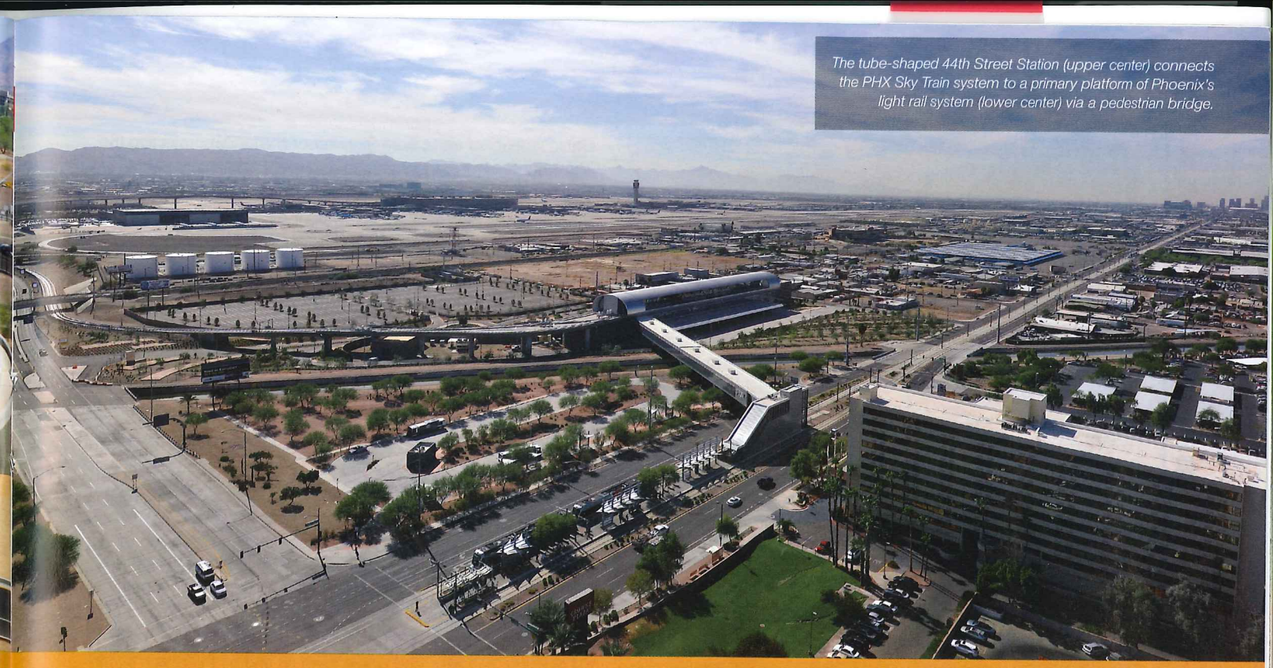
PHX
PHOENIX SKY HARBOR
INTERNATIONAL AIRPORT



The tube-shaped 44th Street Station (upper center) connects the PHX Sky Train system to a primary platform of Phoenix's light rail system (lower center) via a pedestrian bridge.

PHX Sky Train Glides into Sky Harbor & Airport History

By Greg **Gerber**

factsfigures

Project: Automated People Mover

Location: Phoenix Sky Harbor Int'l

Stage 1 Cost: $644 million

Stage 1A Cost: $240 million

Stage 2 Cost: Not yet finalized

Funding: Airport revenue; passenger fees

Of Note: World's first airport transit system to cross an active taxiway via bridge

Train System Provider/Operator: Bombardier

Construction Manager for Stage 1: Hensel Phelps

Facilities Designer: Gannett Fleming

Train System Consultant: Lea+Elliott

Construction Manager for Stage 1A: McCarthy/Kiewit

Taxiway Bridge Subcontractor: Austin Bridge & Road

Civil Engineer/Design Subcontractor for Gannett Fleming: Kimley-Horn and Assoc.

Program Consultant: URS

General Contractor for Bombardier: Weitz

Electrical Subcontractor for Weitz: Wilson Electric

Civil Designer for Bombardier: CK Group

Architect/Subcontractor for Gannett Fleming: HOK

Architect/Subcontractor for Bombardier on Mfg. Service Facility Building Design: RNL

Subcontractor for Hensel Phelps & Weitz: Suntec Concrete

More than a decade in planning, the PHX Sky Train at Phoenix Sky Harbor International Airport (PHX) is on track to begin public service this spring. In addition to providing a new level of customer convenience, the system will drastically reduce landside traffic and the need for airport shuttle buses. Making the service a reality, however, required an unprecedented feat of airside engineering.

Because the train connects with Phoenix's Metro light rail system, PHX passengers will be able to avoid congested highways and "ride the rails" from downtown into the airport's busiest terminal, and vice versa. In addition, passengers parking in PHX's east economy lots and those arriving at the airport's new 44th Street Station will be able to print their boarding passes and ride the airport's free, 24-hour train directly into Terminal 4. Many will also be able to check their luggage before boarding.

Approximately 2.5 million passengers are expected to ride the train during its first year of operation — about 7,000 per day. And airport officials expect annual ridership to balloon to 14 million when subsequent stages of the project extend train service to PHX's other two terminals and consolidated rental car center.

When complete, the entire system is expected to cost $1.58 billion — funded completely with airport revenues and passenger fees, not tax dollars, emphasizes Heather Lissner, acting public information officer for the City of Phoenix Aviation Department. Best of all, Lissner adds, the project will create about 8,000 jobs.

Early projections expect the full system to be up and running in late 2020. That's when PHX will all but eliminate its fleet of shuttle buses — a change that will simultaneously slash operating expenses and vehicle emissions. Initial train service to Terminal 4 alone is expected to reduce greenhouse gas emissions by 5,913 tons per year.

Planes, Trains & Automobiles

Landside traffic congestion at PHX has grown in proportion to the expansion of Phoenix, the sixth largest U.S. city and a regular on the Census Bureau's list of fastest growing cities. With 4.3 million residents, plus millions of annual snowbirds and baseball spring training fans, officials knew local roadways would eventually be unable to accommodate increasing traffic at the airport.

The city envisioned connecting some type of mass transit system to PHX as early as the 1980s, during construction of Terminal 4, says

Mark **Pilwallis**

Mark Pilwallis, senior project manager for Gannett Fleming, the PHX Sky Train facilities designer. In 2005, the city conducted a detailed transportation study to examine the impact the community's growth would have on airport operations.

"The study looked at the real needs of the city and airport and explored how capacity limits would impact daily operations as the facility continued to grow," says Pilwallis. "The study speculated on what the airport would look like in the future and suggested ways to improve capacity. But, eventually, city officials knew they would get to a point where the current road system could not fully handle the airport's ground transportation needs."

System consultant Lea+Elliott prepared the feasibility study that identified various options, including expansions to existing bus service and roadways, adding a dedicated road just for bus traffic, and installing an automated people mover.

"In evaluating our options, we completed simulations as to how quickly we could load people onto and off of buses, and the people mover just made much more sense," says Pilwallis. "We would have had to assist people onto and off the bus, and then secure wheelchairs to the floor. The PHX Sky Train allows people using wheelchairs to roll themselves on and roll off the system quite easily."

Nate **Walnum**

Additionally, Sky Harbor Blvd., which leads into the airport, could not be expanded because of its proximity to the airfield. That meant additional traffic lanes could not be added, even for pass-through traffic, explains Nate Walnum, an engineer with Kimley-Horn and Associates.

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"The plans basically looked at how long the airport could continue to make improvements and minor fixes until the point that failure of the current transportation system would occur due to unacceptable traffic congestion," explains Pilwallis. "It became very clear that the airport needed a secondary ground transportation system if it hoped to sustain its current rate of growth."

At the same time the airport was exploring its options, Phoenix officials were laying the groundwork for the city's light rail system. Anticipating potential problems associated with increased traffic into and around the airport, city leaders had the vision to factor in a connection to PHX when launching the first segment of light rail in 2008, Pilwallis notes.

A lifecycle cost analysis of PHX's various options indicated that an automated people mover system would be the most cost-effective solution. Although it required a large initial capital investment — $644 million for Stage 1 alone — it would allow the airport to eliminate a significant number of buses and reduce annual operating costs over time.

"Eventually, the people mover system will pay for itself," says Pilwallis.

Marrying the large capacity of a people mover to the existing roadway, explains Walnum, allows the airport to alleviate a considerable amount of traffic from Sky Harbor Blvd. "By connecting the airport to the light rail system at the 44th Street Station, people can access the airport from anywhere in central Phoenix," he notes. "And business people heading toward the downtown convention center need only step on the PHX Sky Train to begin their journey."

Using the 44th Street Station will be especially attractive to travelers during peak hours, because they will be able to print boarding passes for all airlines and check luggage for flights on US Airways and Southwest Airlines, two of the airport's largest carriers.

"This is a great service for our customers," says PHX's Lissner. "They can check their bags, then park their cars and be on their way at no additional cost, although airline baggage fees still apply."

Because luggage needs secure transport from the stations to the baggage control facility, early check-in service will be available during select hours based on passenger traffic levels.

Plans were developed to make connecting between the airport train and Metro light rail as seamless as possible. The floor of the 44th Street Station, for instance, was designed to align accurately with the floor of the people mover to make it easy for passengers to roll luggage, golf bags and wheelchairs on and off the airport's train. An enclosed pedestrian bridge allows them to access the Metro platform across the street without navigating street-level traffic.

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The flooring of the 44th Street Station is designed to help lead pedestrians to their destinations.

For comfort during Phoenix' hot summers, the train stations at 44th Street and inside Terminal 4 are equipped with air conditioning; the outdoor station in the economy parking area includes fans and a shaded waiting area to keep passengers cool. The station that will serve terminals 2 and 3 will also be air-conditioned.

Many consider the 44th Street Station the project's most prominent and attractive feature. "It's an impressive facility that really stands out at night," says Doug Ostermeyer, director of operations and maintenance for the Phoenix PHX Sky Train.

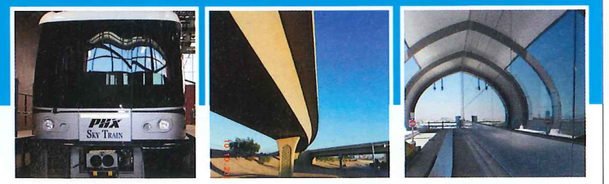
The station's overall form was inspired by the simplicity and beauty of aircraft design, explains Ernest Cirangle, the HOK designer who created the structure's architecture. "In designing the station, our primary goal was to give a public face and physical connection to the facility that would connect the airport to the city's light rail system," explains Cirangle. "Because it brought together ground transportation, buses, cars and trains, we wanted its image to be an iconic symbol of transportation."

Passengers being dropped off at the station are protected by two opposing cantilevered canopy wings — one side for public vehicles, the other for private vehicles. They then enter a common breezeway that takes them to escalators, which deliver passengers to the elevated PHX Sky Train platform. The breezeway's blue iridescent ceiling artfully conveys the sense of sky and air travel, notes Cirangle.

Passengers arriving via the Metro light rail system connect to the PHX Sky Train Station through a pedestrian bridge. The floor of its walkway also includes a colorful art installation designed to help guide passengers to their destinations.

"All along the path, passengers encounter architecture and art that enriches their experience," Cirangle explains. "The station is totally about passenger convenience and making it easy for them

Lea+Elliott was the APM System Consultant for the new **PHX Sky Train™**



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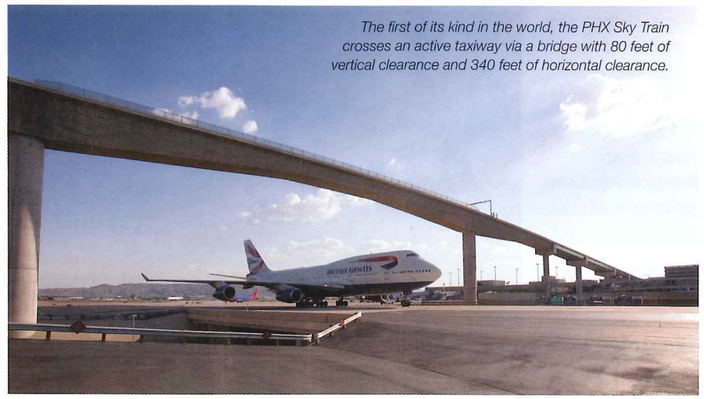


The first of its kind in the world, the PHX Sky Train crosses an active taxiway via a bridge with 80 feet of vertical clearance and 340 feet of horizontal clearance.

to transition from one transportation mode to the next in a stress-free environment. Its sleek contours were created to represent the concept of flight as the visitor's first impression of the airport."

With passengers arriving via Metro, bus, car and cab, PHX's 44th Street Station may represent a new breed of intermodal airport facilities.

A Worldwide First

Designing the train system to flow within the confines of airport property was a unique challenge during the early phases of the project.

To connect with the city's light rail system, planners began the PHX Sky Train route near the 44th Street Metro platform and ran the first alignment along 44th Street to the airport's long-term economy parking lot, so the train could pick up additional passengers. From there, they plotted a course for the train to enter Terminal 4 at a station that straddles the landside and airside of the airport. Doing so would allow passengers to exit the train and proceed directly to the security checkpoint or to connect to other terminals by catching a shuttle bus from the first level.

One major obstacle stood in the way of that plan: an active taxiway.

Ron **Sheahan**

Ron Sheahan, a principal with system consultant Lea+Elliott, describes the situation as "complicated geometry." The guideway not only had to cross a taxiway, roadways and miscellaneous facilities, it also had to maintain the proper slope and grade so the train could operate at peak efficiency while ensuring passenger comfort and safety.

Designers initially contemplated running the system below the taxiway, then up to the station. But planners discovered that the train couldn't attain the necessary lift quickly enough to make the transition back to the Terminal 4 station.

"We had to come up with an alignment that everyone was comfortable with that still provided good connections to the terminal and parking lot," recalls Pilwallis. "Plus, we had to construct the track and station without causing significant impact to airport operations, all while ensuring the project remained within budget."

Running the train system over the taxiway originally seemed like a long shot, because there was no precedent for it anywhere in the world; but it eventually proved to be the answer, explains Kimley-Horn's Walnum.

"We had no design criteria or examples to follow," recalls Pilwallis. "So, we scheduled some early meetings with FAA officials to ask for their opinion. They suggested we assemble some technical data for them to consider."

The team came up with several designs that would allow 747s to travel under the track.

"It was a fairly comprehensive memo that justified the vertical and horizontal clearances," recalls Pilwallis. "We sought input from the tower to see how it would impact operations and even investigated whether lighting on the train would have some type of negative effect."

After reviewing the background data and proposed designs, the FAA gave PHX initial clearance for a bridge with 80 feet of vertical clearance and 340 feet of horizontal clearance. When the tower staff and airline officials green-lighted the final plan, the project was well on its way in 2010.

The taxiway was shut down for six months in the spring and summer — traditionally PHX's slowest traffic period — so crews could construct a bridge over it. Aircraft were rerouted to another taxiway just 2,000 feet away to minimize inconvenience for the airlines and ground staff.

Although the structure's 350-foot main span is not out of the ordinary in the realm of bridge engineering, it was considerably more complicated to develop than a standard freeway overpass, relates Pilwallis.

The system, notes Sheahan, is designed to last at least 30 years.

20/20 Foresight

Despite the size and complexity of the project, Pilwallis reports that it included notably few surprises. "We spent a lot of time up front with the aviation staff showing them how the stations would work and how they would impact customer service and airport operations," he explains. "We met with many people to understand how the Phoenix transit system could work within the airport's traffic system so that the airport and city could get the most bang for their buck. Once we had that buttoned down, we looked to see what else the stations could do to make them more functional and flexible."

On-site baggage check-in and the ability to print boarding passes will likely be just two of the passenger conveniences offered. Airport officials expect private businesses to develop hotels, restaurants and coffee shops within walking distance of the station.

The city's decision to bid facility construction under a construction manager at risk contract also helped the project run smoothly, Pilwallis adds. Because contractors were included when the design was just 30% complete, constructability issues were flagged while designers were still finalizing the plans, he explains.

"Once everyone was comfortable in how the PHX Sky Train would work to serve passengers and how it would be constructed within the airport environment, I think we cleared most of the hurdles before construction started," he reflects. "I felt better knowing the contractor was with us early in the project planning so their crew was ready to step forward and begin construction as soon as the final plans were approved."

Walnum similarly attributes the project's success to ample and effective planning. "We really didn't encounter anything unexpected outside of not being exactly sure where some utilities were located," he explains.

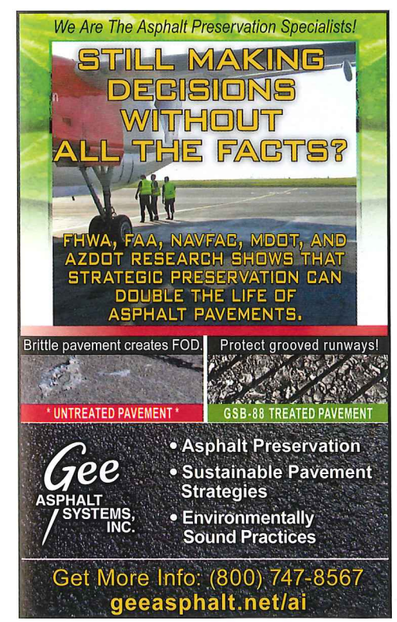
Site selection was also significant, notes Lea+Elliott's Sheahan. "We needed a lot of space not only to construct the station and the PHX Sky Train's maintenance/storage center, but to ensure future expansion as well," he explains.

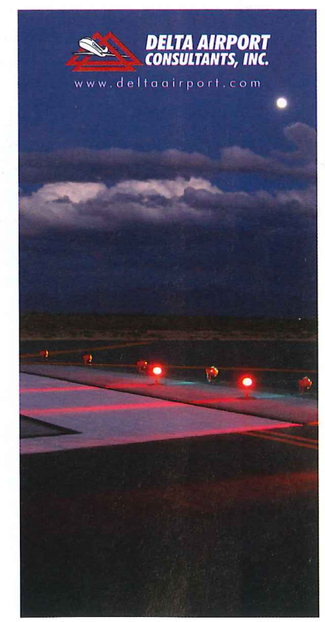
To provide room for the PHX Sky Train track and facilitate planning, the city of Phoenix worked with the Arizona Department of Transportation to convert State Route 153, a six-lane highway, into a four-lane city street (44th).

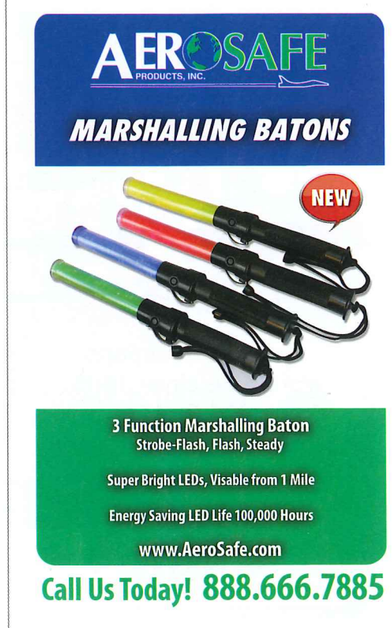
"The roadbed for State Route 153 was already an approved transit area near the runway protection zone," says Kyle Kotchou, special projects administrator at the City of Phoenix Aviation Department. "So, by reducing the lanes from three to two in each direction, we had enough room on the west side of the road to construct the train alignment."

Preparing for Passengers

In its current state, the state-of-the-art PHX Sky Train includes 18 vehicles, 1.7 miles of guideway and an offline maintenance








The architecture of the 44th Street Station was inspired by aircraft design.
Photo Credit: Bob Prezel

facility to house and service the fleet of Bombardier Innovia 200 vehicles. The columns that support the guideway are as deep underground as they are tall — up to 125 feet.

The train itself was built in Pittsburgh and trucked to PHX. Each car can hold 53 passengers and has the capacity to carry 2,000 people per hour, per direction. Throughout the day, Bombardier staff can add and remove cars to keep passengers moving at peak efficiency, says Ostermeyer.

While operation will vary according to anticipated passenger demand, a typical day will start at 4 a.m., when Ostermeyer's staff releases four two-car trains at three-minute intervals. By 9 a.m., the system will typically be reduced to three two-car trains, which continue operating until 9 p.m., when another train is eliminated. A single two-car train will then run continuously throughout the night.

At an average line speed of 23 mph, it takes just three minutes to get from the 44th Street Station to the economy parking area, and another two minutes to travel to Terminal 4. If necessary, the train can travel as fast as 38 mph.

At the request of airport staff, Ostermeyer's team can uncouple a train to run as a single car, or add a middle unit to create a three-car train. The typical configuration will include two cars coupled together at their blunt ends, so their sloped ends make the train look like it is moving forward regardless of the direction it's traveling. In a three-car configuration, the middle unit has blunt ends on both sides.

After the train makes its 1.7-mile journey along the guided track, the software reverses direction and the train's taillights become headlights.

The driverless train is electrically powered, and the stations were designed to require 30% less power than similar facilities. All are expected to earn gold certification in the Leadership in Energy and Environmental Design program because of green construction strategies and energy-saving equipment. More than 50% of all construction and demolition waste created during the project will be recycled or salvaged.

Ostermeyer, who will manage the PHX Sky Train under a 10-year contract, moved to Phoenix from New York City, where he worked on JFK's Air Train. He also helped install an expansion system at Houston's Bush International Airport, and also worked on the Las Vegas monorail.

"The biggest challenge is getting the system set up completely," he notes.

After the cars were mounted to the PHX Sky Train guideway, Bombardier crews began testing the system. In late January, the train completed a crucial precursor to commissioning for passenger service. "We use sand bags as weight to simulate passenger loads at different times of the day," he explains. "The purpose is to make sure we have fleet availability 99.5 percent of the time. By working out any bugs during the demo period, we can prove to the airport that we can run the train according to our contract."

If the system had failed at any point during the 30-day trial, Ostermeyer and his crew would have had to start another 30-day test; but the system succeeded on the first try.

Keeping the Team on Track

Kotchou considers the PHX Sky Train project "by far one of the best" he has worked on for the city of Phoenix. "We had a great team that worked well together because they were constantly coordinating with one another," he explains.

The process, however, was more complicated than usual, because it included two separate contracts: one for the train and another for the stations and guideway. "Getting two contractors to coordinate their work together required time and effort to keep everyone working toward the same goal," he relates.

Sheahan notes that managing expectations up front helped alleviate problems and misunderstandings. He cites an example of disagreements about how complete the station needed to be before work could begin on the train: "Everyone was willing to modify their plans and share some of the inconvenience to keep the project moving forward. That enabled both contractors to be working at the same time in the same place."

Having the track builder and train contractor work together also helped ensure optimum ride quality, he adds. The center guide beam and running surfaces called "plinths" were carefully designed to fit into the space and curvature of the track, Sheahan explains. Civil engineers, in turn, designed the track so loaded trains could cruise along a 6% grade with minimal tweaking needed to navigate curves and slopes.

"The project was not without its challenges," notes Pilwallis, "but the teams gelled together quite well and, from my experience, it was a fun project to work on. When working on a project of this size, relationships can sometimes be strained before the work is finished; but all the contractors on this project still enjoy great working relationships with each other. "

Kotchou concurs: "You expect issues on big projects, but this one has been very smooth and clean."

Sheahan credits city leaders for developing "an end-game solution" that encouraged various contractors to solve potential issues. "That created a productive environment that allowed all major players to make good connections to move the project forward," he explains.

"I'm excited to ride it," says Walnum. "We've been involved in the design process for 10 years. I am anxious to see how it really works."

Next Stop: Terminal 3

With Stage 1 of the project not officially open, the airport has already begun work on Stage 1A, which will bring train service to PHX's other two terminals in early 2015. That stage will require a .7-mile guideway extension and continued airside dexterity, because the train will pass beneath two taxiways before climbing to an elevated station at Terminal 3. A new walkway will connect to Terminal 2.

Estimated cost for Stage 1A is $240 million. When it is complete, officials plan to eliminate the airport's remaining parking shuttles and all inter-terminal and Metro connection buses.

Stage 2, still in planning, will link the PHX Sky Train to the airport's consolidated rental car center. When that 2.5-mile extension is complete, the airport will retire its remaining buses — and further reduce associated emissions, expenses and landside traffic.

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