More Than Just A Maintenance Facility:
The DFW Airport Maintenance & Storage Facility

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Abstract

The new Dallas/Forth Worth International Airport's Skylink Automated people mover functions under a unique arrangement in which the owner's personnel operate the system while the supplier's personnel maintain the system. Both parties share the facility. Design of the maintenance & storage facility (MSF) was accomplished as part of the overall APM program's fast-track approach involving Halff & Associates - the MSF designer, DFW Airport Board - the owner, Lea+Elliott – the owner's APM system consultant and Bombardier Total Transit Systems - the system supplier all collaborating on the design.

In addition to a maintenance control center used to facilitate servicing of the entire APM vehicle fleet, the single-level MSF houses all command, control and communications functions needed to operate the new system. As such, the MSF serves as the nerve center for all start-up testing, commissioning, integration and system demonstration activities and houses system administrative offices for both the owner and supplier's teams. The facility footprint is 9,290 square meters (110,000 square feet). The adjacent storage is 4,645 square meters (50,000 square feet). The yard includes vehicle wash facilities. Moreover, the facility was designed to enable future expansion of additional vehicle service bays while remaining in full operation in public passenger service.

Because the MSF is built in the central terminal area of the active airport, design of the MSF went well beyond traditional technical design criteria requirements to current and long-range airport operational considerations ranging from customer service to airport security. More than just a maintenance facility, the MSF has been a crucial element of the Skylink APM program from system design and construction to testing & commissioning to multi-party operation.

This paper discusses design, construction and use of the DFW maintenance & storage facility. The key to the success of the MSF has been the cooperation of a cohesive, talented team committed to meeting the airport's current operations needs while moving DFW International Airport into the 21st Century.

Key considerations

Each party to the MSF design partnership obviously had individual interests in the facility design. However, in order to develop a functionally efficient maintenance and storage facility that met DFW airport's short and long range operational goals at a reasonable cost several key factors had to be taken into account by the design team. These considerations fell into three categories. A) Integration with existing and planned airport facilities. B) Ability for multiple parties to work cohesively in the facility while retaining the option for DFW staff to inherit maintenance of the system at a future date. And, C) Ability to expand the facility at a future date without disruption to ongoing operations.

The design team first had to grapple with the requirement that the MSF must integrate with other airport facilities, roadways and utility services. The original design concept in the solicitation reference drawings envisioned a two-story facility. However since the facility would be in the central terminal area aesthetics became a key concern of the airport's executive staff and board of directors. As part of DFW's capital development program a new international terminal was being built simultaneously. The terminal, which incorporates two APM stations, is to be the airport's new showpiece. In addition, the new guideway spans International Parkway, the airport's spine road and service roads. Design criteria for the guideway intended the elevated guideway form a gateway to the airport's central terminal area for vehicular traffic. 65 percent of vehicular traffic enters the airport from the north entrance. The MSF site is on the north end of the airport in between the north and southbound lanes of international parkway. Airport executives and planners feared an APM maintenance facility that looked too industrial could detract from the overall appearance of the airport gateway and international terminal showpiece in the central terminal area. The original concept called for a two-story design with administrative offices on the upper level including maintenance control point to look out over the maintenance bay and yard. However initial architectural concepts suggested a single story design could better accommodate aesthetic concerns. The design was changed to a single story facility. Moreover, given DFW's multi-terminal airport layout and the importance of the people mover system to DFW hub operations, executive staff wanted to ensure the MSF would be integral to, and capable of, supporting other airport operational activities. The control center and adjacent training room were designed to be able function as an alternate airport operations center. Facility site preparation required elimination of an access road to a passenger remote parking lot. OnCor (formerly TXU Electric) owns 25KVA primary switchgear on the premises. Adjacent aircraft taxiways added safety & security issues to the design hurdles.

The next design hurdle centered on the need for the facility to be fully capable of meeting any and all anticipated support requirements for the system. Design of the facility, which was being developed as part of the overall fast-track approach to the project, was such that the supplier's technical requirements for support systems were initially unknown. Design had to proceed with the ability to interface with the system supplier's technical

requirements on the fly. Given the owner experience with original AirTrans airport train system where the owner took over operations and maintenance from the supplier, the owner wanted to make sure that every element needed to support the people mover independently was either furnished by the owner or deliverable by the supplier. The supplier would be responsible for finish-out of the facility since the yet to be selected technology was unknown at the time. The current operations & maintenance (O&M) contract contemplates five individual one year periods of system maintenance. There is an option in the O&M contract for the owner to request staff training as a prelude to in-sourcing the system maintenance if the owner feels it is in DFW's best interest to do so. It was imperative that the facility accommodate all necessary support equipment requirements on-site to support any future maintenance in-sourcing if necessary.

From an initial design perspective, it was important to provide for the facility to support the ability of the owner's and supplier's teams to manage operations and maintenance activities jointly or independently. As previously stated the Skylink system is operated under a unique arrangement under which the owner's personnel operate the system while the supplier's personnel maintain the system. Both teams share the facility. One of the key considerations was to develop a facility layout and space allocation scheme that would enable the owner's and supplier's personnel to collaborate in an effective partnership while enabling both to manage and administer their respective personnel groups autonomously.

The final major key area of consideration involved designing the facility with a long-term focus. Although the contract calls for the supplier to maintain the system and reside in the MSF for five years, the owner wanted to ensure that considerations were made for longer range eventualities. For example, the Skylink system is initially sized for 5000 passengers per direction per hour (ppdph). As such the initial fleet being serviced in the MSF consists of 64 cars or 32 married pairs. At a future date, to be determined by airport passenger volumes, the system will be expanded to a capacity to serve 8500 ppdph. The fleet will nearly double in size to 114 cars to meet this capacity requirement. The MSF will need to be expanded to accommodate the servicing of this expanded fleet. The required expansion will need to take place without disruption to the ongoing maintenance and operations in the facility. Much consideration was given to the need for a future expansion in the facility design. The result was provisions for adding three more maintenance bays on the north end of the building in the machine shop area.

The Skylink MSF facility and building systems are maintained by third parties under separate contract to the owner. Facility janitorial needs are met by third parties under contract to the system supplier. The local electric utility service supports their own primary switchgear in the facility. The facility operates on a 24 hour per day 7 days per week basis with personnel of each entity's staff requiring varying degrees of facility access. These divisions of responsibility created design challenges relating to facility access, safety, security and environmental compliance. The facility design and key-core arrangements provide for ease of access for MEP and general maintenance support by third parties. An automated access control system augments physical keying to manage facility access.

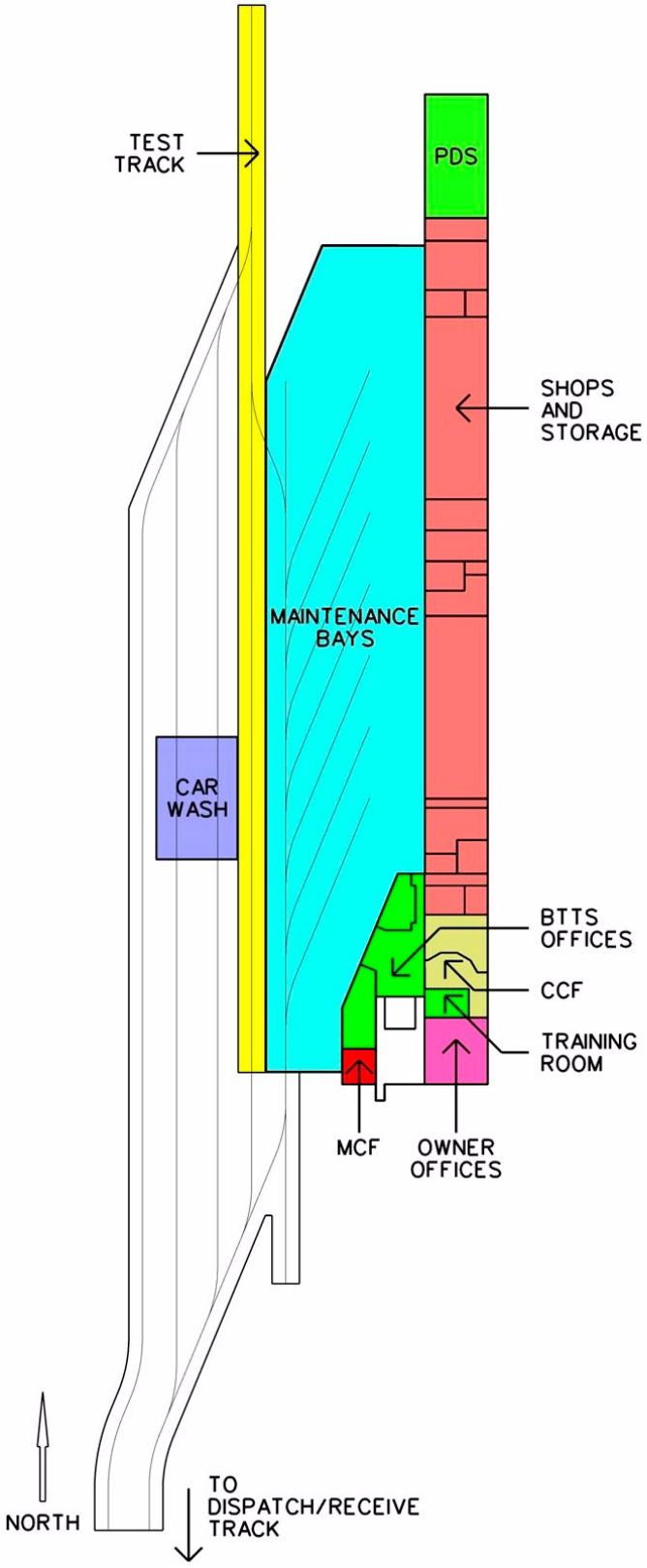

Figure 1: Plan view of the DFW Maintenance and Storage Facility

Facility Overview

Despite the many challenges identified above, the cooperation of a cohesive, talented team resulted in an outstanding facility which effectively and efficiently meets the Skylink partnership's needs today and into the foreseeable future. The following is an overview of the facility.

The facility is designed to meet all operations and maintenance needs of the APM system from a single location to include storage for vehicles and spare parts and materials. It is located north of Terminals A and B between the north and southbound lanes of the airport spine road - International Parkway. Retaining walls were constructed along International Parkway as part of the storage yard. The facility footprint is 9,290 square meters (110,000 square feet). The adjacent storage is 4,645 square meters (50,000 square feet). The overall facility includes parking for 75 company and employee cars.
A Central Control Facility (CCF) controls the overall operation of the Skylink system. From here Central Control Operators (CCO) supervise, monitor and control trains, routes, schedules etc. CCOs monitor and control the Skylink power distribution system and closed circuit television system (CCTV) from this location. Controllers interface with, and respond to, Skylink user needs on vehicles and in station areas through DFW Customer Services Ambassadors, Department of Public Safety (DPS) personnel or others as needed to provide world-class Skylink services. The control center was designed to support the capability to establish an alternate emergency operations center for the airport if necessary. A wall between the Control Center and the adjacent training room incorporates a large amount of glass to allow visitors and staff a view of the Control Center without entering or interfering with operations therein. This provides the airport the capability of establishing and supporting an on-site team response to any scenario that unfolds. Emergency planning, oversight and debriefing can take place in the room.

Although a generalist O&M staff philosophy is employed by other properties, due to the size of the DFW system the owner wanted to ensure that maintenance and yard movements could be managed as a distinct function from revenue area operations. For this reason a separate maintenance control center within the facility is available to control shop maintenance activities and to control automatic train movement within the maintenance yard. Departure tests, vehicle receiving and vehicle wash are also controlled from the maintenance control center. A vehicle wash with two vehicle wash bays and a covered area for cleaning vehicles is included. A catwalk connects the maintenance area to the cleaning dock area. There are two types of maintenance bays to support vehicle servicing in the facility. A total of 7 bays are currently available. Four of these are under-vehicle light maintenance bays for preventive maintenance inspection and running repairs. There are three heavy maintenance bays for major repair actions. There are connecting tracks with switches. A short section of guideway permits the delivery of the Innovia vehicle and acts as the storage track for the maintenance recovery vehicle (MRV). Two garage style roll-up doors allow APM vehicle access into and out of the facility.

A large maintenance support area was designed into the MSF. This consists of an open major repair area for component and assembly rebuilding. This area allows for expansion of two additional heavy maintenance bays for Phase II. An electronics lab is used to test and repair electronic equipment and to act as a secure storage location for storing sensitive bench and portable test equipment. A shift supervisors' area is available to support 24 hour - seven day maintenance. A machine shop features floor model repair, rebuild and fabrication equipment.
Two open administrative areas that are partitioned for the respective owner's and supplier's staff are incorporated into the facility. The idea was to provide an environment in which the respective staffs could work in a collaborative partnering environment while retaining the integrity of their individual teams. The administrative area also includes conference rooms, janitor and office supply accommodations, restrooms, a break room and a lobby receptionist area. Bombardier equipped the building and yard with furniture, tools, specialized equipment, storage bins, shelves and racks that are necessary for maintaining the system. A document control library is incorporated into the facility. Locker Rooms are equipped with full length lockers in both the female and male areas. There are four storage areas in the facility. These are general, heavy, electronics and solvents. Once again the purpose was to make the facility completely capable of self sustaining. While initially a design criteria, a paint booth requirement was later eliminated because the gel coat construction of the Innovia vehicle and the wrapping concept for accenting the cars.

The Skylink Testing and Acceptance Program:
The special features that were included in the overall design of the MSF were included primarily to facilitate effective operation of Skylink. A secondary benefit was also realized. By making provisions for operation of the complex Skylink system, these facilities were also available during the on-site testing and demonstration of Skylink. In order to explain how these facilities were beneficial, it is helpful to first describe the extensive testing program that has been developed for Skylink.

Types of Verification Activities: There are several types of verification activities that are used to prove the performance of Skylink. These include analysis, inspection, tests, and system demonstration.

Analysis: Certain technical requirements must be understood by the system designers before the manufacturing, fabrication, and installation may begin. The Skylink contractor was required to submit detailed documents demonstrating that all of the requirements were clear and would be satisfied. These analyses were provided in the form of design review documents, engineering reports, and engineering analyses.

Inspections: These inspections were performed to assure the system contractor that the facilities that were constructed or modified to accommodate the system were built properly. By inspecting and accepting these areas, the train supplier certified that the system could be integrated into these areas.

Tests: The testing of the system was structured in fashion such that items were tested and accepted from the simplest subsystems to the most complex. Layers of integration were more complex until ultimately the entire system could be tested as a functioning whole. Different types of tests were required for different equipment. The focus of this portion of the paper addresses the on-site testing and verification activities.

Project Elements Requiring Verification:
There are three categories of system elements that require verification. The fixed facilities provided by the Owner, the fixed facilities installed by the train supplier, and the operating system equipment installed by the train supplier.

In order to demonstrate contract compliance, the Skylink System supplier developed a detailed system acceptance plan. In this plan he was required to demonstrate 413 individual contract elements via one or more of the three verification methods described above. While some of these items were demonstrated on only one of the system elements provided. i.e. one of the 26 guideway sections, others were required to be demonstrated discretely for each of the 26 guideway sections, each of the 64 cars supplied, at each of the 12 passenger stations, or at one of the 13 wayside equipment room locations. Because of the large quantity of equipment supplied for the DFW project the total number of verification activities became very large. In all over 4000 individual contract requirements were verified and accepted under the system acceptance plan. The supplier's site test program included 1914 discrete test procedures. Of these, 630 were performed her at DFW. Out of the 630 verification activities performed, 257of these procedures either required, or benefited from the MSF.

The Skylink Maintenance and Storage Facility as the Base of Operations

As described in previous sections of this paper, the MSF served as the base of operations for the most critical portions of the verification program. There are four essential elements of the MSF that were critical to enable the verification of the system. These included the equipment receiving area, the central control room, the maintenance control room, and the vehicle test track.

Because of the scale of the Skylink system, it was very important that the system supplier have adequate space available to receive and store materials that would be used on Skylink. While much of this material was delivered and installed at the stations and along the guideway, a significant amount had to be received at the maintenance and storage facility, and prepared for integration into the system. One of the most important parts of this equipment receiving process was the receiving of the vehicles themselves.

Equipment Delivery and Receiving: The Skylink MSF was designed with the delivery of the vehicles in mind. There is a special location at the MSF designed with a spot for car jacks to be placed and operated. This vehicle receiving area is adjacent to the MSF parking lot. The security fence surrounding the vehicle delivery area is removable to allow the delivery truck to back directly into the delivery area between the jacks. The end-of-track buffer for this section is also removable to permit the entrance of the

delivery truck. The vehicles are then lifted while the truck and trailer drive away. The car is then lowered onto the running surface and this process is repeated for the second car of the two-car vehicle. Vehicles are then connected by the draw bars at the married end of the vehicle and towed into the building for the vehicle receiving inspection. A photograph of a car being offloaded at the MSF is shown in Figure 2.

Figure 2: Car being off-loaded at MSF

In addition to the vehicle receiving area, there are many other provisions for the delivery and storage of materials. There is a garage type door and a driving lane inside the building to allow a fork truck or a road-based vehicle to enter the building and drive right up to the storage areas. The entire maintenance and storage facility is air conditioned to assure that all types of materials, from chemicals to electronics can be safely stored and protected from environmental damage.

Central Control Facility: The Central Control Facility is a key room within the maintenance and storage facility. This room was critical to system verification and acceptance because in order for automatic operation to be monitored by the central control operators all of the functions had to be visible to the central control operators. When the central control room became operational, it allowed the train supplier to test the functioning of the system elements. Correspondence of all equipment, alarm generation,

and equipment monitoring were all performed from the central control room. In addition, the CCO was equipped with guideway and station CCTV monitors that allowed the operator to view activities occurring in the field from the remote location.

Maintenance Control Facility: At DFW, the MSF also houses a maintenance control room. The maintenance control room has been provided primarily for the purpose of controlling vehicle operations in the automated train yard. This allows maintenance operation to occur without interfering with the mainline operations being monitored from the central control console. During the on-site testing, the Maintenance Control Facility (MCF) permitted another function. The MCF allowed simultaneous test activities to be conducted while the central control console was occupied. For example, a test of the vehicle station interaction could be conducted from the central control console while a vehicle dynamic test could be conducted from the maintenance control console. Having this added flexibility allowed the testing team to increase staffing and perform tests more rapidly than would otherwise be possible.

In addition to this, the maintenance control console was also a valuable training tool. Operators could receive instruction on nearly all of the functions that are available on the central control console without interrupting the testing being performed at the central control console. This allowed a much more realistic training environment than could be achieved using a simulator.

Test Track: In the train yard, directly adjacent to the MSF there is a 950 foot long section of guideway that has been dedicated as a test track to be used for the dynamic testing of vehicles. Typically train movements in this area and in the rest of the yard are monitored by an operator at the maintenance control console. This test track has two parking positions, one at either end, which simulate station functions. The design function of this facility is to allow vehicles to be dynamically tested after maintenance activities to assure proper performance before these vehicles are returned to passenger service.

During the test phase of the Skylink implementation, the test track was instrumental in performing the vehicle testing and the inspection of vehicles as they were delivered to the site. The vehicle delivery schedule for Skylink had vehicles arriving at the site until early December of 2004. By enabling the test track, vehicle dynamic testing could be performed as additional vehicles were received while still permitting other testing of the system to continue. The test track can be monitored from either the Central Control console or the maintenance control console.

The Skylink MSF Was Used to Perform Other Miscellaneous Functions

In any large transit project, there are many areas that must be addressed during the course of the implementation that are not clearly planned in the original scoping and scheduling exercise. The training of Skylink personnel is an important example of this. The design of the Skylink MSF had to be flexible enough to allow this training to occur, even though the extent and details of the training program were unknown at the time of the original

proposal. In addition to training, the application of the DFW brand to the vehicles was decided to be performed after the contract has been executed. The Skylink MSF was utilized as a convenient space to apply the large graphic decals to each of the cars.

Training of Personnel at MSF: The MSF is a convenient location to perform most training functions for Skylink maintenance personnel, Skylink operators and Department of Public Safety personnel. At DFW, there are three basic types of personnel that required some level of training related to the new Skylink system. These three types of personnel are the maintenance personnel, the system central control operators, and the Department of Public Safety Personnel who are responsible to respond to any emergency in an area of Skylink.

The maintenance of the Skylink system is performed by the train supplier, Bombardier Total Transportation Systems (BTTS). Under a separate maintenance contract with the Airport, BTTS is responsible for the scheduled maintenance of all system equipment supplied or modified as part of the project, the unscheduled maintenance of that equipment and the recovery of stalled trains during system operation. To satisfy these requirements, BTTS performed a series of classroom training sessions and demonstrations of system functions on the specific equipment being maintained. With the exception of the station equipment, nearly all of this training could be performed at the MSF. A staff of 77 people was fully trained to maintain the system in preparation for system passenger service.

The operation of Skylink is performed by DFW Airport Board employees. These employees are responsible for monitoring the train operations in passenger service. They monitor and interact with passengers as needed to provide a world-class service. This work is performed from the central control console. In order to assure the proper operation of the system, BTTS was required to train all of the airport operators to assure that they take appropriate action when required. All of this training was conducted at the MSF, including operations training on the console.

The third group of trainees for Skylink are the emergency responders from the DFW Department of Public Safety (DPS). This group includes emergency responders from the fire, police and emergency medical services. Key members of these departments were oriented to details of the Skylink system that allows them to respond to emergencies on the system. These personnel were shown how to open the vehicle emergency doors, how power was delivered to the vehicles and other subsystems, the locations of emergency doors, and methods for jacking or hoisting the vehicles. Much of this training was performed at the MSF. DPS then used this basic training course to develop an emergency response plan, standard operating procedures, and emergency drills.

Applying the Graphics to the Skylink Vehicles

When the Skylink vehicles were delivered to the MSF, they were white. After the preliminary inspections were performed, DFW applied a thin graphic film to the exterior surfaces of the vehicles. This film is imprinted with the DFW brand image. The MSF

provided a climate controlled environment where this adhesive-backed film could be applied. This allowed for the control of wind, dust, or precipitation that could have damaged the film. Under these ideal conditions, two-car vehicles were covered in less than two days.

Public Passenger Operation; a Going Concern

As the Skylink system entered public passenger service the concerted efforts of a dedicated team of professionals has turned a vision into a reality. The torch has been passed from DFW's original AirTrans system to the new Skylink system. For years to come the DFW Skylink MSF facility will support the world's largest people mover operations and maintenance activities. It will be the focal point for providing coordination between DFW airport staff, the Skylink system supplier, other Airport Board business units and external support or regulatory entities. The facility will support ongoing budget and payroll management, correspondence tracking, and administrative support to the APM operation. The DFW Airport Maintenance & Storage facility will set the standard for APM support facilities well into the 21st century. It's not just a maintenance facility.