walk from the station.
- ***Transit Neighborhood***: Second one-quarter mile, or approximately 375 acres, of the station area surrounding the transit core; generally a 10-minute walk from the station.

- ***Transit Supportive Area***: Next one-half mile radius around transit station (generally a 20-minute+ walk), beyond the transit core and transit neighborhood, comprising an additional 1,500 acres; often experiencing modest increases in density due to station proximity.

Station Typology and Hierarchy

The following four station types have been developed for intercity and commuter rail service between Tucson and Phoenix. The station types have been defined by considering the unique southwestern context of the study area, the current and planned characteristics of Arizona communities (both urban and rural), combined with requirements based on service and access needs. The four identified station types include:

1. System Hub Station – Located in the center of a major metropolitan area that define an anchor of the proposed service. Only two of these exist in the APRCS: downtown Phoenix and downtown Tucson
2. Regional Station - Stations that serve both a local and a regional function. All trains stop at regional stations. Regional stations serve as a primary collection point for train service
3. Local Station – Primarily a commuter access location. Stations function as gathering places and can spur economic development within the local community, but have a more confined effect than regional stations
4. Transit Emergent Station Location – Locations that are not yet prepared for service, but with the potential to become active stations as population and jobs in the area grow over time.

Table 8-1 illustrates the four station types and the corresponding passenger rail service associated with them. Intercity rail service is proposed to stop at the system's hub and regional stations; commuter rail service can stop at all four station types. Characteristics of specific station typologies will be discussed in more detail in the following sections, including the provision of key information, such as the typical urban setting, employment/commercial/residential land use types, typical transit patronage area, and typical transportation modes and parking types associated with each station type. An overview of these characteristics is presented in Table 8-2.

Table 8-1 - Rail Services at Various Station Types

		Station Types			
		System Hub	Regional Station	Local Station	Transit Emergent Station
Rail Service	Intercity Rail	●	●		
	Commuter Rail	●	●	●	●

Each of the four station types will have different transit connectivity characteristics, based on the urban context in which they are located and the passenger patronage area associated with them. An overview of the general patronage area for each station type by location (urban or rural), generally available transit connections (light rail transit [LRT], modern streetcar, bus rapid transit [BRT], local and circulator bus system), bicycle and pedestrian infrastructure, and parking facilities have also been provided for each station type. Typical block sizes and development densities that support walkability within the station area, and enhance the attractiveness of the development are also discussed.

Prototypical station area plans are provided for system hub, regional and local station types in the Station Area Planning Guidance for Communities, a companion resource for the AA. These plans are not site-specific, and depict typical conditions present in the corridor. Each station type is composed of various land uses, facility types, amenities, and their relationships for access and circulation which remain constant; however, these components can be modified to fit site-specific conditions since each station area will present a different set of opportunities and constraints. The prototypical station area plans should only be used as a guidance tool to develop individual station area plans based on site-specific conditions of host communities.

Intermodal Connectivity

Each potential station location has been evaluated for its ability to offer connections from the new service to activity centers or destinations. Local and intercity buses, for example, or bike and car share programs or simply good bike and pedestrian access.

Tucson opened a modern streetcar in 2014 in their downtown. The line is anticipated to connect the University of Arizona to downtown and serves the existing Amtrak station downtown. The main bus transit center for Tucson is also in the same location creating a multimodal hub brings together all of planned mass transit and rail transportation modes. Similar types of connections exist in Tempe, Phoenix and Sky Harbor Airport and can be readily developed in Mesa and Gilbert.

Table 8-2 - Station Typologies and General Characteristics

Station Type	Typical Urban Setting	Employment/ Commercial Land Use Types	Residential Land Use Types	Transit Patronage Area	Typical Transportation Access Options
Hub Station	Downtown/ center of metropolitan area	Primary office, government, and cultural/sports/ entertainment center with supportive retail and services	High-density, multi-family housing	15 to 25 miles	Intermodal facility/transit hub. Major regional destination with high- quality feeder transit (light rail, streetcar, bus, circulator)
Regional Station	Subregional downtown or major employment center	Regional employment hub and major activity center (retail, services, education, medical, entertainment)	Mid- to high-density residential, often as part of mixed-use developments	10 to 15 miles	May be a subregional destination on fixed-guideway transit corridor. Potential park-and-ride location with structured parking
Local Station	Suburban town center, master planned community commercial core, or historic downtown of rural community	Office/service/retail economic activity center, potential government service center	Medium-density multi-family, possibly single family (e.g., row houses, townhouses)	5 to 10 miles (Suburban) 10 to 20 miles (Rural)	Local activity center linked with high quality feeder bus services (e.g., express bus, regional fixed route bus routes); park-and-ride location with surface parking
Transit Emergent Station	Similar to Local Station, but may be farther from terminal station	Office/service/retail economic activity center, potential government service center; often a “Main Street” activity node	Medium-density multi-family, possibly single family (e.g., row houses)	10 to 20 miles	Transit station linked with local feeder bus service, regional bus transit with service to adjacent towns/cities

9 Capital Programming

9.1 Costing Methodology Summary

Section 9 summarizes the estimated capital cost of the principal elements of the alternatives under evaluation. The costs shown are in 2014 dollars. All costs are planning level with no detailed engineering performed to date. Costs per mile or per track element such as turnouts have been based on passenger rail programs in other areas of the country. For planning level purposes, a 40 percent contingency has been included since no detailed engineering has been undertaken.

The estimates prepared include both the main project corridor between the two system hubs in downtown Phoenix and downtown Tucson. An estimate was also prepared for the extensions considered in the preparation of travel forecasts and operations plans as well as to provide a more comprehensive basis for a benefit/cost assessment.

Because the information contained in this SDP has been refined since the development of the data that were included in the Tier 1 EIS, some of the cost figures may be different from those contained in the EIS. In most cases, the differences are not major, but reflect a more accurate cost based on more analysis and additional review. Some of the costs also reflect longer segments than the EIS to account for the ways service would most likely be operated.

9.2 Project Capital Cost Estimates

The following assumptions were made for the development of the rail capital and operating cost estimates for the ADOT Tucson to Phoenix Passenger Rail Corridor Study.

1. For calculating fleet size, the average speed provided for commuter service (52 mph) and intercity service (82 mph) was used for each service level. A total of 40 minutes (20 minutes at each terminal) is allocated for terminal turn-back time. The number of trains will be adjusted for commuter and intercity services based on demand, but preliminary service based on forecasts proposes two commuter and one intercity trains hourly in both directions during the peak period and a lower frequency during the off-peak

2. Double track is assumed only where a conflict has been identified by stringline analysis. This limitation may be reconsidered at key locations to allow future growth to occur easily and to minimize additional construction costs and impacts.

3. While different technologies could be used in the corridor, for purposes of this estimate, trains were assumed to be similar to the Siemens Charger locomotive noted earlier in this report with 4-car consists for both commuter and intercity train sets. The assumption does not suggest a preferred technology at this stage of analysis, and is only used to establish a realistic basis for the analysis.

4. Most bridges such as those across canals, streets, and some washes are assumed to be 200 feet or less in length. Some bridges across freeways, washes, and wide roadways are assumed to be

between 200 feet and 300 feet in length. Major bridges will be estimated on a cost per linear-foot basis.

5. Universal crossovers consist of four turnouts arranged in sets of two to form single crossovers in opposite directions. Crossovers allow trains to cross from one track to another and are located at terminal stations, connections to servicing and maintenance facilities, and at intermediate locations to allow trains to operate over only one track due to maintenance or a problem on the other track. It is assumed crossovers will be spaced 5 miles to 10 miles apart.

6. At-grade highway/railroad crossings would be rebuilt for higher train speeds and multiple tracks (freight and passenger) in accordance with federal and state regulations. Each at-grade crossing would be equipped with medians and quadrant gates (to prevent motorists from driving around the gates), constant warning predictors, concrete panel crossing surfaces, and all required signage and graphics.

7. Automatic train control will consist of cab signaling and automatic train protection and supervision.

8. Passenger stations will consist of system hub stations located at terminals and key junction points, and local stations located along the system or within freeway median locations.

9. Unit costs are based upon experience, industry articles, and costs which have been rounded up after allowing for inflation.

10. A contingency of 40% has been added to the construction cost due to the planning level of the cost estimates.

11. Annual operating and maintenance cost estimates are based upon the 2010 National Transit Database vehicle mile and train hour costs inflated by 3% per year to 2014.

12. Right-of-way costs in these estimates are calculated parametrically by general land use category and by location within the corridor.

Table 9-1 summarizes the anticipated costs for the proposed project.

Table 9-1 – Full System Capital Costs (in FTA Standard Cost Category Format and 2014$)

FTA Major Standard Cost Categories (SCC)		Base Year Cost w/o Contingency (x000)	Base Year Allocated Contingency (x000)	Base Year Dollars Total (x000)	Base Year $ % of Construction Cost	Base Year $ % of Total Cost
10	Guideway & Track Elements	$1,351,826	$236,570	$1,588,395	52%	33%
20	Stations, Stops, Terminals, Intermodal	$106,667	$10,667	$117,333	4%	2%
30	Support Facilities: Yards, Shops, Admin. Bldgs	$130,000	$13,000	$143,000	5%	3%
40	Site Work & Special Conditions	$401,838	$60,276	$462,114	15%	10%
50	Systems	$653,280	$81,660	$734,940	24%	15%
	Construction Subtotal (10 - 50)	$2,643,611	$402,172	$3,045,782	100%	
60	60 ROW, Land, Existing Improvements	$198,154	$39,631	$237,785		5%
70	70 Vehicles	$352,000	$52,800	$404,800		8%
80	80 Professional Services	$280,527	$0	$280,527		6%
	Subtotal (10 - 80)	$830,682	$494,603	$3,968,895		
90	90 Unallocated Contingency			$895,114		18%
	Total (10 - 90)			$4,864,009		100%

Table 9-2 shows the estimates of the cost of the various segments, including extensions, considered in forecasting ridership and developing operating plans.

Table 9-2 – Approximate Individual Component Segment Capital Costs and Proposed Timelines

Phase	Segment	Construction Begin	Open	Segment Cost[8]
Phoenix Metro				
	Santan-Phoenix	2025	2029	$ 1,200,000,000
	Phoenix-Surprise	2025	2029	$ 400,000,000
	Phoenix-Buckeye	2025	2029	$ 600,000,000
Tucson Metro				
	Marana-Tucson	2028	2030	$ 800,000,000
	Tucson-TIA	2028	2030	$ 300,000,000
Intercity				
	Santan-Marana	2033	2035	$ 1,300,000,000

[8] The amounts shown for each segment are approximations shown only to indicate the relative capital cost of each individual portion of the overall operating plan. Each segment requires assumptions about the cost estimate that will change when applied to a different segment or when combined with other segments.

10 Operating and Maintenance (O&M) Costs and Capital Replacement Forecast

10.1 Assumptions and Methodology

The O&M cost estimates are based on the real world costs incurred by transit agencies that provide commuter or intercity rail service using diesel trains. The information was obtained from annual transit agency reports to FTA.

A few different alternatives for cost development were considered and it was determined that the Annual Operating and Maintenance Cost/Route Mile data provided the most reasonable O&M cost estimates for the scale of the proposed Base and Alternative Service Plans.

Cost inflation includes a 25% increase compared to the national average obtained from FTA operating cost database and is primarily based on desired operating speeds. The desired speed for the ADOT Passenger Rail at up to 125 mph is considerably higher than the existing passenger rail systems, which typically have maximum speeds of 59 or 79 mph. Higher operating speeds have the following impacts on operating costs:

1) More stringent tolerances for infrastructure that will require more frequent inspections / maintenance and impacts the following subsystems:
    a. Rolling stock
    b. Rail and track beds
    c. Bridges
    d. Railroad / Roadway at-grade crossings
    e. Signals, communications and positive train control systems
    f. Fencing
2) Safety concerns will be greater with higher speed operations, leading to additional costs for security measures.
3) Higher operating speeds could result in greater fuel consumption.

Table 10-1 through Table 10-4 provide a summary of operating and maintenance cost estimates for each of the BSP and the ASP using comparable service level assumptions. The average rates used in this analysis include maintenance of equipment, rolling stock, rail and track beds as well as crew and labor costs. Other combinations of frequency, period of service, and number of the services offered, if any, can be estimated from the primary alternatives.

Fleet and Crew Considerations

Evaluation of crew and rolling stock needs are only generic. At such time that passenger rail service is funded and operational specifics are better defined, a full assessment of fleet and crew utilization will need to be completed to maximize crew efficiency and minimize empty trains and crews having to return from long distances to their home depots at the end of a shift. Figures in this programmatic document only account for such costs as part of an average cost approach to such considerations.

Table 10-1 – Operating and Maintenance Costs for BSP

Base Service Plan: Hub-to-Hub Annual Operating and Maintenance Costs

Technology and Distance

Technology:	Diesel-electric
Route Miles:	
Intercity	119.8
Commuter	119.8

Travel Time

Travel Time		Northbound	Southbound
Intercity	One-Way Trip Time (min)	83	82
Commuter	One-Way Trip Time (min)	95	96
	Turnaround Time (min)	20	

Annual Operating Statistics

Weekday Revenue Service				
Service Type	**Trip Length**	**Daily Weekday One-Way Trips**	**Weekday Mileage**	**Annual [b] Revenue Miles**
Intercity	119.8	12	1437.6	373,776
Commuter	119.8	36	4312.8	1,121,328
		Total	5750.4	1,495,104

Fleet Size

Service Type	Number of Cars	Fleet [a] Size
Intercity	4	5
Commuter	4	13

Annual Operating Costs

Annual Cost Statistic	Unit	Unit Cost[c-f]	Annual Veh-Miles	Estimated O&M Cost
Intercity Vehicle Miles	Operating Expense / Veh-Mile	$29.79	373,776	$11,134,000
Commuter Vehicle Miles	Operating Expense / Veh-Mile	$29.79	1,121,328	$33,402,000
		Total Estimated Annual O&M Cost		**$44,536,000**

ANNUAL O&M COST ASSUMPTIONS

- a Includes 1 spare train for each type of rail service.
- b Weekdays only rail service. Includes 260 operating days / year.
- c Operating Expense per Vehicle Revenue Mile are in 2013 U.S. Dollars.
- d Operating Expense per Vehicle Revenue Mile from 2012 National Transit Database plus 3% inflation per year to 2013.
- e Operating Expense per Vehicle Revenue Mile is based on an average value of 14 existing transit systems across the United States that have similar operations.
- f Operating Expense per Vehicle Revenue Mile average cost inflated by 25% to take into account higher operating speed assumed for this rail system.

Table 10-2 – Operating and Maintenance Cost for ASP

Alternative Service Plan: Hub-to-Hub Annual Operating and Maintenance Costs

Technology and Distance

Technology	Diesel-electric
Route Miles:	
Intercity (Phoenix-Tucson)	119.8
Commuter Phoenix (Santan Valley-Phoenix)	41.2
Commuter Tucson (Marana-Tucson)	18.3

Travel Time

Service Type	Direction	Northbound	Southbound
Intercity	One-Way Trip Time (min)	104	103
Commuter Phoenix	One-Way Trip Time (min)	73	72
Commuter Tucson	One-Way Trip Time (min)	26	26
	Turnaround Time (min)	20	

Annual Operating Statistics

Weekday Revenue Service				
Service Type	Trip Length	Daily Weekday 1-Way Trips	Weekday Mileage	Annual [b] Revenue Miles
Intercity	119.8	14	1677.2	436,072
Commuter Phoenix	41.2	36	1483.2	385,632
Commuter Tucson	18.3	38	695.4	180,804
		Total	3855.8	1,002,508

Fleet Size

Service Type	Number of Cars	Fleet [a] Size
Intercity	4	5
Commuter	4	13

Annual Operating Costs

Annual Operating Costs	Unit	Unit Cost [c-f]	Quantity	Estimated O&M Cost
Intercity Vehicle Miles	Operating Expense / Veh-Mile	$29.79	436,072	$12,989,000
Commuter Vehicle Miles Phoenix	Operating Expense / Veh-Mile	$29.79	385,632	$11,487,000
Commuter Vehicle Miles Tucson	Operating Expense / Veh-Mile	$29.79	180,804	$5,386,000
			Total Estimated Annual O&M Cost	**$29,862,000**

ANNUAL O&M COST ASSUMPTIONS

a Includes 1 spare train for each type of rail service.
b Weekdays only rail service. Includes 260 operating days / year.
c Operating Expense per Vehicle Revenue Mile are in 2013 U.S. Dollars.
d Operating Expense per Vehicle Revenue Mile from 2012 National Transit Database plus 3% inflation per year to 2013.
e Operating Expense per Vehicle Revenue Mile is based on an average value of 14 existing transit systems across the United States that have similar operations.
f Operating Expense per Vehicle Revenue Mile average cost inflated by 25% to take into account higher operating speed assumed for this rail system.

Table 10-3 – Extensions Operating Costs

Extensions Operating and Maintenance Costs

Technology and Distance

Technology	Diesel-electric
Route Miles:	
Intercity (Phoenix-Peoria)	13.8
Commuter (Phoenix-Surprise)	21.9
Commuter (Phoenix-Buckeye)	30.5
Commuter (Tucson-TIA)	7.0
Intercity (Tucson-TIA)	7.0

Extensions Travel Times

Service Type	Direction	Northbound	Southbound
Intercity (Phoenix-Peoria)	One-Way Trip Time (min)	15	15
Commuter (Phoenix-Surprise)	One-Way Trip Time (min)	23	23
Commuter (Phoenix-Buckeye)	One-Way Trip Time (min)	29	29
Commuter (Tucson-TIA)	One-Way Trip Time (min)	6	6
Intercity (Tucson-TIA)	One-Way Trip Time (min)	6	6
	Turnaround Time (min)	20	

Annual Operating Statistics

Weekday Revenue Service				
Service Type	Trip Length	Daily Weekday 1-Way Trips	Weekday Mileage	Annual [b] Revenue Miles
ASP - Intercity (Phoenix-Peoria)	13.8	14	193.2	50,232
BSP - Intercity (Phoenix-Peoria)	13.8	12	165.6	43,056
Commuter (Phoenix-Surprise)	21.9	18	394.2	102,492
Commuter (Phoenix-Buckeye)	30.5	18	549	142,740
Commuter (Tucson-TIA)	7.0	38	266	69,160
ASP - Intercity (Tucson-TIA)	7.0	14	98	25,480
BSP - Intercity (Tucson-TIA)	7.0	12	84	21,840

Fleet Size

Service Type	Number of Cars	Fleet [a] Size
Intercity	4	5
Commuter	4	13

Annual Operating Costs

Annual Cost Information	Unit	Unit Cost [c-f]	Quantity	Estimated O&M Cost
ASP - Intercity (Phoenix-Peoria)	Operating Expense / Veh-Mile	$29.79	50,232	1,496,000
BSP - Intercity (Phoenix-Peoria)	Operating Expense / Veh-Mile	$29.79	43,056	1,283,000
Commuter (Phoenix-Surprise)	Operating Expense / Veh-Mile	$29.79	102,492	3,053,000
Commuter (Phoenix-Buckeye)	Operating Expense / Veh-Mile	$29.79	142,740	4,252,000
Commuter (Tucson-TIA)	Operating Expense / Veh-Mile	$29.79	69,160	2,060,000
ASP - Intercity (Tucson-TIA)	Operating Expense / Veh-Mile	$29.79	25,480	759,000
BSP - Intercity (Tucson-TIA)	Operating Expense / Veh-Mile	$29.79	21,840	651,000

Total Estimated ASP Annual O&M Cost for Extensions	**$11,620,000**
Total Estimated BSP Annual O&M Cost for Extensions	**$11,299,000**

ANNUAL O&M COST ASSUMPTIONS

a Includes 1 spare train for each type of rail service.

b Weekdays only rail service. Includes 260 operating days / year.

c Operating Expense per Vehicle Revenue Mile are in 2013 U.S. Dollars.

d Operating Expense per Vehicle Revenue Mile from 2012 National Transit Database plus 3% inflation per year to 2013.

e Operating Expense per Vehicle Revenue Mile is based on an average value of 14 existing transit systems across the United States that have similar operations.

f Operating Expense per Vehicle Revenue Mile average cost inflated by 25% to take into account higher operating speed assumed for this rail system.

Table 10-4 – Summary of Total Annual Operating and Maintenance Costs by Service[9]

SEGMENT	BSP	ASP
	Operating Cost	
Phoenix-Tucson (Intercity)	$ 11,134,000	
Phoenix-Tucson (Commuter)	$ 33,402,000	
Phoenix-Tucson (Intercity)		$ 12,989,000
Phoenix- Tucson (Commuter - Santan-Phoenix)		$ 11,487,000
Phoenix-Tucson (Commuter - Marana-Tucson)		$ 5,386,000
ASP - Peoria-Phoenix (Intercity)		$ 1,496,000
BSP - Peoria-Phoenix (Intercity)	$ 1,283,000	
Phoenix-Surprise (Commuter)	$ 3,053,000	$ 3,053,000
Phoenix-Buckeye (Commuter)	$ 4,252,000	$ 4,252,000
ASP - Tucson-TIA (Intercity)		$ 759,000
BSP - Tucson-TIA (Intercity)	$ 651,000	
Tucson- TIA (Commuter)	$ 2,060,000	$ 2,060,000
TOTALS FOR ALTERNATIVE PLAN	$ 55,835,000	$ 41,482,000

10.2 Summary Financial Projections

Table 10-5 summarizes the incremental and total costs for each alternative outlined above in 2014 dollars, along with the operating deficit required for the proposed system. The operating shortfall funding that has not yet been identified.

Table 10-5 – Summary of Operating and Maintenance Financial Performance (2014)

Service Plan	Annual Revenue Miles	Annual Revenue	Total Annual O&M	Operating Subsidy Required
Base Alternative	1,943,864	$13,790,501	$ 55,835,000	$ 42,044,500
Alternative Service Plan	1,379,456	$9,786,379	$ 41,482,000	$ 31,695,600

10.3 Long-Term Financial Projections

Operating and maintenance cost forecasts annually between 2025 and 2055 for the ASP operating scenario are in Table 10-6 and Table 10-7. Escalation for operating costs in years following 2014 was assumed at an average of approximately 3.0 percent based on IHS Global Insight Consumer Price Index (CPI) projections for the West census regions.

[9] Commuter service assumes daily trips are divided equally between Buckeye and Surprise runs. If one of the options is not used, the other would need to be evaluated for an increased level of service.

Table 10-6 - Lifecycle Cost over 30 years assuming Proposed Phasing of All Segments

Present Value Cost Projections						
Year	**Year of Project**	**Capital [1] (000)**	**O & M [1] (000)**	**Vehicle [1] Replacement (000)**	**Additional [1] Replace & Rehab (000)**	**Annualized Cost [1] (000)**
2015	0					$0
2016	1					$0
2017	2					$0
2018	3					$0
2019	4					$0
2020	5					$0
2021	6					$0
2022	7					$0
2023	8					$0
2024	9					$0
2025	10	$550,859				$550,859
2026	11	$548,211				$548,211
2027	12	$545,575				$545,575
2028	13	$986,491				$986,491
2029	14	$441,406	$18,908			$460,314
2030	15	$0	$25,880			$25,880
2031	16	$0	$25,756			$25,756
2032	17	$0	$25,632			$25,632
2033	18	$601,521	$25,509			$627,030
2034	19	$598,629	$25,386			$624,015
2035	20	$0	$40,165			$40,165
2036	21	$0	$39,972			$39,972
2037	22	$0	$39,780			$39,780
2038	23	$0	$39,589			$39,589
2039	24	$0	$39,398			$39,398
2040	25	$0	$39,209			$39,209
2041	26	$0	$39,020			$39,020
2042	27	$0	$38,833			$38,833
2043	28	$0	$38,646			$38,646
2044	29	$0	$38,460		$72,523	$110,983
2045	30	$0	$38,275		$28,696	$66,971
2046	31	$0	$38,091			$38,091
2047	32	$0	$37,908			$37,908
2048	33	$0	$37,726			$37,726
2049	34	$0	$37,545			$37,545
2050	35	$0	$37,364			$37,364
2051	36	$0	$37,185			$37,185
2052	37	$0	$37,006			$37,006
2053	38	$0	$36,828			$36,828
2054	39	$0	$36,651			$36,651
2055	40	$0	$36,475			$36,475
Totals		**$4,272,692**	**$951,198**	**$0**	**$101,218**	**$5,325,109**

Note: Costs expressed as base year dollars

Table 10-7 – Lifecycle Cost over 30 years in Year of Expenditure Dollars for All Segments

Year-of-Expenditure Cost Projections						
Year	**Year**	**Capital [1] (000)**	**O & M [1] (000)**	**Vehicle [1] Replacement (000)**	**Additional [1] Replace & Rehab (000)**	**Annualized Cost [1] (000)**
2015	0					$0
2016	1					$0
2017	2					$0
2018	3					$0
2019	4					$0
2020	5					$0
2021	6					$0
2022	7					$0
2023	8					$0
2024	9					$0
2025	10	$784,045				$784,045
2026	11	$811,486				$811,486
2027	12	$839,888				$839,888
2028	13	$1,579,403				$1,579,403
2029	14	$734,973	$31,483			$766,456
2030	15	$0	$44,817			$44,817
2031	16	$0	$46,385			$46,385
2032	17	$0	$48,009			$48,009
2033	18	$1,171,703	$49,689			$1,221,392
2034	19	$1,212,713	$51,428			$1,264,141
2035	20		$84,622			$84,622
2036	21		$87,584			$87,584
2037	22		$90,649			$90,649
2038	23		$93,822			$93,822
2039	24		$97,106			$97,106
2040	25		$100,504			$100,504
2041	26		$104,022			$104,022
2042	27		$107,663			$107,663
2043	28		$111,431			$111,431
2044	29		$115,331		$217,474	$332,805
2045	30		$119,368		$89,492	$208,860
2046	31		$123,546			$123,546
2047	32		$127,870			$127,870
2048	33		$132,345			$132,345
2049	34		$136,977			$136,977
2050	35		$141,771			$141,771
2051	36		$146,733			$146,733
2052	37		$151,869			$151,869
2053	38		$157,185			$157,185
2054	39		$162,686			$162,686
2055	40		$168,380			$168,380
Totals		**$7,134,211**	**$2,833,275**	**$0**	**$306,966**	**$10,274,452**

Note: Costs expressed as year-of-expenditure dollars

11 Segmentation/Phasing Options for ASP

11.1 Project Segmentation/Phasing Considerations

The length of the primary segment of the proposed alternative (Phoenix - Tucson) is 115 miles and the estimated cost is approximately $3 billion. The cost of the connections to serve the West Valley in the Phoenix metro area and TUS south of Tucson add about $1.6 billion if all 59 miles are built to link Surprise, Buckeye and TUS to the primary segment. The length and the cost suggest the project will need to be divided into logical phases for implementation. Based on the analysis completed to date, phasing of the corridor would emphasize the segments most likely to generate high ridership or those of moderate cost. Using travel forecasting results, the Alternative Service Plan (ASP) offers more focused service and has a significantly lower lifecycle cost than the Base Service Plan (BSP) for the primary corridor.

Though high ridership and a reasonable return on investment are important, phasing of the ASP, will need to assess not only where the ridership is strongest, but the best way to ensure the implementation of the plan. The Phoenix Metro portion of the project has the highest potential ridership and generates the greatest benefit, but to be constructible it will require substantial funding and potentially the identification of a new or renewed source of revenue. There are various ways to introduce service in a potentially shorter timeframe than full improvement of the most productive phases. While more expeditious, they could have implications for long term service quality. Among the short-term options could be the opportunity to offer service sooner without the full improvement proposed in this analysis. For example, a modified Amtrak-style service could be instituted within the next five to ten years, coordinating with UPRR and using existing freight track. Amtrak-style service could help show the value of the Phoenix-Tucson connection and help resolve concerns of the host railroad in a way that would set up the full project to be more efficiently delivered. Conversely, because of the limitations of such an operation, it could have a detrimental effect on the potential rider's perception of the service. Such a short term approach and building toward a more comprehensive service is one strategy that could shape the manner in which the passenger rail program is implemented.

The paragraphs that follow are intended to show potential strategies built on logical operating segments that could be considered to introduce and expand passenger rail services. Some of the options may overlap or they can be introduced incrementally building upon earlier phases. This strategic approach could help fund the project progressively and minimize any "throwaway" steps. There are costs associated with even the most efficient deployments. Station placement and construction, for example, would be located to avoid future relocation once a dedicated track is built. That could require building station access tracks and station facilities in a permanent location. The exact definition of each phase will require further analysis and completion of pertinent environmental (i.e., Tier 2 EIS/ROD) and design documentation.

These strategies are not intended to be viewed as sequential implementation steps, but as independent segments that, when combined, could help deliver the overall project. Funding possibilities presented are also preliminary and range from federal sources to local taxes and P3 or value capture options.

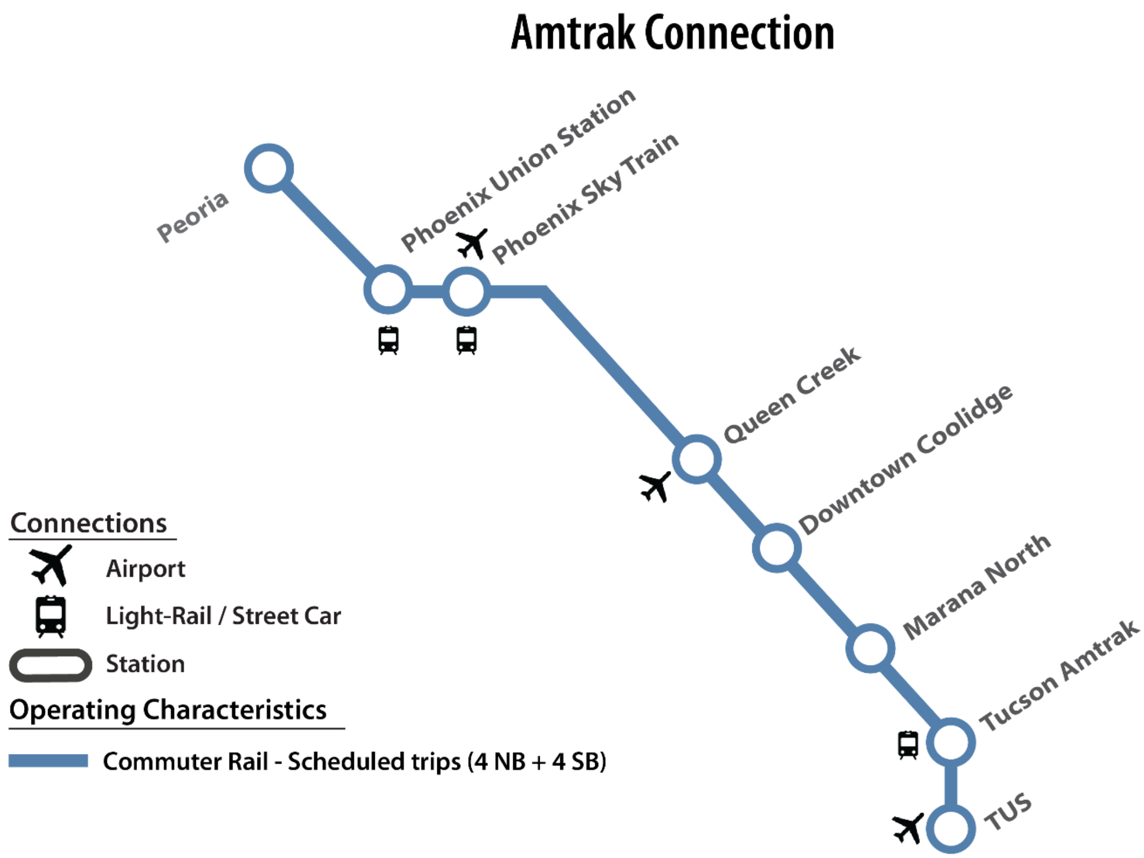
Amtrak Connection Strategy

With a more modest investment in track infrastructure, limited service could be introduced using existing freight track within a relatively short time. This option would provide a basic transportation connection as well as a possible market introduction for passenger rail services in the Sun Corridor. There are obstacles to such an undertaking, largely related to safeguarding UPRR's ability to run freight operations unhindered, but under the Amtrak provisions made by Congress in the Rail Passenger Service Act of 1970 for adequate service and the use of facilities, an agreement could be reached and a commitment made to fund the necessary improvements (i.e., stations, sidings, parking, etc.) and introduce passenger rail services in the corridor. Because the service would rely largely on existing freight track, it would be subject to coordination with UPRR freight activity and would need to commit to minimizing impact on freight movements, which could limit it to only a modest operating plan. Improvements would also be limited to building stations at select locations and ensuring a safe operating environment for passengers at those locations (e.g., double tracking, shelters, etc.). As much as possible, stations would be built in their preferred location to avoid additional cost for relocation at a future time when a permanent dedicated passenger track is built. While this approach could help to establish the service more quickly, its limited operation has the potential to limit the effectiveness of the operation and the perception of the traveling public toward passenger rail service.

This configuration, shown in Figure 11-1, extending from Surprise to TUS, would cost approximately $1.1 billion to build, $3.7 million to operate per year and attract 6,000 riders per day, based on operating assumptions of four trains per day each way, and could be delivered in about three years following environmental clearance and agreement with UPRR. The actual number of stations could change based on ridership expectations, but Figure 11-1 shows a proposed first listing of locations as a basis for discussion.

Because of the characteristics of this type of service, very likely carrying both commuter and intercity riders, the potential funding sources for such an introduction of service could come from both FRA and FTA at the federal level. The exact split between the types of service will require further study and more refined forecasting. In either case, a local funding source would be needed to complete a capital program and to pay for operations. Local funding sources would most likely be from a regional sales tax or private or Public-private partnerships (P3) funding from benefits derived at or near stations on the route

Figure 11-1: Amtrak Service Connection



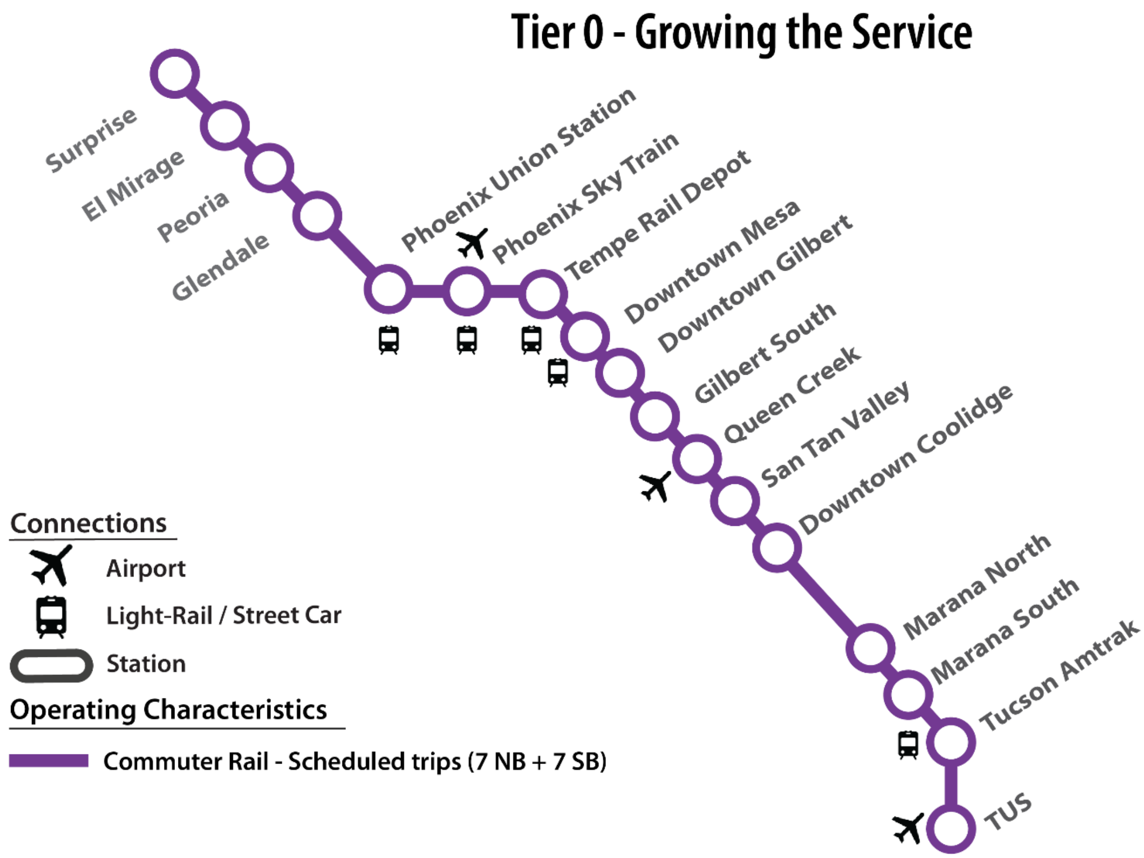
Tier 0 – Growing the Service Strategy

The intent of this approach is to expand passenger service between the two major metropolitan areas. In cooperation with UPRR, the use of existing UPRR freight track on the Phoenix Subdivision north of Picacho and the construction of new track along I-10 south of Picacho could afford a link that would support a more frequent passenger service. This option represents a substantial additional commitment of capital resources that expands performance capabilities in the southern portion of the corridor and helps to build the service. This plan, shown in Figure 11-2, would also be a limited operation that would need to be coordinated with freight train activity in the Phoenix Subdivision portion of the corridor (i.e., north of Picacho) to minimize conflicts with freight traffic. The intent would be to view passenger rail as a transportation benefit that would lead to a more comprehensive implementation of the full system at a much higher level of service.

The partial expansion option for the passenger rail service between the two major metropolitan areas would cost $2.2 billion, could carry about 15,000 passengers per day based on seven trains per day each way and could be constructed in four years following the preparation of environmental and design documents and agreement with UPRR.

Because this approach is also a combination of intercity and commuter services, the funding approach would be similar to the Amtrak Connection strategy, above. There is a higher commitment of capital funding needed south of Picacho, which could place demands on not only regional, but statewide or multi-regional sources of funding.

Figure 11-2: Tier 0 Service Concept



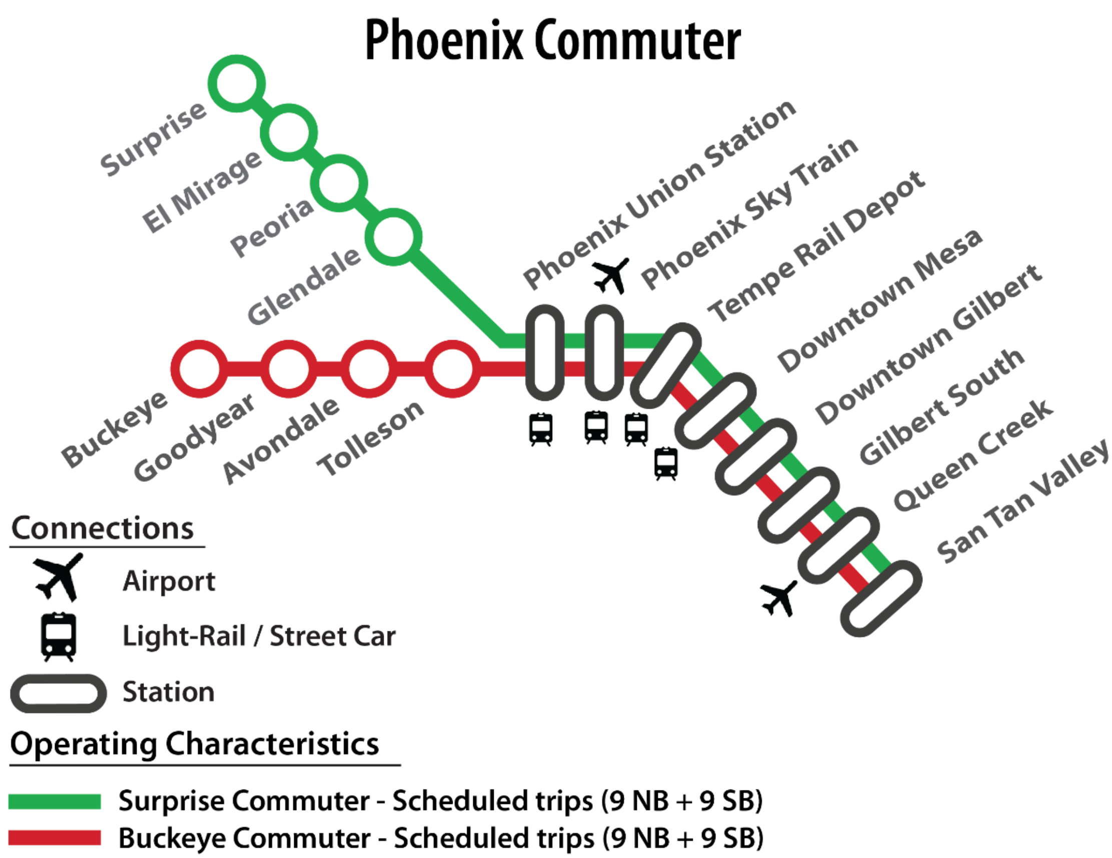
Phoenix Metro Phase

The highest potential to implement service in the short term is commuter service in the Phoenix metropolitan area (see Figure 11-3 and Figure 11-4). An analysis of commuter services from Santan Valley to the Phoenix hub, connecting most major East Valley communities, shows the potential to carry major passenger loads in a corridor yet unserved by passenger rail along the UPRR freight line (this phase could be divided into additional subsections to reduce capital and operating commitments in the short term or to provide additional time to develop solutions to complex problems within the corridor.) This is the most challenging of the phases from a construction perspective because of the highly urban nature of development within the corridor, with an estimated cost of $1.5 billion for the 45-mile segment. The Phoenix Metro phase is also the most likely to generate ridership and effectively complement other transportation options. Higher ridership will help support the passenger rail service and allow for expansion over time.

Connections to Surprise (on BNSF freight lines) and Buckeye (on Union Pacific), west of the Phoenix hub, provide access to a large additional population and potential ridership base. These additional 52 miles of service add about $1.3 billion to the project total capital cost. This total could be reduced in the short term by not building either connection, building only one of the connections, or limiting service to only stations that generate significant ridership.

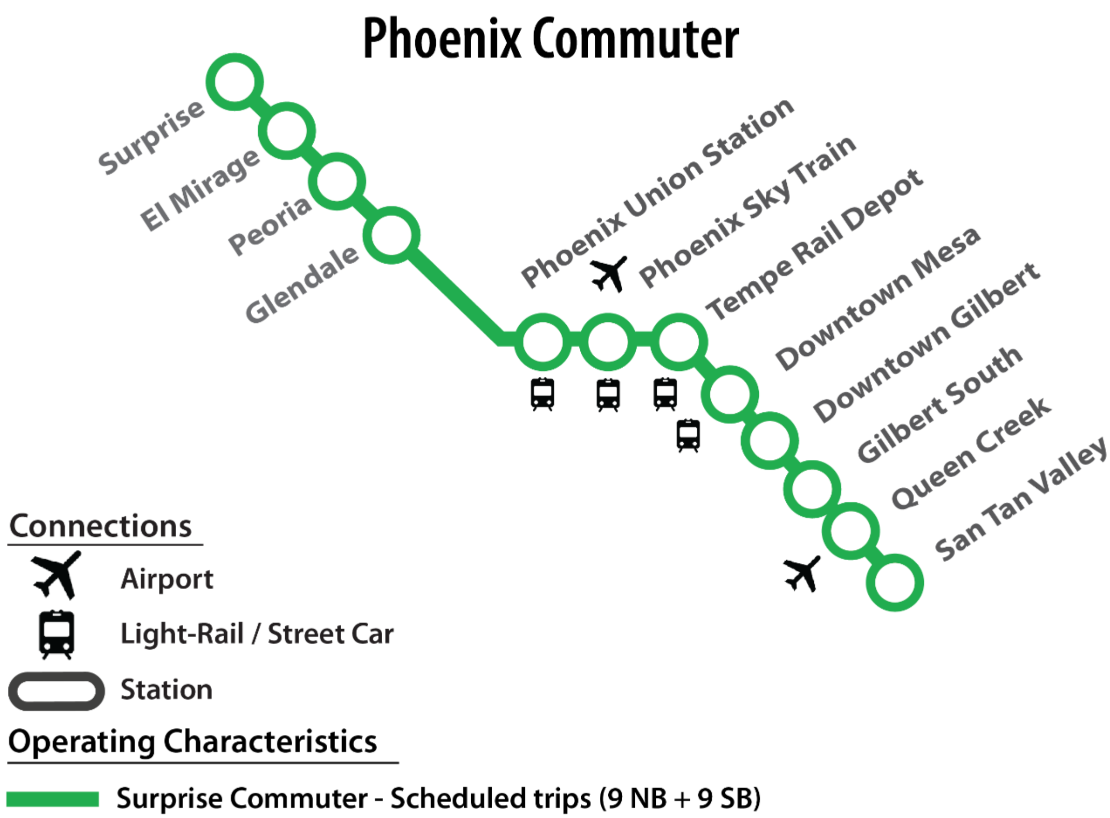
Phoenix Metro 1 is assumed, for purposes of this SDP, to complete a Tier 2 EIS, prepare all necessary designs, clear needed rights-of-way and utilities, etc. for all needs between Santan Valley and both Surprise and Buckeye prior to 2025 with construction planned as soon as funding can be identified and could be completed over a 4-year period. This phase is assumed to be considered in any future regional transportation funding source initiatives in addition to any federal funding for which it might qualify or private funding it might attract.

Figure 11-3: Phoenix Commuter Concept



Phoenix Metro 2 would complete similar documentation, but connect downtown Phoenix with Surprise only, deferring a connection to Buckeye until a later time.

Figure 11-4: Alternate Phoenix Commuter Concept



These phases focus on commuter services in the Phoenix Metro area, so federal funding opportunities may be more heavily weighted toward FTA 5309 grant money under the New Starts program than other federal sources. As far as a needed local match, the Maricopa Association of Governments (MAG) is assessing the introduction of commuter rail service that includes the segments covered in this SDP. As noted above, one possibility for a local funding source would be a renewal or expansion of the current 0.5 cent countywide sales tax for transportation that runs through 2024. A reauthorization initiative could go to voters within the next few years.

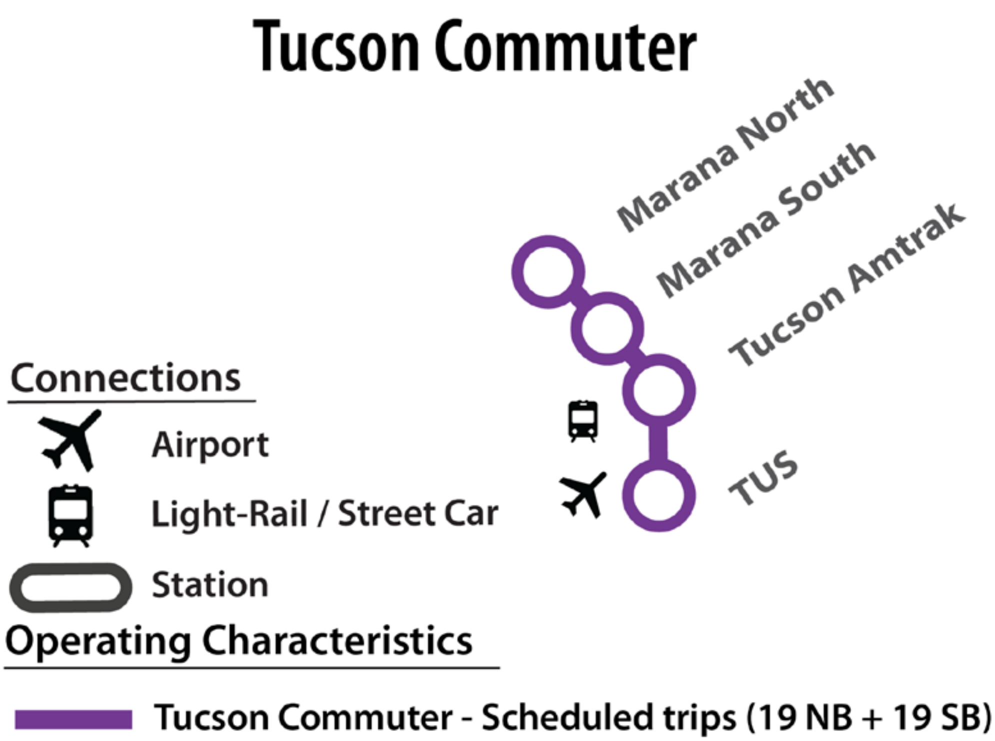
Tucson Metro Phase

Another key phase would be the implementation of commuter service in the Tucson metro area between Marana and Tucson where the project follows the I-10 freeway from Marana to south of Grant Road and UP freight lines from Grant Road, into downtown Tucson as shown in Figure 11-5. This phase is relatively straightforward from a construction perspective, but will need to address a series of decisions related to local impacts to the existing transportation system along the I-10 freeway and in the downtown section of the alternative. The cost between Marana and Downtown Tucson is estimated at about $900 million. Depending on the approach taken to project segmentation and funding, this segment is included in the “Growing the Service Phase” as part of new track south of Picacho.

Though a desirable connection to TUS is largely through an urban industrial community, it will need to negotiate a series of property acquisition obstacles, a reconfiguration of the Nogales Branch "wye" and potential neighborhood protection questions that will need further development. That effort is estimated to cost about $255 million for the approximately 7 miles of the connection.

The Tucson Metro Phase could be built in about two years and, like the MAG region, would require identification of local or private funding in addition to any federal funding that may apply. Also like MAG, the Pima Association of Governments (PAG) would most likely need to consider a reauthorization of the existing Regional Transportation Authority 0.5 cent transaction privilege tax to fund various improvements, including high capacity options such as commuter rail. Also like the Phoenix Metro plan, a commuter service would be more likely to seek FTA funding that another federal source.

Figure 11-5: Tucson Commuter Concept



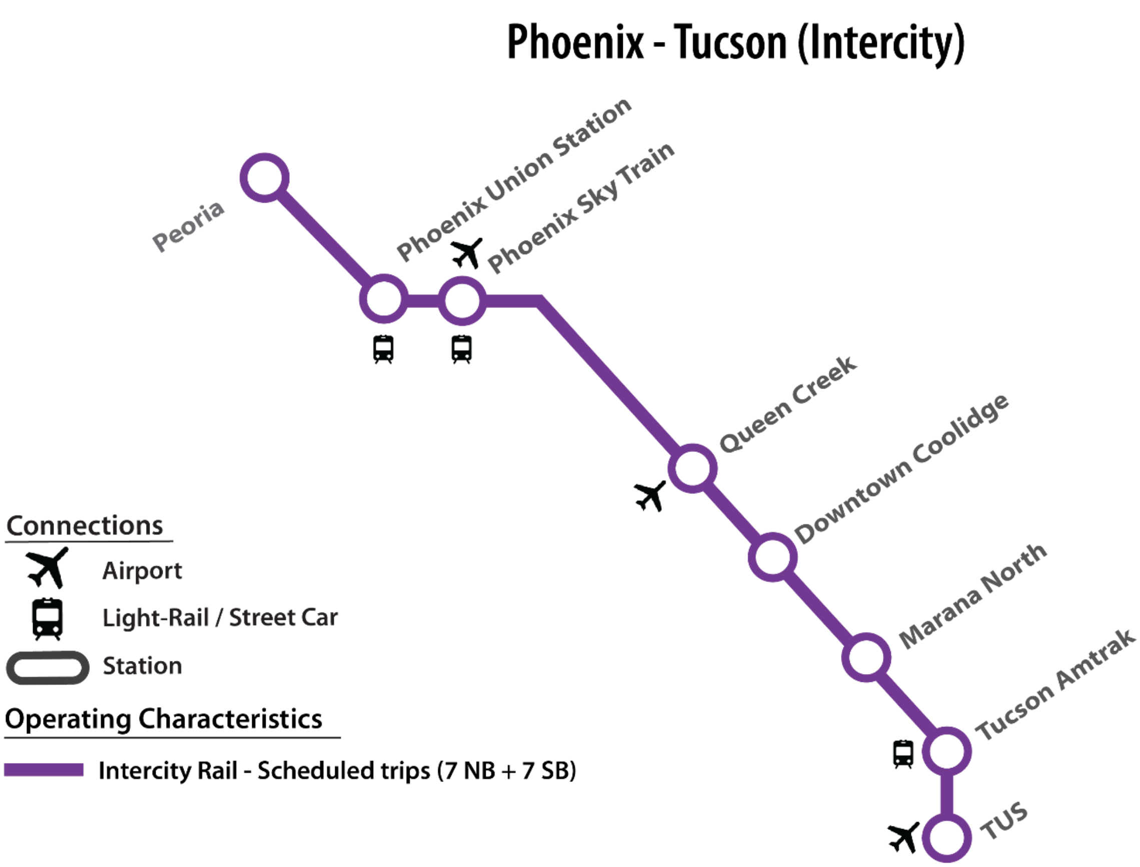
Intercity Phase

The intercity phase represented by Figure 11-6 would complete the main length of the project, joining the two commuter phases in the Phoenix and Tucson Metro areas with a 58-mile link and allowing a high level of intercity service. This element of the project could develop sooner depending on how the region evolves over the next 10 or 15 years. Intercity is a highly popular feature of the project and will afford a critical link in the system that could provide access to many growing communities in Pinal and Pima Counties. It is also the phase that could support the highest speed performance along the line.

The Picacho to Tucson section of this phase is included in the "Growing the Service Phase". The link between Santan Valley and Picacho would cost about $600 million.

As currently defined, the full Intercity Phase would cost about $1.5 billion and would take about two years to build, subject to available funding. Federal sources for the intercity service could share some FTA funding for commuter segments if they are included in the service planning, but most of the funding would more likely come from the FRA (if grants for passenger service implementation become available). From the local match perspective, the character of the operation, spanning multiple counties and agencies could precipitate a need to define a multi-regional entity that would operate or contract for operating any ongoing services. If a joint powers authority or some similar organizational structure were introduced, it would need to be able raise funds through some kind of revenue generating authority or be able to combine local/regional funds from all benefitting areas to pay for an intercity link. As with all other phases described, the private sector would be able to contribute in various ways, including development opportunities at station areas.

Figure 11-6: Intercity Concept



Alternative Segment/Phasing Options

The above ASP shows a number of possible scenarios for developing intercity and commuter rail services in the corridor. The order could be based exclusively on ridership potential, on funding availability, constructability, community support and considerations for private sector involvement or a combination of any or all of these. The segments discussed and possible order of phasing were defined to allow a lifecycle cost analysis of the key project components. Other alternative phasing plans could also be developed that address other identified priorities and needs. Influences from other projects that would contribute to the success of the Tucson to Phoenix segment (e.g., North-South Corridor, high speed passenger rail connection to the LA Basin, etc.) could also provide a basis for defining a phasing plan.

Because of the length and cost of the total project, the proposed phases/segments above should be considered aggressive and may still prove challenging to complete within tight timeframes. They are designed to provide a complete system within the corridor serving both local and intercity needs within 20 years. Should additional phasing be appropriate to defer expenditures for some segments, the individual component segments of some of the services can be subdivided further with each portion timed over an extended schedule. For example, if ridership and funding availability made it impractical to build both the Surprise and Buckeye segments of the Phoenix metro commuter services, they could be scheduled at different times with the associated effect on the required funding over that deferral period.

Based on ridership forecasts, there can be an argument made to defer or shorten the northwesterly portion of the Surprise extension to reach only as far as Peoria or El Mirage. The entire Buckeye extension could be deferred until a later date or built only as far as Avondale without a major reduction in ridership. Those changes could substantially improve the financial viability of the project. The extensions could be completed as part of later efforts to reach newer populations in the Phoenix metro area or as part of efforts to build a high-speed rail connection to Los Angeles.

At the opposite end of the spectrum, referring to the opening paragraph in this section, a combination of segments (e.g., Phoenix Metro and Intercity) could serve both the high ridership demand and ease the implementation of the whole system.

12 Benefit-Cost Analysis

When evaluating an investment, decision makers must determine if the benefits outweigh the costs. To help make this determination, Benefit Cost Analysis (BCA) is utilized. BCA compares the economic benefits to society arising from the investment against all costs incurred during a predetermined evaluation period. Societal benefits include both general public benefits, such as reduced air emissions, benefits to transportation system users and, in some cases, private benefits such as increased worker productivity as measured in value of time. Worker productivity benefits arise as long distance business travelers are not occupied by having to drive to business destinations as they would be without the train, and due to a work-friendly passenger environment (e.g., Internet access) on the train. In the case of passenger rail services, virtually all measurable benefits included in a BCA are public – either benefits available to all citizens generally or to rail and other transportation system users.

Benefits and costs are also adjusted in a BCA to account for the time value of money through discounting. BCA discounts all costs and benefits to their present value to establish a common reference for all costs and benefits identified. To maintain apples to apples comparisons, a “real discount” rate is applied to “real” dollar benefits and costs -- i.e., costs and benefits throughout the lifecycle of the project without the effects of inflation.

A benefit-cost ratio is a primary indicator of the effectiveness of proposed infrastructure investments. The benefit-cost ratio is a comparison of the discounted present value of quantifiable societal benefits versus project costs. It is measured by comparing the societal impacts of building the system to a no-build scenario or another project alternative. A benefit-cost ratio more than 1.0 indicates that a project will generate more benefits to society than it will incur in costs within the defined parameters of the study, and is justified within the premise of BCA. Other related economic and financial measures provided in the economic analysis include the net present value, and the economic rate of return. Other factors and criteria must be used in conjunction with a BCA to make a broad decision as to the merits of an investment.

The BCA described below uses WSP|Parsons Brinckerhoff’s program PRISM™ and follows industry methodology best practices consistent with the U.S. Department of Transportation guidance, including FRA’s new BCA Guidance for Rail Projects released in June 2016. It also includes guidelines for BCA promulgated by the USDOT about its discretionary grant programs (e.g., TIGER). These methods are conservative in their assumptions and are intended to produce results which do not overstate or double-count benefits.

The benefit components of the benefit-cost analysis are largely driven by the ridership forecasts, which is a potential challenge for the APRCS results in that the forecasting tools used do not comprehensively cover all service options. In this analysis, travel time savings, as measured in value of time, can be substantial for riders who shift from car to rail, and results in reductions in vehicle use which decreases automobile operating and maintenance costs, vehicle ownership costs, vehicle emissions, and railroad collisions that would otherwise incur. In addition, new riders who simply would not have made trips without the new service, also receive a benefit from this new travel opportunity.

Because ridership is a primary determinant of benefit, intercity services, in particular, will also be greatly affected by the prospects of a passenger rail connection between Arizona and California because that link is forecast to dramatically increase the number of travelers in the Phoenix-Tucson Corridor. While not included here, the potential improvement in the benefit measures is significant.

Other benefits result from reductions in vehicle miles of automobile travel. These reductions produce benefits -- in addition to direct user cost savings – resulting in less road maintenance, lower vehicle emissions, and fewer highway crashes. Since commuter and intercity passenger rail have fewer negative environmental effects than automobile or air travel, the more riders on the passenger rail system, the more benefits are realized for the public.

Distinguishing between the benefit-cost analysis and wider, or indirect, economic impacts is important. The benefit-cost analysis measures the societal benefits that are most readily quantifiable. Benefit-cost analysis adheres to formal definitions that are generally conservative in nature. In particular, the analysis does not include a range of indirect economic benefits that can be forecast and which could materialize, such as increased state and regional competitiveness, increased employment from new business attractions or startups, or increased real estate development around new rail stations. These effects, to the extent they occur, could lead to increased economic output and employment in Arizona.

At this planning level analysis, inputs such as ridership and even costs are subject to change once more detailed engineering work is completed, therefore the BC ratios, while the best information available now should only be considered as approximations of final values. Further study and more precision in the input data will be needed to increase the precision of the BC ratios.

The phasing or segment concepts developed at a high level to assess what alternative or combination of alternatives would result in the optimum performance of the proposed passenger rail service were considered in developing the BCA. The project is consistent with the objectives of the ADOT State Rail Plan and the long-term vision for the corridor. The economic impact, not monetized in the benefit-cost analysis, is expected to spur growth within the corridor and provide a new transportation option to thousands of area residents.

12.1 Key Analytic Assumptions

Analytical Assumptions

Benefit Cost Analysis Framework

A Benefit Cost Analysis (BCA) is an evaluation framework to assess the economic advantages (benefits) and disadvantages (costs) of an investment alternative. Benefits and costs are broadly defined and are quantified in monetary terms to the extent possible. The overall goal of a BCA is to assess whether the expected benefits of a project justify the costs from a national perspective. A BCA framework attempts to capture the net welfare change created by a project, including cost savings and increases in welfare (benefits), as well as dis-benefits where costs can be identified (e.g., project capital costs), and welfare reductions where some groups are expected to be made worse off as a result of the proposed project.

The BCA framework involves defining a "No Build" Case, which is compared to the "Build" Case, where the funds requested are awarded and the project is built as proposed. The BCA assesses the incremental difference between the No Build Case and the Build Case, which represents the net change in welfare. BCAs are forward-looking exercises which seek to assess the incremental change in welfare over a project life-cycle. The importance of future welfare changes is determined through discounting, which is meant to reflect both the opportunity cost of capital as well as the societal preference for the present.

The analysis was conducted in accordance with the benefit-cost methodology as recommended by the U.S. DOT in the 2016 FASTLANE Benefit-Cost Analysis Guidance.[10] This methodology includes the following analytical assumptions:

- Defining existing and future conditions under a No Build base case as well as under the Build Case;
- Estimating benefits and costs during project construction and operation, including at least 20 years of operations beyond the Project completion when benefits accrue;
- Using U.S. DOT recommended monetized values for reduced fatalities, injuries, property damage, travel time savings, and emissions, while relying on best practices for monetization of other benefits;
- Presenting dollar values in real 2015 dollars. In instances where cost estimates and benefits valuations are expressed in historical dollar years, using an appropriate Consumer Price Index (CPI) to adjust the values;
- Discounting future benefits and costs with real discount rates of 7 percent and 3 percent (sensitivity analysis) consistent with U.S. DOT guidance.

As noted above, this benefit cost analysis was done using PRISM™, a proprietary WSP|Parsons Brinckerhoff benefit cost analysis tool that uses a methodology consistent with the most recent guidelines developed by USDOT.

[10] U.S. Department of Transportation. Benefit-Cost Analysis Guidance for 2016.

Evaluation Period

The APRCS evaluation period includes the relevant engineering and design costs, land acquisition costs, construction of the various phases of the project, and 20 years of operations beyond final project construction completion.

For the purposes of this study, different scenarios were evaluated with engineering and design costs incurred at various times. The construction period starts in 2024 and continues through the end of 2032 in the longest forecast project schedule with operations of the last phases of the project assumed to begin the same year. The analysis period, therefore, begins with the first expenditures in 2024 and continues through construction and 20-years of operations, or through 2044.

All benefits and costs are assumed to occur at the end of each year.

Analysis Tool

The benefit cost analysis was supported using a Microsoft Excel-based benefit cost analysis tool with methodology consistent with the most recent guidelines developed by USDOT. The tool determined benefits according to the following five categories: State of Good Repair; Economic Competitiveness; Livability; Sustainability; and Safety. In addition, quantifiable benefits are adjusted to develop a high and low scenario for evaluating a range of expected benefit-cost ratios.

Overview of Benefits and Costs

The following identifies and groups the benefits that are included in the BCA for the APRCS. Most of these benefits occur as a result of reducing travel time for rail users, and benefits associated to reductions in vehicle miles traveled. The costs considered are typical for most projects: land acquisition, construction, operations and maintenance (O&M), and rehabilitation and replacement (R&R) costs.

Economic Competitiveness

Travel Time Savings

Travel time savings includes reductions for travelers who mode shift from vehicle to rail, in-vehicle travel time savings for auto drivers and passengers as well as truck drivers and bus passenger who benefit from reduced congestion from fewer vehicles on the road, and offsets for increased travel times for vehicle users who are delayed at at-grade crossings associated to the rail project. Travel time is considered a cost to users, and its value depends on the disutility that travelers attribute to time spent traveling. A reduction in travel time translates into more time available for work, leisure, or other activities.

Value of Time Assumptions

Travel time savings must be converted from hours to dollars in order for benefits to be aggregated and compared against costs. This is performed by assuming that travel time is valued as a percentage of the average wage rate, with different percentages assigned to different trip purposes.

Because the exact division between personal and business travel is not known for trips potentially impacted by this project, the values of time for “all purposes” are used; these represent a weighted average of the personal and business values of time according to national proportions of personal and business as calculated by the U.S. DOT.[11]

Additionally, U.S. DOT guidance accepts the use of a real growth rate of 1.2 percent a year for the value of time.[12]

Reductions in Vehicle Operating Costs

Vehicles have operating costs beyond fuel costs that will be addressed in the next section. These costs include maintenance and repair, replacement of tires, and the depreciation of the vehicle over time. The per VMT factors of these costs were estimated by the American Automobile Association[13] and the American Transportation Research Institute,[14] and used in this analysis. The per VMT costs are multiplied by the total projected annual reduction in VMT. The VMT reductions associated to the APRCS are assumed to be primarily auto users switching modes to rail. Similar adjustments were made for trucks, however buses were assumed to maintain their existing routes, with no change in associated VMTs.

Fuel Prices

Fuel efficiency values were derived from the U.S. Energy Information Administration (EIA), which provides estimates for fuel efficiency through 2040. The values used to calculate fuel efficiency can be found in the table published by EIA titled "Transportation Sector Key Indicators and Delivered Energy Consumption."[15] The following fuel efficiency values were used for the different vehicle classes:

- "Light Duty Stock" energy efficiency (mpg) for passenger vehicles.
- "Freight truck" energy efficiency (mpg) for trucks.

The EIA provides estimates for fuel prices through 2040 that were used for the purposes of estimating the reduction in fuel costs associated to the reduction in VMT.

Because fuel taxes are considered a pecuniary benefit, or transfer payment, they cannot be accurately included in benefit calculations of a BCA. Thus, the federal and Arizona state taxes published by the EIA are subtracted out of the end user fuel prices.

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[11] Ibid.

[12] Office of the Secretary of Transportation. (2014). *Revised Departmental Guidance: Valuation of Travel Time in Economic Analysis (Revision 2),* p. 14. (http://www.dot.gov/sites/dot.gov/files/docs/USDOT%20VOT%20Guidance%202014.pdf)

[13] AAA Exchange. (2013). *Your Driving Costs*, p.7-8. (http://exchange.aaa.com/wp-content/uploads/2013/04/Your-Driving-Costs-2013.pdf)

[14] American Transportation Research Institute. (2014). *An Analysis of the Operational Costs of Trucking*, p.15. (http://atri-online.org/wp-content/uploads/2014/09/ATRI-Operational-Costs-of-Trucking-2014-FINAL.pdf)

[15] Energy Information Administration. (2015). Annual Energy Outlook 2015. *Components of Selected Petroleum Product Prices, United States, Reference case.* [Microsoft Excel] (http://www.eia.gov/beta/aeo/#/?id=7-AEO2015)

All dollars were reported in real 2013 dollars by the EIA. These dollar amounts were subsequently converted to real 2015 dollars using the U.S. Bureau of Labor Statistics Consumer Price Index adjustment for "motor fuel" between 2013 and 2015.[16]

To account for change in the cost of motor gasoline over time, this analysis applies the CAGR forecasted for likely fuel costs across the time period of the analysis, from 2017-2037 for each fuel type. This allows the cost of fuel to grow over time which is consistent with historic trends.

Safety

Accident Cost Savings

The BCA assumes constant accident rates for the "build" and "no build" scenarios. As a result, any changes in the number of accidents will be a result of changes in VMT, not of structural changes to the safety conditions on the roadway network. Additional potential for crashes is assumed with increased train movements and additional at-grade crossings which more than offsets the improvements associated to drivers who mode shift to rail from driving.

The cost savings that arise from a reduction in the number of accidents include direct savings (e.g., reduced personal medical expenses, lost wages, and lower individual insurance premiums), as well as significant avoided costs to society (e.g., second party medical and litigation fees, emergency response costs, incident congestion costs, and litigation costs). The value of all such benefits – both direct and societal – could also be approximated by the cost of service disruptions to other travelers, emergency response costs to the region, medical costs, litigation costs, vehicle damages, and economic productivity loss due to workers' inactivity.

In order to convert state average crash rates into the appropriate AIS scale for calculating benefits, national statistics from the National Highway Traffic and Safety Administration were used. [17] By using the national statistics, it was possible to derive the distribution of total injuries into their respective AIS categories which lists each AIS category as a proportion of all possible injuries

Monetized values for fatalities, and accidents categorized on the AIS scale are reported in the U.S. DOT's guidance for "Treatment of the Economic value of a Statistical Life"[18]. Values pertaining to property

[16] U.S. Bureau of Labor Statistics. Consumer Price Index, All Urban Consumers, U.S. City Average, Motor Fuel. Series CUUR0000SETB. 1982-1984=100, 2010=240.724; 2011=301.448
[17] National Highway Traffic Safety Administration (2002), The Economic Impact of Motor Vehicle Crashes, 2000, p. 9, Table 3 "Incidence Summary – 2000 Total Reported and Unreported Injuries."

[18] Office of the Secretary of Transportation, *Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Department of Transportation Analyses* (2013 update), Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Department of Transportation Analyses.

damage only accidents were reported by the National Highway Traffic and Safety Administration,[19] and provided in 2015 dollars by the U.S. DOT.[20]

Sustainability

Noise Pollution

Reducing VMT, creates environmental benefits to society in the form of noise reduction. On a per-VMT basis, these values were estimated based on a Federal Highway Administration cost allocation study report.[21] VMT reductions associated to the APRCS are assumed to be primarily from rail users who mode shift from car which are offset by increased noise due to idling of road vehicles at at-grade crossings.

When calculating the impact of truck noise, the 40 kip[22] 4-axle single unit trucks were used for the low value, 60 kip 4-axle single unit trucks for the likely value and 60 kip 5-axle combination units for the high case.

An urban and rural split of 94 percent and 6 percent respectively was used to create a weighted average of the FHWA values for those environments. All values were adjusted from the study's 2000 values to 2015 dollars using a CPI adjustment.[23]

Emissions

The APRCS will create environmental and sustainability impacts relating to air pollution associated with automobile and commercial truck travel. Five forms of emissions were identified, measured and monetized, including: nitrous oxide, particulate matter, sulfur dioxide, volatile organic compounds, and carbon dioxide. Reductions associated to the APRCS are assumed to be primarily from rail users who mode shift from car which are offset by increased emissions from the diesel train engines and due to idling of road vehicles at at-grade crossings.

Emission Rates

Per-mile emissions rates for automobiles were derived from the California Environmental Protection Agency's Air Resources Board EMFAC2011 Emissions Database.[24] This tool provides emissions rates projected out to 2035. After 2035, emissions rates are assumed "flat-line." The flat-line represents both

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[19] National Highway Traffic Safety Administration (2002*), The Economic Impact of Motor Vehicle Crashes, 2000,* p. 62, Table 3.
[20] U.S. Department of Transportation (2015), *Tiger Benefit-Cost Analysis (BCA) Resource Guide*, p.3. (http://www.dot.gov/sites/dot.gov/files/docs/Tiger_Benefit-Cost_Analysis_%28BCA%29_Resource_Guide_1.pdf).

[21] Federal Highway Administration, *Addendum to the 1007 Federal Highway Cost Allocation Study,* Table 13. (http://www.fhwa.dot.gov/policy/hcas/addendum.htm).
[22] A kip is a unit of mass, equal to 1,000 pounds, i.e. one half of a short ton and is used as a unit of deadweight to compute shipping charges.
[23] Bureau of Labor Statistics, Consumer Price Index, All Urban Consumers, US City Average, All Items, Series CUSR0000SA0.
[24]California Environmental Protection Agency Air Resources Board. (2011). EMFAC2011 Emissions Database. (http://www.arb.ca.gov/emfac/)

a leveling out of emissions rates, as well as consideration for the uncertainty in estimating rates that far into the future. Per mile emissions factors differ depending on vehicle, fuel efficiency, average speed, and driving conditions. This BCA used emissions factors for automobiles at aggregated model years. It is important to note that a unique set of emissions factors exists at each speed. Thus, the emissions data set consists of emissions factors for each emissions type, by year, and by speed.

Value of Non-CO2 Emissions Costs

In order to monetize the emissions, the values of PM_{10}, NO_x, SO_x, and VOC emissions were derived from a National Highway Traffic and Safety Administration's CAFE standards for MY2017-MY2025.[25] These are consistent with U.S. DOT guidelines.

Value CO_2 Emissions Costs

The per-ton costs of carbon emissions were derived from the Interagency Working Group on the Social Cost of Carbon[26] as well as the analysis conducted by U.S. DOT in the TIGER Benefit–Cost Analysis Resource Guide.[27] The social cost of carbon was discounted at a 3 percent discount rate, consistent with the U.S. DOT's guidance. [28]

To account for change in the social cost of carbon overtime the CAGR from the likely scenario, over the time period of the analysis, from 2020-2039, is applied to each case. This allows the social cost of carbon to grow over time which is consistent with EPA guidance.[29]

State of Good Repair

As with noise pollution, reductions in VMT lead to societal benefits in the form of reduced costs of pavement damage. Fewer vehicle-miles lead to a lower need of maintenance on roads. The per-mile costs of these values were estimated based on the same Federal Highway Administration cost allocation study report that reported estimations of the cost of noise pollution.[30]

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[25] National Highway Traffic and Safety Administration (August 2012), *Corporate Average Fuel Economy for MY2017-MY2025 Passenger Cars and Light Trucks*, page 922, Table VIII-16, "Economic Values Used for Benefits Computations (2010 Dollars)", http://www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/CAFE_2012-2016_FRIA_04011510.pdf

[26] U.S. Environmental Protection Agency, Interagency Working Group on Social Cost of Carbon (2013), *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866,* p.18., Table A1, (https://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf).

[27] U.S. Department of Transportation (2016), *Tiger Benefit-Cost Analysis (BCA) Resource Guide*, p.7. (https://www.transportation.gov/sites/dot.gov/files/docs/BCA%20Resource%20Guide%202016.pdf)

[28] U.S. Department of Transportation (2015), *Tiger Benefit-Cost Analysis (BCA) Resource Guide*, p.7-9. (http://www.dot.gov/sites/dot.gov/files/docs/Tiger_Benefit-Cost_Analysis_%28BCA%29_Resource_Guide_1.pdf)

[29] U.S. Environmental Protection Agency, Interagency Working Group on Social Cost of Carbon (2010), *Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866,* p.2., Table 19, (http://www.epa.gov/oms/climate/regulations/scc-tsd.pdf).

[30] Federal Highway Administration, *Addendum to the 1007 Federal Highway Cost Allocation Study,* Table 13. (http://www.fhwa.dot.gov/policy/hcas/addendum.htm).

When calculating the impact of truck pavement maintenance effects, the 40 kip[31] 4-axle single unit trucks were used for the low value, 60 kip 4-axle single unit trucks for the likely value and 60 kip 5-axle combination units for the high case.

The same urban/rural split used in the noise pollution calculations of 94 percent to 6 percent were used to create a weighted average of the FHWA values. All values were adjusted from the FHWA study's 2000 values to 2014 dollars using a CPI adjustment.[32]

Economic Costs Included and Assumptions

In the benefit-cost analysis, the term "cost" refers to the additional resource costs or expenditures required to implement, and maintain the investments associated with the APRCS.

The BCA uses project costs that have been estimated for the APRCS on an annual basis. Operations and maintenance costs and rehabilitation costs were initially expressed in real dollars while the capital costs were initially expressed in real 2014 dollars.

Initial Project Investment Costs

Initial project investment costs include engineering and design, construction, real estate services, vehicles, other capital investments, and contingency factors. These costs were provided by WSP | Parsons Brinckerhoff and included costs beginning in 2024 and ending in 2032. Under the full build out assumptions all the lines are expected to be operational in 2032.

Annual Operating and Maintenance Costs

The annual costs of operating and maintaining the APRCS are included in the analysis. Operations and maintenance activities apply to the stations, at-grade crossing, vehicle and track infrastructure. Operating and maintenance costs are assumed to begin in 2025.

The O&M costs reported are the marginal operating costs, or the costs above and beyond those expected in the "no build" scenario.

Periodic Capital Equipment Replacement Costs and Major Rehabilitation

Included in the O&M cost category several types of initial asset investments will need to be replaced or rehabilitated during the evaluation period. To account for this, WSP | Parsons Brinckerhoff created a schedule of rehabilitation and associated costs. These costs are annualized and included in the O&M cost values.

Residual Value

The APRCS is assumed to have assets with 25, 30, or 70-year life cycle depending on the cost item, after which point the facility will need replacement and rehabilitation. This benefit cost analysis however ends in 2044, therefore at the end of the analysis period, infrastructure that has been put in place

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[31] A kip is a unit of mass, equal to 1,000 pounds, i.e. one half of a short ton and is used as a unit of deadweight to compute shipping charges.
[32] Bureau of Labor Statistics, Consumer Price Index, All Urban Consumers, US City Average, All Items, Series CUSR0000SA0.

initially or during scheduled replacement cycles, will not have been completely worn out, and will continue to provide benefits into the future. These future benefits are captured in the Residual value, also known referred to as "Remaining Capital Value," or RCV. In this analysis, the RCV is calculated using a straight-line depreciation method.

Discount Rate

For evaluating the proposed passenger rail investments, dollar figures are expressed in constant 2014 dollars. In instances where certain cost or benefit estimates are expressed in dollar values in other (historical) years, the U.S. Bureau of Labor Statistics' Consumer Price Index for Urban Consumers (CPI-U) for the respective year was used to adjust the figures.

The discount rate used in the analysis is 3 percent. This discount rate is consistent with US DOT guidance and with OMB Circular No. A-94 and A-4 (Office of Management and Budget, 1992, Revised December 2014) which permits the use of lower discount rates when projects are being financed with public funds.

Evaluation Period

Benefits and costs are typically evaluated for a timeframe that includes the length of construction and an operating period of 30 years after the initial project investments are completed. To analyze the service alternatives for this corridor, the evaluation period includes the projected construction period for the required infrastructure, plus 30 years of operations during which the benefits of the services materialize.

Travel Demand Sources & Forecast Years for Highway Benefits

The project team provided estimates of ridership, revenue, and passenger-miles traveled for each of the new services (i.e., commuter and intercity) in the region. They represent the total demand in 2010 if the new service had been in operation and provides a baseline from which future years were calculated.

Future years were projected based on forecast socio-economic changes to 2035 and forecast using the FTA STOPS model to generate ridership estimates. For all benefit calculations, ridership estimates attributable to the new services were used for calculations.

Average Vehicle Occupancy Assumption

One type of benefit is reduced use of motor vehicles in exchange for riders on the train. This affects emissions and safety, for example. Consequently, it was necessary to translate passengers into eliminated vehicle-miles. This analysis assumes average vehicle occupancy (AVO) rates of 1.2 persons per vehicle for trips shorter than 50 miles and 2.4 for trips longer than 50 miles. This AVO rate is adopted from the travel forecasting model (STOPS) used to forecast ridership in the analysis and is generally consistent with other systems' experience. For purposes of this calculation, it was assumed that 80 percent of the ridership came from automobiles, 10 percent from bus or air, and 10 percent from new trip making.

12.2 Benefit-Cost Analysis Results

Results in Brief

Alternative Service Plan includes Tucson-Phoenix (Peoria) intercity service, Tucson commuter service offering morning and evening connections between Tucson International Airport and North Pima County (Marana), and Phoenix commuter service between Santan Valley and Surprise and Buckeye. Summary results are shown in Table 12-1. A conservative 40 percent contingency was factored in the analysis as the cost estimates are only at the planning level. Using a high (30 or 40 percent) contingency factor is accepted practice when no detailed engineering has been performed to account for potential variance between the planning level estimate and engineered costs

Table 12-1 - Summary of Benefits and Costs for ASP (in 2014 $) with Possible Segments/Phases over a 30-year Horizon

Scenario	**Full Phoenix-Tucson Intercity and Commuter**	**Full Phoenix-Tucson Intercity and Commuter** [Use of BNSF Track (Phoenix-Surprise)]	**Amtrak Connection** (All existing UP track)	**Tier 0 – Growing the Service** (Existing UP track n/o Picacho and new track s/o Picacho)	**Phoenix-Tucson Intercity** (Peoria-TIA)	**Tucson Commuter** (Marana-TUS)	**Phoenix Commuter** (Santan Valley-Surprise/Buckeye)	**Phoenix Commuter** (Santan Valley-Surprise)
Service								
	Commuter Service: - Buckeye to San Tan (*18 trips*) - Surprise to San Tan (*18 trips*) - Marana to TUS (*38 trips*) ***Intercity:*** - Peoria to TUS (14 trips)	***Commuter Service:*** - Buckeye to San Tan (*18 trips*) - Surprise to San Tan (*18 trips*) - Marana to TUS (*38 trips*) ***Intercity:*** - Peoria to TUS (14 trips)	***Commuter Service:*** - Surprise to TUS (*8 trips*)	***Commuter Service:*** - Surprise to TUS (*14 trips*)	***Intercity:*** - Peoria to TUS (14 trips)	***Commuter Service:*** - Marana to TUS (*38 trips*)	***Commuter Service:*** - Buckeye to San Tan (*18 trips*) - Surprise to San Tan (*18 trips*)	***Commuter Service:*** - Surprise to San Tan (*18 trips*)
Benefits								
Travel Time Savings	$2,376,610,591	$2,376,610,591	$1,251,721,647	$1,568,462,340	$609,488,358	$368,862,314	$1,978,097,203	$1,680,912,580
Roads and Highways								
Highway User Fuel Savings	$413,900	$413,900	$128,833	$244,900	$21,306,328	$77,600	$300,789	$244,119
Oil Import Savings	$73,517	$73,517	$20,929	$39,784	$3,461	$13,452	$54,296	$44,066
Reduction in Pavement Damages	$5,449	$5,449	$1,674	$3,181	$276,772	$1,021	$3,967	$3,220
Emissions Savings	$21,426,609	$21,426,609	$(8,520,265)	$(16,188,147)	$784,118	$4,947,014	$21,115,887	$16,538,579
Noise Savings	$5,449	$5,449	$1,674	$3,181	$276,772	$1,021	$3,967	$3,220
Safety Savings	$428,229,513	$428,229,513	$116,842,731	$315,753,999	$5,149,642	$124,448,006	$682,207,893	$554,159,786
Total Benefits	**$2,814,204,930**	**$2,814,204,930**	**$1,358,950,053**	**$1,865,986,315**	**$705,403,386**	**$496,794,609**	**$2,674,569,791**	**$2,244,508,564**
Costs								
Capital Costs	$3,518,711,110	$3,242,639,622	$1,018,813,428	$1,474,925,584	$2,410,042,963	$ 582,079,873	$ 2,134,277,123	$1,590,610,619
Net O&M costs	$695,381,446	$695,381,446	$115,755,473	$202,562,642	$196,575,464	$ 121,266,201	$ 377,539,781	$176,725,664
Residual value	$(391,600,698)	$(374,793,993)	$(30,063,262)	$(187,977,972)	$(311,695,952)	$ (55,728,464)	$ (203,508,971)	$(148,411,714)
Total Costs	**$3,822,491,858**	**$3,563,227,075**	**$1,104,505,639**	**$1,489,510,254**	**$2,294,922,474**	**$ 647,617,610**	**$ 2,308,307,933**	**$1,618,924,570**
B/C Ratio	0.74	0.79	1.23	1.25	0.31	0.77	1.16	1.39

(40% contingency included on infrastructure and rolling stock)

12.3 Summary

This analysis shows that the preliminary anticipated quantifiable benefits from the Tucson-Phoenix APRCS compared to their anticipated costs. The Phoenix commuter segment, in particular, performs very well as do the short-term host railroad options. The fact that some segments perform better than others may offer guidance regarding the most likely phasing of the project upon implementation, but the numbers alone should not be the primary determining factor in how the project moves forward. Other considerations based on local needs, funding availability for certain types of service and opportunities to attract private investment can influence the implementation decision in a way that is not directly covered by the benefit cost analysis.

It is important to note that, at this planning level analysis, inputs such as ridership and even cost (which include a very conservative 40% contingency) are subject to change once a more detailed analysis is completed and more refined forecasting tools can be applied, therefore the BC ratios, while being the best information available at this time, should only be considered approximate values.

13 Recommendation

The APRCS SDP studied how passenger service could be introduced into the Phoenix-Tucson Corridor. Two main corridor-wide options were developed based on a blended intercity-commuter service concept supported by the travel needs and demand in the corridor, the Base Service Plan (BSP) and the Alternative Service Plan (ASP). The BSP provided both commuter and intercity service throughout the corridor and attracted slightly higher ridership than the ASP. The ASP offered commuter service only in the two metropolitan areas in addition to the intercity service between Tucson and Phoenix. This operation, though slightly lower in terms of ridership, was substantially less costly in annual operating expenses yielding a more favorable lifecycle cost. Hence, the ASP was selected as the preferred alternative for the proposed corridor service and is the recommendation of this SDP to serve the Phoenix-Tucson Corridor.

The cost of the entire corridor program is just under $5 billion which suggests phasing will be needed to deliver it. The SDP looks at a number options for how the service can grow over time with an emphasis on ridership potential and opportunities for cost savings or funding. From an all-host-railroad option of intercity service to commuter rail services at one or both ends, there is a wide range of phases possible.

While the recommended first step is the Tier 0 or the Growing the Service option which would build new passenger track between Picacho and Tucson, it is also recommended to pursue further discussion about any possible early implementation steps that would introduce service sooner in a way that can be built upon going forward. A combination of early actions will show a commitment to a corridor-wide program that connects the two metropolitan areas that makes a major investment in new track, eliminates or minimizes use of the Sunset Route (which is important to UPRR) and carries reasonable ridership numbers that will add a new travel option and contribute to improving travel in the corridor.

Appendix A - Program Management

Marketing

Customer Expectations

A successful passenger rail corridor service, and the protection of the public investment to construct and operate it, depends on outstanding customer service to grow and retain ridership. The goal is to attract not only riders dependent on public transport, but the broader market of those that have a choice about their travel. Meeting customer expectations is designed into the system and maintained and improved through competent management of the service.

Designing customer expectations into the system means setting convenient schedules with appropriate frequencies, trip time commensurate with the trip purposes, and the infrastructure required to reliably meet those requirements. Customers also expect to reach their final destinations without difficulty. Convenient intermodal connections such as convenient walking distances, curbside pickup, availability of taxis, rental cars, and local transit must be available. In addition, origin stations must assure that adequate parking is available.

Other customer service provisions are the result of competent management. The passengers expect courteous personnel, accurate information regarding their passage, straightforward ticketing and adequate signage for those unfamiliar with train travel, on-board amenities appropriate to the trip length and hours of travel, comfortable seating and temperature control, and clean surroundings.

The successes and growth experienced by other rail services around the country and the world is usually the result of constant attention to customer service. In the public's eye, the brand and the service are closely associated. The branding and marketing plans of these new services need to be addressed early in the implementation stage.

Rail Service Management Models: Implementing Agency

In many states, the management of the passenger rail program is the responsibility of the state department of transportation. In some cases, the passenger rail program is managed by a separate department or authority. There are successful examples of both options. Regardless of how a passenger rail program is institutionally organized, a management model will be needed to define the implementing agency for the project. A workable balance must be struck between the ability to compete for resources afforded by independence and the need for support services that stems from being a part of a large established organization.

State DOT Program Management Models

In Arizona, there is currently no state-level governance entity for intercity rail services. ADOT could be assigned responsibility for intercity service, but that decision would have to be weighed against other options. While commuter services could fall under a local transit agency's purview, at present there is no structure in place to provide for that. There is also the possibility that both intercity and commuter rail services could be organized under a single entity such as a joint powers authority (JPA) or similar to create an "implementing agency."

The question about governance has broad implications for how the program develops (i.e., funding, construction, operations, etc.) and how the program and promotes services (i.e., branding, marketing, etc.). At some point, a decision on governance will have to be answered to move the program toward implementation.

If the implementing agency is a state agency, several states have attempted to balance the often conflicting access to independent resources and support services by elevating the rail program within their DOT as a separate division with an element of independence. The State of Texas recently created a Division of Rail within TxDOT. As part of the service development program, the states will evaluate the rail management models and develop the management program.

Rail Authority Models

Maine Passenger Rail Authority: The State of Maine created a state passenger rail authority (Northern New England Passenger Rail Authority or NNEPRA) to be responsible for the development, management and operation of the state's intercity passenger program. The service that operates between Portland, Maine and Boston and is known as the "Downeaster" is one of the best run intercity corridor services in the country and recognized for outstanding customer service and efficient operations.

One of the principal issues that influenced the creation of the separate rail authority was the liability associated with the operation of passenger rail service. The principle was that having separation between the Maine DOT and the Authority would limit the state's liability in event of an accident.

California Regional Passenger Rail Authority: In California, the choice of model centered on the desire for local control of the corridor service and that regional management would produce rail service suited to the needs of the region and the service could be better coordinated with local transit and land use planning.

California law provides for a region to create a JPA and to assume the day to day management of the rail program from the state. The Capitol Corridor service, which currently comprises 32 intercity passenger rail corridor trains per day between San Jose-Oakland and Sacramento, started under the management of the California Department of Transportation Division of Rail. After several years, the jurisdictions served by the Capitol Corridor passenger rail service petitioned the state to allow creation of the JPA. The Capitol Corridor JPA has successfully managed the service for more than thirteen years. During this timeframe, the service grew from a start up to having the third largest corridor ridership in the entire country behind only the Northeast Corridor (NEC) between Washington DC and Boston and the Surfliner Corridor in Southern California.

Program Delivery Requirements

The complexity of the proposed project would require an integrated approach to project delivery. While premature to develop a detailed program delivery plan, it is reasonable to begin to outline the agreements that are required to be developed should the program move forward.

There are three types of agreements that would need to be established:

- Agreements between the implementing agencies and the Federal Railroad Administration related to federal funding.
- Agreements between implementing agencies and local jurisdictions for improvements and operation of stations.
- Operating agreements between the implementing agencies and the host railroad concerning terms of access and operation of passenger rail service. This will involve an agreement with UP and a selected operator.

The state agencies may act independently; however, their efforts will be closely coordinated.

Coordination Elements: Agreements

Operating Agreements

Operating agreements exist between Amtrak and the host railroad for the operation of Amtrak trains. A similar arrangement would have to be established for a new service regardless of who ultimately is responsible for it if the service runs on an underlying freight line or right-of-way. While Amtrak could certainly be considered to operate the proposed Tucson-Phoenix Intercity service, it should not be assumed that Amtrak would be selected as the operator.

Several private firms who have been successful in operating major commuter rail systems in this country (e.g., TransitAmerica, Veolia, Keolis, etc.) could be an alternative to Amtrak as a service provider:

While some freight railroads will take on passenger services, UP, the owner of much of the rail right-of-way within the Tucson-Phoenix corridor, has not historically been interested in doing so except under very specific conditions.

The agreement between the implementing agency and the operator will address the quality and cost of the service including the specific service outcomes (frequency of service, trip times, on time performance objectives, costs, etc.) and flow to the host railroad regarding relevant contract provisions such as on-time incentives.

Operating agreements may also have provisions for the maintenance of equipment unless the decision is made to contract for maintenance services separately. Depending on ownership and maintenance arrangements, the operating agreement may address equipment availability and reliability issues.

Host Railroad Agreement

The implementing agency would negotiate an agreement with the host railroad in conjunction with the negotiations with the selected operator of the service. This contract would include an agreed upon level of service, schedule of trains, cost of service and the liability arrangements between the parties.

The FRA insists that the host railroad agreement address the maintenance of the infrastructure improvements when the railroad is the recipient of federal constructions funds. This is to ensure that the level of utility established under the construction agreement is provided. When the construction agreement provides for the improvements to be owned by the host railroad, there must be provisions to ensure that the public receives the benefits from the passenger rail service that are anticipated and funded. In the Tucson-Phoenix Corridor, the concept has been to take advantage of the UP right-of-way, but on a completely separate track. This configuration could justify that maintenance remain the responsibility of the operating entity.

Liability Issue

Amtrak has negotiated national agreements with each individual Class 1 freight railroad that specify how the liability will be shared in the event of an accident. These agreements are complex and have evolved over many years. Irrespective of any negligence or fault of the host railroad, Amtrak agrees to indemnify and hold harmless the freight railroad for many types of risk (Amtrak's employees, their equipment, their contractors, their passengers including property damage, persons at stations who are there in connection with the Amtrak service and collisions with vehicles and pedestrians). This is referred to as the "but for" clause. This simply means that the freight railroads have no additional risk of liability as a result of Amtrak operating passenger rail service over the freight's right of way. While there are exceptions to this "but for" approach to apportioning risk and the freights do indemnify Amtrak for all liability for injury or death of any freight railroad employees, the basic assumption of risk by Amtrak for the operation of passenger rail service is fundamental to the relationship between Amtrak and the freight railroads and has set the standard for the rail industry. A similar arrangement could be needed for a new implementing agency in the Sun Corridor for operations along the Union Pacific rights-of-way.

Stakeholder Terms

The FRA has articulated certain minimum requirements for stakeholder agreements, which include compliance with applicable Federal laws and agreement on performance outcomes. These requirements are to ensure that proposed infrastructure projects are implemented as planned and that the performance of the federally-funded projects is realized and sustained. The FRA expects the implementing agency and host railroad to reach agreement on appropriate modeling and other processes necessary to determine the specific amount of trip time savings, the number of additional frequencies and reliability, and that the approach be consistent with the basic operating agreement between the host railroad and the operator.

Proposed Steps for Developing a Stakeholder Agreement

The implementing agency must:

- Reach agreement with the host railroad that modeling and empirically supported operations analysis necessary to define the final project list and the attainable performance outcomes. Prior to modeling implementation, the parties and the FRA will decide upon the appropriate modeling assumptions, outputs and the scenarios to be incorporated in the modeling and also the scope, schedule and cost for modeling.
- Finalize the project list based on the modeling performed and subject to further modification and re-analysis of modeling as a result of findings, conclusions and mitigation plans from the project's environmental assessment or budget limitations.
- Develop concurrence on the cost estimates for the project.
- Establish a project design and implementation schedule with responsibilities assigned among the parties. Performance outcomes must be aligned with the implementation.
- Reach agreement on the method of construction oversight, roles and responsibilities.
- The parties must agree on what is the useful life in the final project development.
- Negotiate with the host railroad to ensure agreement related to data accumulation for compliance with FRA reporting requirements. The responsibility for federal reporting requirement, assuming federal funding, will be the responsibility of the implementing agency or the state.
- Develop agreement with the host railroad on the roles, responsibilities, and processes by which the performance outcomes will be monitored and managed over the useful life of the projects.
- The implementing agency and host railroad must obtain written acceptance from the FRA prior to signing any corridor improvement stakeholder agreement.

Adequate Enforcement Remedies

The FRA places significant importance on defining performance outcomes and their enforcement. Any future grant applications for improvements to the corridor must satisfy FRA that the applicant(s) will have sufficient continuing control through provisions of the corridor improvement stakeholder agreements or through a tri-party agreement with the operator to ensure performance outcomes.

Enabling Legislation

Ideally, each state should have enabling legislation that fully contemplates the long term commitment to rail passenger transportation service. However, there may be other options that rely on existing legal avenues to enable passenger rail transportation. If rail is publicly funded, any enabling legislation needs to account for the anticipated level of capital, operating and maintenance funding, organizational leadership and management resources that the passenger rail program will require.

In Arizona, the Arizona Department of Transportation (ADOT) has the authority to operate passenger rail transportation though it has never taken on that responsibility. Nonetheless, it would be possible to broaden ADOT's assignments to include passenger rail if it was decided such an assignment would be in the State's long term transportation interest. Other options could include the formation of a joint powers authority with the authority for passenger rail service or an existing operator could take over the role. This is an area that will require further analysis as the project takes shape because the question of governance will define how the project comes together.

Station Development

The development or redevelopment of a rail station is an opportunity for the community to leverage their investment and take advantage of the increased activity that would occur in and around the station. The existing land use and zoning should be reviewed along with parking availability and the anticipated circulation patterns for autos, local transit, and taxi.

For many communities, the initial questions will be more basic. Who will own the station? How will the station be maintained and how will the basic operating cost of the station such as electricity, heating and janitorial service be covered? These issues can be addressed in different ways but in most cases across the country, the rail station is in public ownership and is operated by a city or town. This makes sense since a train station becomes the front door to a community and city officials want to make a good first impression. The financial burden of owning and operating a rail station usually falls to the local community since federal and state resources are devoted to operating the service. It also offers an incentive to the community to organize around how a station will contribute and the decisions needed to permit a station to be developed in the best way possible. Many communities have addressed limited funding by creatively using station space. By co-locating compatible uses in the station such as a rental car office or coffee shop, it is possible to create a revenue stream to help offset a portion of the operating costs while improving the safety of stations and making the station a catalyst for larger community objectives.