

PHX Sky Train™ - Positioned for Success

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Abstract

After several years of planning and design work related to a landside APM system, the City of Phoenix officially began construction of the Sky Harbor International Airport PHX Sky Train™ project facilities in April 2009 and awarded the train system supplier contract in June 2009. The first stage of the PHX Sky Train™ system will replace the existing bus connection between the Metro Light Rail station at 44th Street and Washington, the East Economy Parking structure and Terminal 4. Future stages will connect to existing and planned terminals to the west, a planned ground transportation center and the new Rental Car Center. Under an accelerated schedule, the first stage of the PHX Sky Train™ is scheduled to begin carrying passengers by the spring of 2013.

Central to the planning process for PHX Sky Train™ was the City's goal to provide a state of the art transportation system that would link all of the airport facilities to regional transit to help reduce traffic congestion within the terminal core. The PHX Sky Train™ project is timely in accomplishing this goal given that the first segment of the METRO light rail system that links downtown Phoenix, the airport and Tempe began operation in December 2008.

Upon completion of the entire system, the PHX Sky Train™ system length will be about 8km (5 miles) with up to seven stations. The system will serve a total daily ridership of 96,000 passengers and a total annual ridership of 35 million passengers and will operate 24 hours a day with peak headways of less than three minutes.

This paper focuses on the unique challenges and opportunities related to the PHX Sky Train™ system planning and procurement activities, as well as provides an overview of the progress of the system implementation and construction activities.

Introduction

Phoenix Sky Harbor International Airport (Figure 1) has experienced significant growth in passenger volume, aircraft movements, and cargo traffic since 1990. Sky Harbor served approximately 21.7 million passengers in 1990. Passenger volume estimates grew to nearly 42 million annual passengers in 2007. About 60% of the passengers are

Origin/Destination passengers making Sky Harbor one of the busiest O/D airports in the world.

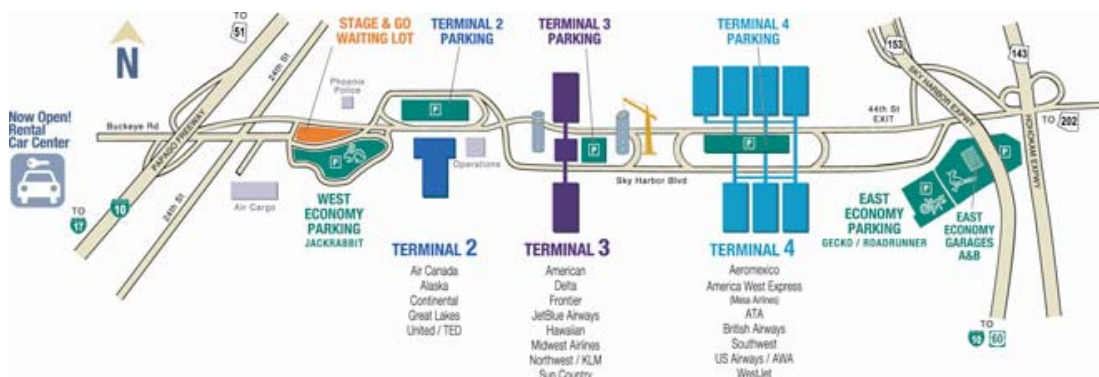


Figure 1: Phoenix Sky Harbor International Airport

The number of aircraft landing and departing the airport also increased. With over 450,000 operations per year, Sky Harbor currently ranks as the fourteenth busiest airport in the world for takeoffs and landings (in 2007 with 550,000 operations annually it was the fifth busiest airport in the world). In early 2006, Sky Harbor began operation of its consolidated Rental Car Center. Passengers arriving at the terminals board buses operated by Sky Harbor and are transported to the Rental Car Center to pick-up their cars.

The dramatic increase in demand caused the airport to outgrow its terminal and ground transportation facilities and made it difficult to maintain quality customer service. In an effort to improve customer service, the City of Phoenix Aviation Department undertook a comprehensive expansion program in early 2002. Subsequently, with the recent downturn in the global economy that resulted in industry-wide reductions in air passenger activity, the current estimate of annual air passengers at Sky Harbor is about 38 million. This, coupled with the general economic uncertainty, caused much of the expansion program to be postponed. An exception is the PHX Sky Train™ which will provide a second means to transport passengers through the airport thereby reducing congestion on the frontage roadways and curbs. It is envisioned that the PHX Sky Train™ will result in more the 20,000 fewer vehicles per day on the airport roadways which accounts for nearly 20 percent of the traffic.

PHX Sky Train™ is being implemented in two stages and when both stages are complete, the 8 km (5 mile) system will connect the Rental Car Center on the west side of the airport with a planned ground transportation center, existing and planned airline terminals, economy parking, and the Metro Light Rail station at 44th Street and Washington Street (44th Street Transit Center). The system alignment generally follows the airport access roadway through the terminal area and is a combination of at grade and elevated guideway.

The PHX Sky Train™ was planned and designed as a joint effort of the Facilities Designer, Gannett Fleming, Inc. and the System Designer, Lea+Elliott, Inc. Both firms

are working under the management of the City of Phoenix Aviation Department. The companies involved in the construction of the PHX Sky Train™ are Hensel Phelps, Facilities Contractor and Bombardier, System Supplier.

PHX Sky Train™ Planning

The following system planning phase discussion focuses on alignment issues, project phasing, reduction of roadway based traffic, regional transit connection planning, connectivity with existing and future airport facilities, coordination with the airlines and other stakeholders, funding, and public outreach considerations.

Initial Planning Activities

The City of Phoenix Aviation Department initiated studies and the development of the conceptual design for the PHX Sky Train™ in 1985. Subsequent studies with the development of the schematic design for a potential West Terminal included the evaluation of alternative alignments and station locations for the PHX Sky Train™. Some goals of the initial planning studies included determining the connectivity requirements, identifying the existing and future physical constraints on the airport, identifying interface issues, determining system ridership, identifying a recommended alignment and operational configuration, and determining through numerical analyses and simulation, the train performance, level of service, fleet requirements and order of magnitude cost of the system.

The initial planning studies considered both underground and elevated alignments. It was determined that due to the linear layout of the airport facilities, the configuration that best served the facilities is a spine with one route operating on a dual-lane guideway in a pinched-loop serving the 44th Street Transit Center, East Economy Parking Lot (EEL), the existing and planned terminals and the Rental Car Center. Initially the preferred alignment was underground through the terminal area at the existing transit level of the terminals and elevated on the east and west sides of the airport beyond the taxiway bridges. After detailed cost estimates were finalized for both the elevated and underground alignments, it became apparent that the elevated alignment solution with at-grade sections of guideway on the east and west side of the airport was the most cost effective and feasible alternative.

Detailed Alignment Description and Project Staging

The final alignment was developed in subsequent planning and design activities. A general description of the alignment and system operations follows. PHX Sky Train™ will operate in a pinched-loop configuration. When viewed from east to west, the PHX Sky Train™ exits the 44th Street Transit Center (LRT Station) to the south and curves west, to the EEL station, and remains elevated passing above Taxiway R. The guideway remains elevated to the Terminal 4 station, then descends and passes under Taxiways S and T, and travels up a grade to an elevated condition in the Terminal 3 station. The PHX Sky Train™ alignment continues to the west into the area of a potential West Terminal. The PHX Sky Train™ alignment would be routed through the area west of the

terminal core towards a new Ground Transportation Center (GTC) near the existing West Economy parking Lot (WEL) and then continues on to the Rental Car Center.

The GTC will provide service to employee parking, hotel shuttles, kiss and fly passengers, employee parking, off-airport parking and other functions. These passengers will use the PHX Sky Train™ to connect to the airport terminals. Design of the west side of the PHX Sky Train™ is ongoing. For the purpose of planning the system and facilities requirements, the PHX Sky Train™ team developed a preliminary alignment for the west side of the system for the purpose of generally defining the system requirements for the system procurement process.

The maintenance and storage facility for the system is located on the east side of the airport and would be served by a maintenance guideway exiting the mainline guideway between the LRT station and the EEL station.

Due to funding constraints, the PHX Sky Train™ is being constructed in (at least) two stages. The initial stage provides a connection to the intermodal 44th Street Transit Station which is the new transit gateway to the airport. The PHX Sky Train™ will provide a seamless connection between airport facilities and the transit systems serving the local community. Stage 1 is currently under construction and consists of a fleet of fully automated vehicles and stations at the 44th Street Transit Center (LRT Station), EEL and Terminal 4 (which currently serves 80 percent of airport passengers). Stage 1 also consists of a Maintenance and Storage Facility for Stage 1 and a Central Control Facility. Stage 2 consists of the Stage 1 system and up to four additional stations, additional fleet, additional electrical power substations and an expanded Maintenance and Storage Facility. The alignment and project staging plan is shown in Figure 2.

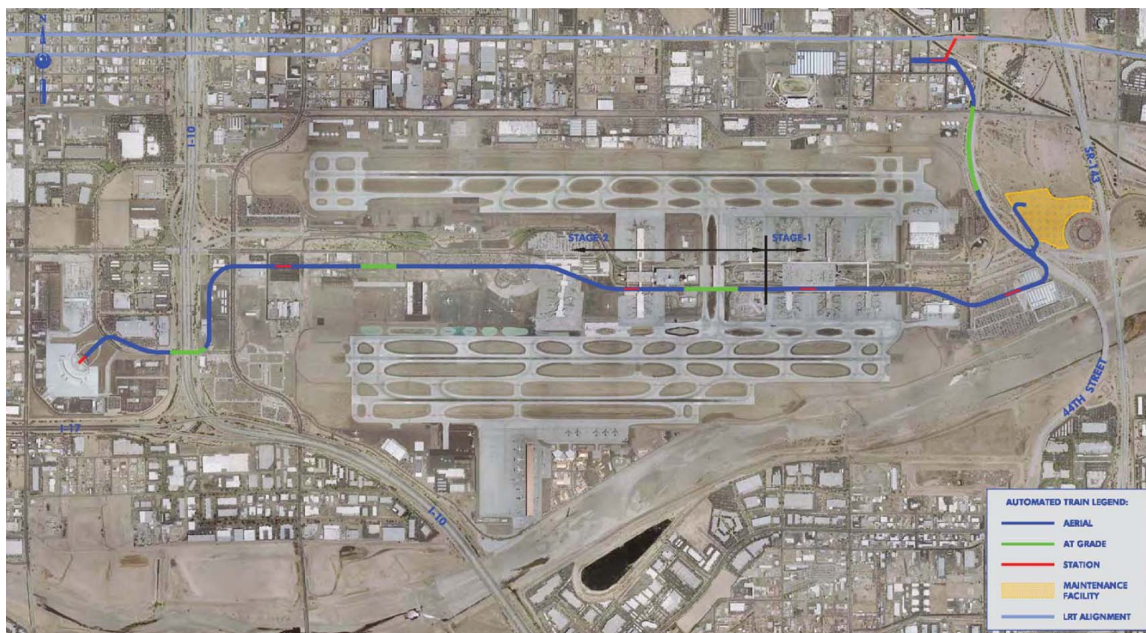


Figure 2: PHX Sky Train™ Alignment and Project Staging Plan

Detailed System Planning

After the alignment and station locations were defined, the System Designer began the definition of the system design parameters so that generic design criteria could be developed for the purpose of advancement of the facilities design and to define the system performance criteria for the purpose of preparing contract documents for a competitive procurement of the system equipment. Some of this detailed system planning and analysis is described below.

Operations Modeling

Lea+Elliott's LEGENDS[®] model was used to determine the operational characteristics of the PHX Sky Train[™] using the plan and profile data of the planned alignment. A generic, large APM technology was used for this analysis. Analyses were conducted for two cases. The first assuming the vehicles would travel at a maximum cruise speed of up to 80 kph (50 mph), and in the second case, at a maximum cruise speed of 50 kph (30 mph). In each condition, a car has a nominal length of 12 m (40 feet).

LEGENDS[®] is an integrated group of transportation computer models used to analyze and evaluate all aspects of transportation systems performance, including passenger travel times, system headways, energy consumption, failure management, capital cost, operational cost, vertical circulation and passenger station population/queuing. The LEGENDS[®] Train Performance Simulator was used to assess the performance of the trains operating on each stage of the recommended alignment. It calculated individual train performance and power demand characteristics on a per-second and guideway-location basis throughout a single round trip. The Train Performance Simulator, along with the Ridership Model and the Operations Model, allowed the team to model passenger demand and round trip time of the PHX Sky Train[™] to define appropriate and optimal system headways.

Estimated Capacity and Trip Times

The results from the LEGENDS[®] Train Performance Simulator were used to estimate system capacity and headways. The technologies that are currently available and most likely to be implemented would produce typical round trip times of about 26 minutes or less for the PHX Sky Train[™]. Trains would be operable as individual cars and can be entrained in up to 4-car train lengths. Individual cars holding about 50 people would provide line capacities of as much as 6000 passengers per hour/per direction under the baggage considerations expected on the system. This could also provide two-minute headways (or less) between trains. This system capacity is compared against the required capacity to determine if the system is capable of satisfying demand.

Ridership Considerations

Ridership estimates have been developed from the passenger forecasts in the *Aviation Demand Forecasts West Terminal EIS Phoenix Sky Harbor International Airport* by Leigh Fisher Associates, dated November 2002, and subsequent planning documents developed by the PHX Sky Train[™] Team. Estimates through 75 million annual passengers (MAP) have been used to help determine the PHX Sky Train[™] fleet requirements and size the associated facilities. To assure adequate capacity at system

opening, the PHX Sky Train™ team planned for a system that will serve the expected passenger demand for several years after the opening of the system.

The PHX Sky Train™ team evaluated the system development in stages. Multiple ridership scenarios were evaluated during the planning period of the PHX Sky Train™. These studies indicated that the largest passenger demand is generated by the passenger traffic to and from the Rental Car Center. Sky Harbor currently uses buses to transport passengers between the terminals, economy parking and the Rental Car Center. At certain peak times, the amount of curb space that is required to berth all of the buses that are necessary to carry all of these passengers is not adequate to serve passenger demand. Ridership estimates indicate that the peak passenger demand will occur on the link between the West Terminal and the Rental Car Center. This link will generate passenger demands of approximately 5600 passengers per hour during the expected design life of the system.

Additional studies of passengers using the Rental Car Center have shown that passengers carry multiple bags, or large bags. The buses are specially outfitted with luggage racks designed to hold large suitcases, packages, and golf clubs. Because of the large baggage space requirements, the PHX Sky Train™ team has determined that luggage carts will be permitted on the PHX Sky Train™, and passenger space requirements have been set accordingly.

The PHX Sky Train™ team studied the types of users at the airport who currently use ground transportation. Ground Transportation Centers (GTCs) are to be implemented to consolidate potential riders at a location on the alignment, and the use the PHX Sky Train™ to bring these riders to the terminals instead of using buses. By locating these GTCs outside of the central terminal area, fewer bus and car trips to the terminals are necessary. This will help to reduce congestion along the terminal roadway. One GTC is located on the east side at the LRT station. The other would be located on the west side at a station east of the Rental Car Center station.

Fleet Size

During the planning process, the number of trains needed to meet the demand of the different alignment configurations and staging options was determined by comparing the forecast passenger demand with the capacity provided.

With two ready standby trains, the total operating fleet that would be required by the PHX Sky Train™ at the completion of Stage 2 would be about 60 cars (not accounting for maintenance spares). This was calculated based on a passenger demand of 5600 pph for a maximum 7-station configuration at an airport passenger demand level of 65 MAP. Based on the baggage space requirements at Sky Harbor, and a nominal large APM class of car, we have estimated that each car will carry approximately 50 people. To serve the passenger demand, four-car trains would be required.

System Requirements

The PHX Sky Train™ will provide fully automated service with every train serving all stations. The PHX Sky Train™ operation plan includes shuttle and run-around routes to maintain service to destinations in the event of a partial system or component failure. Failure modes of operation will also enable continued service among destinations.

Wayside and onboard automatic train control equipment will provide all functions necessary for safe and efficient operation, including train movements and protection, door operations, and central control and supervision.

Power systems will supply all train electrical needs, including traction power, onboard auxiliaries, track equipment, and related station equipment. A power distribution system will provide transformers, rectifiers (if necessary), switchgear, cabling, trackside power rails, and other equipment as needed to ensure proper voltages for all trains at ultimate train lengths and headways even during single-point failure conditions. Separate traction power substations are located at various facilities along the alignment.

Reliability and Availability Considerations

Reliability and availability are key factors in the technology selection. Reliability refers to the lack of system failures that can disrupt operations of the automated trains, normally referenced in terms of “mean time between failures.” Availability is a combination of the system reliability and the required time to restore the system to operation after a failure. Availability is then expressed in terms of the percentage of the scheduled operations time that the system is actually operating.

For this application it is critical that the PHX Sky Train™ have high availability. To reach most of the airport destinations served by the alignment, walking is not a realistic alternative because the distances are too great. Maintaining a backup bus system with adequate capacity would be cumbersome to operate and very non-responsive due to the time required to initiate service. Based on their operating history, the APM technologies will be capable of achieving availability in excess of 99 percent in this application.

Passenger Comfort

Many factors affect passenger comfort, including at least the following: ride time; smoothness of ride during acceleration and braking; noise and vibration levels; light levels; heating/ventilation/air conditioning characteristics; seating and stanchion arrangement; boarding and alighting door configurations; size of gaps between vehicle floors and station platforms; passenger seating arrangements, vehicle operating speeds and availability of communications systems. Most of these are governed by industry standards, such as the *Automated People Mover Standards* (ASCE 21) published by the American Society of Civil Engineers.

The key variable among the technologies is the door configuration, including the door-open width and the number of doors per side of each train. Wider doors allow better flow of passengers with baggage. Greater numbers of doors per side (closer spacing between doors) will encourage better distribution of passengers. These dimensions are important

to the analysis of congestion on the boarding platforms as well as internal vehicle circulation congestion.

Project Funding

The overall project budget for the PHX Sky Train™ is \$1.6 billion of which \$625 million is for Stage 1 and \$945 million is for Stage 2. The funding comes from airport bonds that are backed by airport revenue and ticket surcharges. Every airline ticket sold for travel in and out of Sky Harbor includes a \$4.50 passenger facility charge. The money can be used to fund airport capital expenses and to pay off airport improvement bonds. Other revenue sources include airport parking, shops and restaurants. The drop in airport revenue since 2007 due the recession has caused other capital projects on the airport to be postponed however, Stage 1 of the PHX Sky Train™ has not been affected. The current schedule for the completion of Stage 1 is the first quarter of 2013 and Stage 2 will be operational in 2020.

Airline/Agency Coordination and Public Outreach

Public outreach and coordination with the public agencies and the airlines has been a top priority of the PHX Aviation Department through-out PHX Sky Train™ planning and design process. Regular meetings and briefings have kept all the stakeholders informed regarding important project developments. Unique to this project was the coordination required with respect to the LRT station interface and the archeological dig site that contains the remains of part of the thousand year old civilization of the Hohokam.

The project planning team worked very closely with the Metro Light Rail Transit design team and its affiliated consultants to develop a multimodal transfer interface between the LRT, the regional and city bus systems, and the PHX Sky Train™. The planning and design of the interface considered optimizing passenger level of service and system operational issues while balancing programmatic requirements to provide the best possible interface between the systems given the site physical constraints.

Phoenix Sky Harbor International Airport is located adjacent to Pueblo Grande Museum and Park of Four Waters, which are just to the east of the LRT station site. At Pueblo Grande, the Hohokam operated the head gates for one of the Valley's largest canal systems whose source of water is from the Salt River. In order to comply with historical and environmental requirements of the project, the construction of the PHX Sky Train™ included a survey of the ancient fields and canals associated with the nationally registered historic landmark.

PHX Sky Train™ Procurement

The Phoenix Sky Train™ was procured under the Title 34 of the Arizona Revised Statutes (ARS Title 34) using a two-step procurement process. ARS Title 34 was developed to allow for alternate delivery methods including Design-Build contracting and job-order contracting. The two step process for Design-Build contracting defined by ARS Title 34 is substantially similar to other two-step processes used to select APM

contractors on many APM projects. Candidates were requested to submit their qualifications first in response to a formal Request for Qualifications (RFQ). Short-listed candidates who were determined to be qualified were then issued a Request for Proposal (RFP) where detailed specific information was submitted to and evaluated by a selection committee. A complete schedule of the procurement process is included in Table 1.

Request for Qualifications:

The City of Phoenix issued the Request for Qualifications (RFQ) on June 4, 2007. Respondents to the RFQ submitted a Statement of Qualifications (SOQ) in the format defined in the RFQ. The SOQ contained information about the structure of the team, experience of the team members, experience of key personnel, approach to the project, ability to meet performance standards, and financial qualifications. Respondents were required to describe their qualifications to perform the entire project, including both stages of development - Stage 1 and Stage 2. Statements of Qualifications were submitted by four teams. Of these four teams, three were issued an RFP.

Request for Proposals (RFP):

The RFP was structured such that two contracts would be awarded to the successful team. The first proposal defined in the RFP was for the Design-Build portions of the work. The second proposal would address the Operations and Maintenance of the system. The overall score was the combined score of the Design-Build (DB) proposal and the Operations and Maintenance (O&M) proposal.

The design-build section of the RFP included all of the major subsystem elements of a typical APM and in addition, it also required that the successful team would design and construct the Maintenance and Storage Facility building on a graded site provided by the City. Proposers were also required to describe how they would build the system in two stages, Stage 1 and Stage 2.

The Stage 1 system specifications included equipment for three passenger stations, approximately 2.7 km (1.7 miles) of dual-lane guideway equipment, vehicles, electrical power system, train control, audio and video communications, station equipment, the maintenance and storage facility, maintenance equipment, the maintenance and storage facility building and all other work necessary to successfully meet the performance requirements. The Stage 1 system required that the proposer be capable of providing service for 2900 passengers per hour per direction including luggage and bag carts.

The Stage 2 system specifications included equipment for 4 additional passenger stations, guideway equipment for approximately 5.5 km (3.4 miles) of additional dual-lane guideway, additional vehicles, additional electrical power system equipment, additional Automatic Train Control (ATC) equipment, additional audio and video communications, expansion of the maintenance and storage facility building, and all other work necessary to successfully meet the performance requirements. Proposers were also required to describe how they would meet passenger service requirements for 5600 passengers per hour per direction including luggage and carts.

The operations and maintenance section of the RFP required proposers to develop a plan to operate and maintain the system for the City and meet a system service availability of 99.5% each month for 5 years, with renewable options to extend the contract at the end of that term. Failure to maintain the system service availability would result in damages accruing to the City in the form of reduced payment to the Contractor. The O&M contract requires that the successful proposer maintain all the equipment supplied under the DB contract, including the Maintenance and Storage Facility (MSF) building.

Pricing Proposals:

The proposers were required to provide detailed pricing information with both the DB proposal and the O&M proposal including prices for the Stage 2 work. Because the system was procured in stages, the City was interested in securing the pricing for the entire system, including the Stage 2 work, to mitigate the disadvantages related to a sole-source procurement for the later stage.

Price proposals were sealed in separate packages from the management and technical proposals, and were not opened until the management and technical proposals were fully evaluated by the selection committee.

Evaluation and Selection:

The City of Phoenix issued a Request for Proposals (RFPs) for the PHX Sky Train™ system to the three qualified firms on February 8, 2008. Preliminary Technical proposals were received by the City on July 18, 2008. The preliminary proposals were evaluated for material responsiveness. Preliminary proposal that were determined to be responsive were further evaluated for technical and contract compliance. A detailed set of comments were issued to each of the proposers for incorporation into the final proposals. One proposer withdrew their proposal at this stage.

The remaining two proposers submitted final DB and O&M proposals on January 16, 2009. The preliminary price proposals were returned to the proposers unopened when the final price proposals were received. The final management and technical proposals were evaluated by a selection panel as defined by the ARS Title 34 requirements. The panel consisted of one Arizona registered professional engineer, one executive manager from a contractor licensed in Arizona and five other technical and management professionals from the City of Phoenix. The selection committee was assisted by a technical advisory team that responded to questions about the contract requirements, and compiled comments and performed research to expedite the selection panels review process. Following the evaluations, the Selection Panel prepared scores for each management and technical proposal.

Upon completion of the scoring, the procurement manager opened the price proposals and affirmed the responsiveness of the financial information, and security documents. A score for both proposers' price proposals was conducted based on an algorithm defined in the Instructions to Proposers. The scores for the price proposals were added to each proposal and the total scores were then submitted to the Selection panel for confirmation. The Selection Committee affirmed the results of the final scoring, and submitted their

recommendation to the City Engineer for approval. Successful and unsuccessful proposers were notified of the City Engineer's intent to enter into negotiations with the highest ranked proposer.

Negotiations and Award:

Bombardier Transportation (Holdings) USA (Bombardier) was the highest ranked proposer, but the proposal was not within the City of Phoenix budget for the project. Extensive negotiations were conducted in order to reduce the proposed price. Two major considerations helped to bring the price within budget. The first were changes to the schedule and access to the fixed facilities to reduce the overall project duration by about 13 months. This required ancillary coordination with the fixed facilities design team to accelerate the design of the guideway structure, stations, and enabling airport improvement projects. The second was a deferral of some of the infrastructure work, especially at the maintenance and storage facility that reduced the Stage 1 cost of this building and surrounding yard. At the end of these negotiations, the contract was awarded to Bombardier at a price of \$186,000,000.00 (USD). Notice to Proceed (NTP) was given to Bombardier on July 1, 2009.

February 8, 2008	Issue RFP
February 22, 2008	Deadline for initial submittal of questions on RFP
February 29, 2008	Pre-Proposal conference
March 14, 2008	Deadline for submittal of questions on RFP
April 11, 2008	Issue RFP Addenda in response to questions
April 18, 2008	Deadline for submittal of additional questions on RFP
May 9, 2008	Issue RFP Addenda in response to additional questions on RFP
July 18, 2008	Deadline for submittal of <i>Preliminary Technical Proposals</i> and written comments on <i>Design-Build Agreement</i> and <i>Operations and Maintenance Agreement</i>
August 1, 2008	Issue Addenda for M/W/SBE goals and final construction schedule
November 3-7, 2008	Discussions/meetings held with Proposers to clarify <i>Preliminary Technical Proposals</i> and comments on <i>Design-Build Agreement</i> and <i>Operations and Maintenance Agreement</i>
January 16, 2009	Deadline for submittal of <i>Final Technical Proposals</i> and <i>Price Proposals</i>
January 23, 2009	Selection Committee recommends Selected Proposer for City of Phoenix approval
March 4, 2009	Determination to accept/reject Selection Committee recommendation
July 1, 2009	(If the Owner accepts) Execute final, conformed <i>Design-Build Agreement</i>
December 16, 2013	Deadline for Substantial Completion of Stage 1 Operating System

Procurement Schedule - Table 1

PHX Sky Train™ Implementation

The PHX Sky Train™ Implementation Phase began at system Notice to Proceed on July 1, 2010. The System implementation is roughly divided into five major sections: interface, design, manufacturing/construction, testing/commissioning, and acceptance.

Interface

As part of the proposal, Bombardier provided a draft Design/Construction Interface Document (DCID) for use by the fixed facilities design team (Gannett-Fleming) to allow for the incorporation of details in the facilities infrastructure to assure that the specific requirements of the system will be accommodated. The draft DCID contained information about the supplier's specific technology. This included vehicle dimensions, weights, operating speed, loading criteria, switch dimensions, station door dimensions, and rough power demand estimates.

Immediately following the system NTP, the draft DCID was issued to the facilities designers. Simultaneously, the design packages that had been prepared by the facilities design team were provided to Bombardier for review. The facilities designers began a thorough review of the draft interfaces and prepared questions about the information in the DCID. The system designer reviewed the facilities design packages and prepared additional interface information that applied specifically to the PHX Sky Train™ project. Several coordination meetings were held over the next few months as more detailed information was developed that defined the specific interfaces for the PHX Sky Train™ project.

This interface period was extremely critical to the overall project because the facilities design had already progressed to approximately 60% before the System Supplier was selected. Facilities design had basically gone as far as it could without the system supplier information.

Approximately 90 days after NTP the supplier provided an updated preliminary DCID. This document contained refinements and additional criteria that were not included in the draft. Approximately 180 days after NTP, the system supplier provided the final DCID for use by the facilities designers.

Design

The system design phase began as the interface period neared completion. The system contract is a Design-Build contract. The system supplier prepares design reviews for the major subsystems of the project and presents this information to the Owner for acceptance. The design reviews were divided into eight system equipment subsystems and three fixed facilities reviews.

System Equipment Design Review

The System equipment Design reviews were broken down into categories defined in the ASCE APM Standards and included the following:

- General system
- Vehicles
- Electrical power system
- Automatic train control
- Audio and visual communications equipment
- Station equipment
- Guideway equipment
- Maintenance equipment

Fixed Facilities Design Reviews

The system supplier also provided three design submittals that included the infrastructure work for the system. These three subsystems were described in fixed facilities design review documents:

- Guideway facilities
- Station facilities
- Maintenance and storage facility

Preliminary design review meetings with the City of Phoenix and the facilities design team were held throughout the months of January and February, 2010. During these meetings the PHX Sky Train™ team provided feedback in the form of written comments and verbal comments during the meeting discussions. The train supplier then took these comments and finalized the system design to address the feedback provided. The final design for the system work was substantially completed in May of 2010.

One of the key provisions of the design was for the system supplier to ensure that the system design can accommodate expansion of the system to handle the Stage 2 capacity. The facilities design team made the station platforms long enough to accommodate Stage 2 trains. All of the Electrical Power Systems (EPS) substations and system equipment rooms are sized to provide adequate space to accommodate equipment sized to meet Stage 2 system parameters. The train supplier developed designs that provide for Stage 2 parameters for elements that would be difficult to take out of service during an expansion. The system design for the EPS equipment, ATC equipment, and the central control facility are all sized for the Stage 2 system. The MSF building and the MSF yard are laid out to accommodate expansion to the Stage 2 system without a shutdown in passenger service. The Stage 1 MSF layout is shown in Figure 3 and the Stage 2 MSF and yard expansion is shown in Figure 4. The system supplier has provided all station platform doors for the Stage 2 system. In Stage 2 the automatic door operators will be added so that the doors can open automatically.

Maintenance and Storage Facility Stage 1

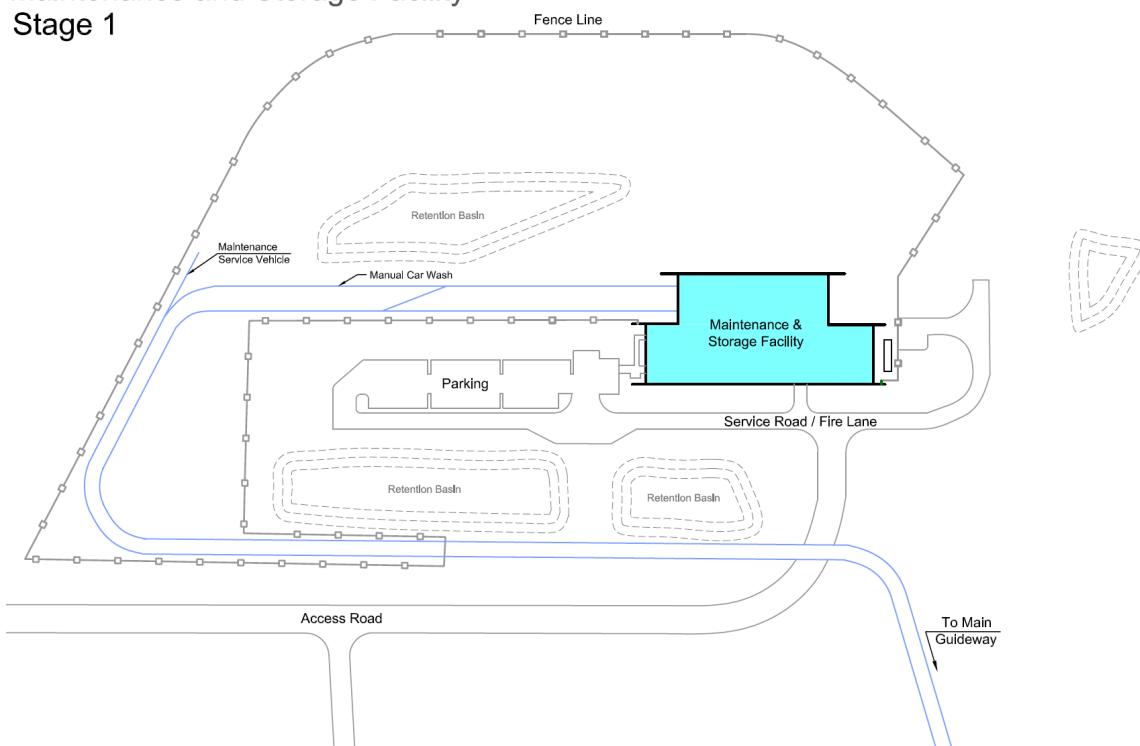


Figure 3: Maintenance and Storage Facility - Stage 1

Maintenance and Storage Facility Stage 2

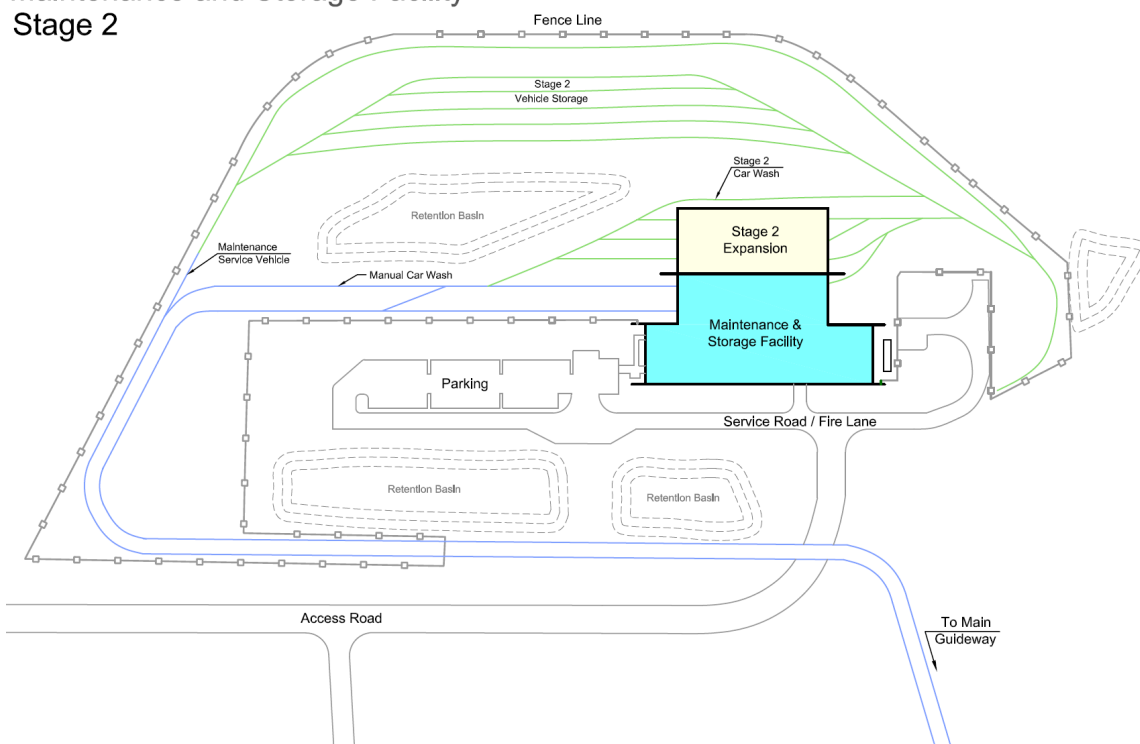


Figure 4: Maintenance and Storage Facility –Stage 2 Expansion

Manufacturing/Construction

The acceptance of the design of the system by the City essentially authorized the system supplier to begin the procurement of equipment, manufacturing items, and the construction activities on the system fixed facilities.

Construction activities on the MSF building began on June 17, 2010 and are scheduled to be completed in January of 2011. Guideway equipment construction on the system guideway elements began on November 08, 2010 and is scheduled to be completed in March of 2012. Station equipment installation is scheduled to begin in February, 2011 at the EEL station, and will be completed in March of 2012. A photo of the MSF shell building, the 44th Street station construction and the EEL Station/Guideway construction are included in Figure 5, 6 and 7 below, respectively. The Stage 1 building is approximately 2800 square meters (30,000 sf) and will be expanded to be approximately 9300 square meters (100,000 sf) in Stage 2.



Figure 5: Maintenance and Storage Facility Building (Jan. 2011)



Figure 6: 44th Street Station under construction (Dec. 2010)

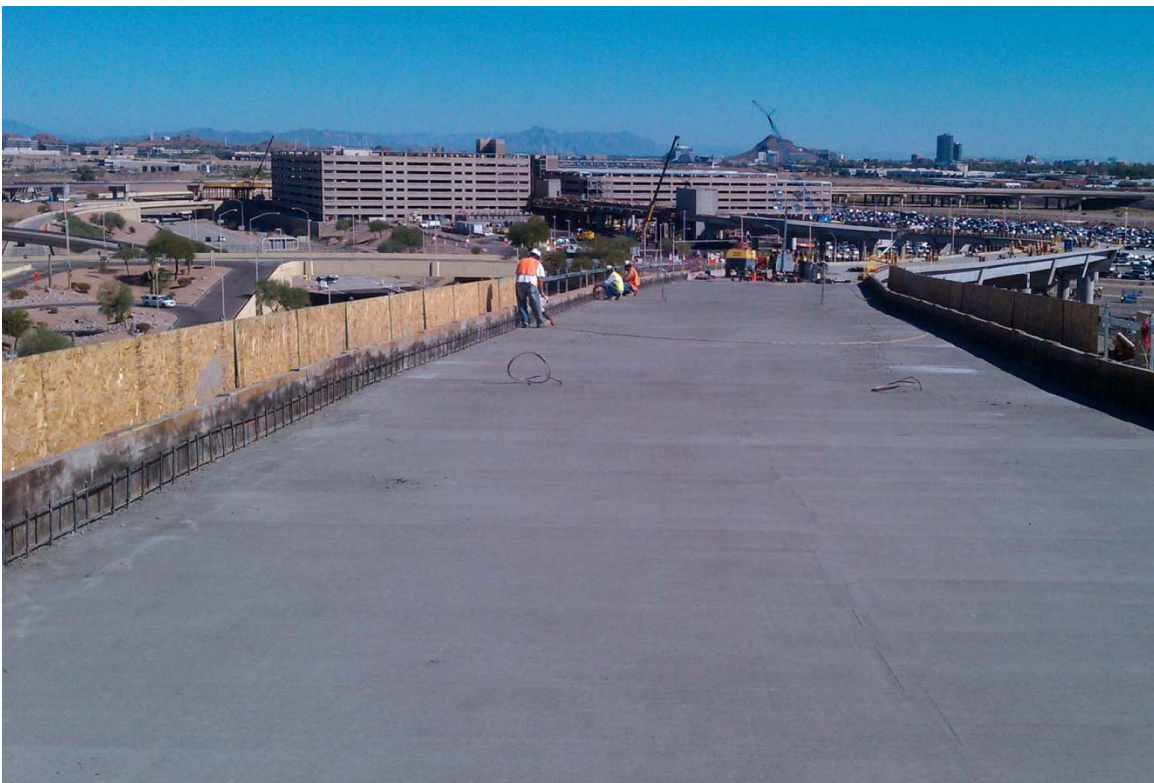


Figure 7: Guideway west of EEL Station under construction (Dec. 2010)

Permanent power at the 4 EPS substations is scheduled to be available in March of 2011 at the MSF substation, July 2011 for both the Terminal 4 and EEL substations, and October 2011 for the 44th street substation.

Except for certain long-lead elements that were ordered before the completion of the final design, system equipment manufacturing began at the same time as the equipment construction. The system supplier began to manufacture items that will be part of the PHX Sky Train™ project in June of 2010. Procurement of materials and components required by the system is expected to be completed by June of 2011. Manufactured items are expected to be completed in August of 2011 except vehicles which are expected to complete in late 2011.

Testing/Commissioning

In order to verify compliance with the Technical Provisions of the contract, the system supplier must verify over 450 specific requirements. To satisfy these verification requirements the system supplier's acceptance plan has identified 80 different test procedures. Some of the procedures are performed on several pieces of equipment, or on multiple guideway sections. It is estimated that about 300 separate acceptance test procedures will be performed to verify contract compliance for roughly 20,000 discrete technical requirements on all system equipment for this contract.

The system acceptance plan is designed to perform verification activities on the simplest equipment first, and increase the amount of complexity as the system becomes more and more integrated. Early tests consist of verification of as-built conditions and tolerances. Qualification testing of manufactured components also occurs at this level. These activities are followed by verification that the equipment has been properly installed according to design requirements. After installation, equipment is then energized and diagnosed in a static condition. After static testing, manual dynamic operation can begin, and adjustments are made to the operating equipment. This is followed by dynamic testing where interaction of different subsystems is tested. After all of the system elements have been verified to perform in an integrated fashion, the system is ready to enter into an acceptance phase.

Acceptance

The system acceptance period is the last stage of the project. During this stage, the system has been verified to meet the requirements of the contract, and to be safe to provide service to passengers.

System Demonstration

The system demonstration begins when the system equipment has been verified to be capable of operation as an integrated functioning whole. In addition, all O&M staff must have been hired, and be fully trained to perform their duties as if they were in actual passenger service.

The system demonstration operates the system according to all operating criteria defined in the contract documents. During the system demonstration the train supplier will operate 24 hours per day according the system operations schedule. The train supplier will also be required to maintain the approximately the same system service availability levels during the demonstration period as during actual passenger service. During the system demonstration, the system must maintain a system service availability of 98.5% for a consecutive 30-day period. The system supplier must perform all system maintenance, according to the maintenance plan, as if the system were in passenger service. Upon completion of this system demonstration, the system will be allowed to enter the final acceptance stage of the contract.

Final Acceptance

Upon completion of the system demonstration, the system has been determined to be adequately reliable and safe enough to enter passenger service. The system supplier then enters the final acceptance phase of the project. During this phase, the system supplier will be operating the system normally, and at the City's discretion, the system will be open to passenger service. At substantial completion of the system, the City will issue Notice to Proceed on the O&M contract with the system supplier.

The system supplier will continue to operate the system and monitor the system service availability under the O&M contract. The supplier must maintain a system service availability of 99.5% averaged for a period of 180 days to achieve final acceptance. In addition, the number of downtime events must be limited, including no single downtime event of greater than 45 minutes duration. Other criteria for final acceptance include: Delivery of all spare parts and consumables as specified in the contract, Final completion of all work under the DB contract including punch-listed items; and Receipt of all operations manuals, repair manuals and third-party equipment manuals.



Figure 8: Rendering of PHX Sky Train™ vehicle (*image courtesy Bombardier Transport*)

Conclusion

The PHX Sky Train™ is on track to provide Sky Harbor International Airport an efficient, effective, convenient and environmentally friendly way to move airport visitors, passengers and employees through the airport. Moreover, the elevated train will provide a seamless connection to the new transit gateway to the airport at 44th Street and Washington, thereby reducing airport roadway and curb congestion. A rendering of the vehicle is shown in Figure 8.

The PHX Sky Train™ will be free to the public and will run 24 hours a day, arriving at stations during peak periods of operation every three minutes and delivering passengers to their destination in an average of five minutes. Customer service is foremost at Sky Harbor International Airport and the PHX Sky Train™ is an important component in maintaining these standards. Given the flexibility of operations and the expandability of the PHX Sky Train™ system, the region's growth will be accommodated into the future and the train will help to maintain the airport's reputation for superior customer service.