Model Number :
Model Name : Airtrans
Model Type: Automated Transit System

The most complex completely automated transit system ever built was designed and installed at the new Dallas/Fort Worth Airport in the period from mid-1971 to mid-1974. This system, designed to carry passengers, employees, baggage, mail and supplies between the terminals, post office and supply depots, is still in operation today. The airport, as owner, has made numerous changes in system operation and capability in the intervening years but the basic system is still the same as designed, even after many millions of miles of safe operation. Several patents were awarded to LTV Aerospace Corp. for system innovations. The system was licensed to the Niagatti Engineering Co. of Japan and several derivatives are operating in Japan. The system described here is that which was designed, built, and placed in operation at the Dallas/Fort Worth Airport. This description does not cover the subsequent changes and modifications by the airport as a result of changed or expanded requirements

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Program Background

In 1970, as a part of a program to broaden the business base, a study team was formed under the Vice President of Engineering to investigate ground transportation systems. At that time the Dallas/Fort Worth Airport was under construction and a people mover was one of the requirements. The Varo Corp. of Garland, Texas, had a prototype monorail-type system. LTV was asked to team with them to prepare and submit a proposal late in 1970 using Varo's existing system. There were three proposals submitted and all were rejected as being more costly than the system for which the airport had budgeted. The Airport Board issued a new Request for Proposal in May, 1971. The Varo Corp. elected not to resubmit; therefore, LTV Aerospace Corp. chose to submit a proposal based on its earlier studies using off-the-shelf hardware in an innovative and completely new automatic transit system concept. No prototype or operating hardware was in existence and a creative effort was required with models and simulations to convince the Airport Board that the system could be built. The proposal period was only 30 days and the completed system was to go into full operation on 13 July, 1973, There were three proposals submitted with Westinghouse and Dashaveyor submitting in addition to LTV. LTV was declared the winner and notice to proceed was given on 2 August, 1971 – leaving less than two years to bring a very complex newly designed system to full operation.

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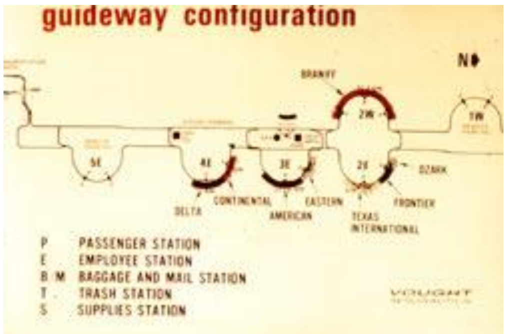
System Requirements and LTV's Proposed Solution

The airport design consisted of four half-circle terminals with remote parking both on the north.and on the south, a hotel, a transportation maintenance complex, postal facility and supply facilities.

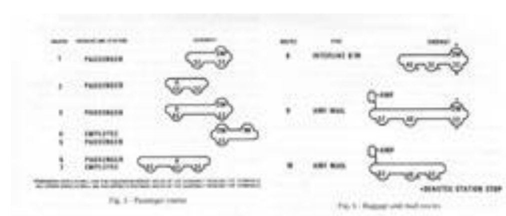


System operating requirements were as follows:

- 20-minute trip time for interline passenger transfers
- 30-minute trip time for passenger travel to remote lots
- 30-minute interline baggage transfer
- 30 minutes to restore a downed system to operation
- 500-hr. mean time before failure of vehicle
- One-year warranty on all components
- 30-year design life (20 years on vehicle)
- Expandable to meet future needs

The number of passengers and employees to be moved, and the quantities of mail, trash, supplies, and baggage to be moved were detailed in the specifications for the airport and became a part of the contract obligation, with severe penalties for failure to meet them.

LTV employees John Loutrel and Ruth Huffman developed an extensive computer simulation. The simulation was very advanced for that time and was a factor in winning the program and enabling it to meet the specifications with minimum cost. Without using all of the available right-of-way, a series of overlapping routes was developed to meet the requirements by building the guideway shown . These routes are shown in the Individual Scheduled AIRTRANS Routes illustration. This Routes illustration does not show the trash and supply routes, which provided on-demand service.



AIRTRANS vehicles travel over these dedicated routes using the common guideway and switching automatically as required to maintain the route unless commanded to change by Central Control.

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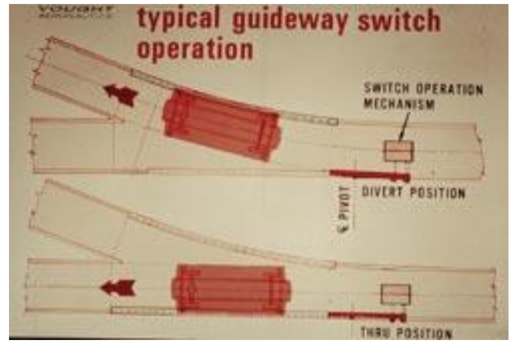
Switch and Switch Machine



The switch, an LTV Aerospace-developed system for which a patent was granted, is a fast-acting guideway switch that can divert a vehicle to a siding, to another line, or can permit it to proceed in a direct line. It consists of both a movable part and a fixed entrapping rail attached to the top of the parapet wall. Depending on the position of the movable section, entrapping wheels on the vehicle cause the vehicle to be steered in the proper direction. The *Typical Guideway Switch Operation illustration* shows the two switch positions and the behavior of the vehicle as it is steered through or to the right or left. The vehicles cannot split the switch because the vehicle is entrapped all the way through the switch area. The switch actuator, or switch machine, is a standard railroad actuator that has been in service on the nation's railroads for many years and is a fail-safe device. This machine was originally located in the center of the guideway, as shown, for esthetic reasons. The Airport later moved it to the outside of the parapet wall for easier maintenance. The selection of this critical item off the shelf saved a great amount of time and development cost. The new-concept switch and the selection of off-the-shelf switch machines were significant contributors to the success of the program.

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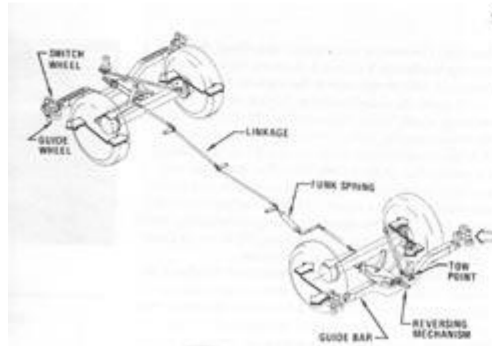
Power Distribution

Electrical power is distributed to the vehicles from 14 substations located throughout the guideway system shown in the *Guideway Configuration illustration*. Each substation serves a section of guideway, providing 15 power zones. However, in the event of a failure of any substation, the adjacent one can assume the load and permit uninterrupted operations. Three-phase a/c power at 480 volts is supplied to the vehicles through three copper-steel rails. The three power rails are recessed inward from the safety ground rail at the bottom and the signal rail at the top. All five rails are attached to the inside of the parapet wall as shown in the *At-grade Guideway illustration*. Rails are on both sides only in switch areas so that power will not be lost while transiting that area. Power rails are recessed to reduce inadvertent contact by someone walking in the guideway.

Vehicles

The 51 AIRTRANS personnel vehicles and 17 utility vehicles are on the same chassis and have the same basic controls. The passenger and employee vehicles are identical except they are inserted in the guideway with opposite ends in front to provide for the door on the right or left to correspond to the location of the employee or passenger stations which are on opposite sides of the guideway. (The employee stations are on the right and passenger stations on the left of the direction of travel). The vehicle is 21-ft. long, 7-ft. wide, and 10-ft. high. It has an empty weight of 14,000 lbs. In addition to the bi-parting entrance door, there is an emergency exit on each end of the vehicle. Exterior panels are of acrylic-coated fiberglass with the colors impregnated in the acrylic finish. Vehicles were produced in the high bay manufacturing area of LTV Aerospace Corp. in Grand Prairie, Texas. The final assembly line for production of A-7 aircraft may be seen in the background of the Vehicle Assembly illustration that shows production of the AIRTRANS vehicles.



The vehicle interior, provides seating space for 16 people and standing room for an additional 24, for a total of 40 passengers. Hand holds and colors were carefully selected to blend with the color scheme of the airport. The floor is carpeted and the seats are upholstered. The vehicle contains a public address system , two-way voice communication equipment, and an on-board automatic station announcement system. Vehicle controls are located under the carry on luggage rack. The vehicle chassis is made as a welded structural steel frame. Axles are a standard automotive truck type, with one driven through a standard differential. They are supported by an air bag suspension system and foam-filled tires, size 8.25x20. The innovative use of existing and proven hardware in a new concept transit system resulted in lower cost, greater reliability, and a long service life. Propulsion is by a continuous rating d/c motor driving through the automotive drive shaft to the differential. The 480 V a/c. source power is rectified and controlled by a motor controller located on the chassis under the floor of the vehicle. Also under the floor is the emergency storage battery, an alternator to charge the battery, an air compressor for the suspension system, door operator, brakes, and vehicle dock leveling system. Two heating and air-conditioning units are suspended below the chassis – one on each side. A nominal 5 tons of air-conditioning is provided.

The vehicle steering system is another system patent of LTV Aerospace. Steering is accomplished with 6-inch diameter polyurethane wheels, which are fixed to a guide bar that is connected to the steering linkage. The front wheels are linked to the rear wheels, so that tread-over-tread tracking takes place. As the front wheels steer in one direction the rear wheels steer in the opposite direction. The steering mechanism is directional; therefore a reversing mechanism is provided to reverse the sense of the steering for vehicle operation in the opposite direction.

The switching wheels are located in a fixed position above the steering wheels. These wheels steer against the outside of or become entrapped under the switch rail, thus steering the vehicle through the switch. In a switch area, one wheel is always entrapped under a rail, providing protection against splitting a switch. Additional safety is provided by backup smaller diameter steering and switching wheels just ahead of the service wheels. These come into play only in case of failure of the service wheels.

Power collection is by three articulated brushes, a set on each corner of the vehicle, with two sets in normal use for redundancy. The vehicle wheel illustration shows these, as well as the upper brush, which collects the wayside signal and the lower brush, which provides vehicle earth grounding. A vehicle bumper permits non-damaging impacts at speeds up to at least 3 mph. A draw bar and umbilical allows two-car trains to be operated.

The 17 utility vehicles have a chassis identical to that of the passenger vehicle. The car body is replaced with a powered flattop conveyor bed and framework. The conveyor drive has controls, which automatically power containers on or off the vehicle onto similar powered conveyors at the baggage, mail, trash, and supply stations. These controls are located in a compartment at the end of the vehicle. The vehicle can also carry and automatically handle the airline's standard LD3 container. (As of 1998 the utility vehicles no longer existed as all have been converted to passenger vehicles to satisfy increased passenger loads; and trash, supplies, mail, and baggage are being handled in other ways.).

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Controls

The automatic control system is divided into three subsystems: Automatic Vehicle Protection (AVP), Automatic Vehicle Operation (AVO), and Central Control. Their functions are summarized in the following:

- Automatic Vehicle Protection
- Assures safe train spacing
- Safe switching
- Speed limits
- Vehicle safety systems

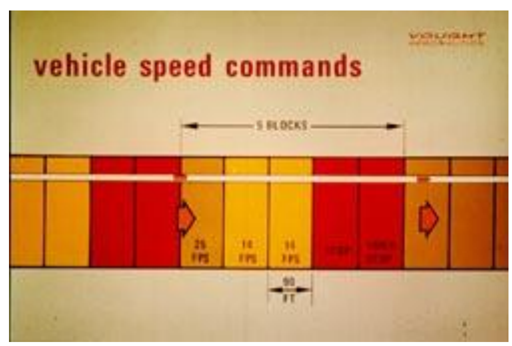
Automatic Vehicle Operation

- Route control
- Position stopping
- Door controls
- Speed controls

Central Control

- System status monitoring
    - Supervisory Controls
    - Speed commands
    - Switch positioning
    - Route changes
    - Bunch control
- Station monitoring
- Power distribution monitoring and control
- Voice, video, data communications
- System status monitoring
- Supervisory controls
- Speed commands
- Switch positioning
- Route changes
- Bunch control

Components of the AVP and AVO subsystems are located both on the vehicle and in the wayside control rooms. All vehicles may be driven manually with a plug-in unit, which overrides the AVO system; the AVP system cannot be overridden. Vehicle route information is stored in an onboard control logic assembly. This device responds to an interrogation from the wayside every 0.2-sec. and sends back route information as well as malfunction information. The wayside controls decode the route information and set the switches to the proper position. The proper speed command for each vehicle, depending on its location and other traffic, is transmitted to the vehicle from the wayside control units by the block control system. The vehicle control units are located under the baggage rack in the center of the vehicle opposite the entrance door. The wayside controls are located in each terminal and at the maintenance building in secure rooms. These units are made up of standard fail-safe relays that have been in use for many years on the nation's railroads. One room is shown in the Wayside Control Room Illustration. The use of this equipment in an innovative way played a role in the long life, low cost and high reliability of AIRTRANS.



The system was designed for a nominal operating speed of 25 ft./s (17 mph). A higher speed would not significantly reduce the trip time because of the many station stops. Also, because of the many curves, both laterally and vertically, a higher speed would have reduced the ride quality. Vehicle operating safety is obtained through a five-block control system. The guideway was divided into 708 blocks by insulators spaced at intervals along the signal rail. A nominal block is 90-ft. long. The vehicle maximum stopping distance under emergency conditions is 165 ft. In a five-block system, two blocks must be allowed for emergency stopping. With provisions for some margin, the block length was thus established at 90 ft. During any operation, at least one full block must separate the vehicles. For the various speed commands sent to the vehicles, see Vehicle Speed Controls illusttration. A green signal (tan in the photo) to proceed at full speed is sent to the vehicle from the wayside whenever a vehicle is cruising at high speed and separated from other vehicles by five full blocks or more. When the separation becomes less than four blocks, a signal is sent to the vehicle to slow to medium speed (14 ft./s). Within two blocks, the command is to stop. This allows one clear block between queuing vehicles. In a high-speed dynamic case, the vehicles have a minimum separation of 450 ft. At 25 ft./s the minimum headway is 18 seconds (that is, a vehicle passes a given point every 18 seconds).

The central control, from which the system is supervised, is located in the central heating and air conditioning building. The console in the Central Control illustration shows the status of the system and permits the operator to override the automatic controls of the system, if it is safe to do so. The route map shows the location by block of each vehicle and its status. TV screens permit viewing all passenger terminals, and two-way voice communication is possible with any and all vehicles. A CRT display also displays vehicle status and malfunction information. A smaller route map on the console displays power distribution information. The supervisor does not operate the system but he may add or subtract cars, change the routes, dispatch service crews or interface with the passenger. A printed copy of all operations and malfunctions of vehicles and stations is available from the line printer and computer storage. The supervisory system consists of a hierarchy of computers located in terminals and maintenance areas, all reporting to the central computer as shown in the Supervisory Computers illustration

AIRTRANS was designed to carry all baggage between terminals in 89 containers. These had rollup doors and three were carried on a cargo vehicle. (**NOTE**: The baggage system was constructed and demonstrated but was never implemented because interline transit times from airline to airline were changed after the system was installed.) Powered conveyors on the vehicle matched an array of powered conveyors in the terminals to move the containers from the vehicle to positions for unloading by airline baggage handlers. The Terminal Cargo Handling Conveyors illustration shows the array of conveyors in a terminal. These have subsequently been removed.

AIRTRANS was also designed and constructed to carry United States Postal Service mail to and from terminals to a Post Office in the maintenance area shown in the Guideway Configuration illustration as "AMF" (Air Mail Facility). This service was demonstrated as satisfying contract requirements but was terminated by the USPS as being too demanding in that it required their employees to interface with an automatic system. An incinerator was built by the DFW Airport in the transportation maintenance area, and AIRTRANS cargo vehicles were designated to carry trash there from the terminals. This facility was never able to operate as planned and the service was never implemented. An additional system capability was to carry supplies to the terminals from a large supply depot adjoining the transportation center. This system was an “on-demand” system and used the same cargo vehicles and container types as the other cargo services It was a highly successful operation and was used until 1991 at which time it was reluctantly terminated to increase passenger capability on AIRTRANS. All cargo systems, although of great complexity and far ahead of their time for automated systems, performed to the contract specification and would have remained in use except for changed requirements.

Stations

AIRTRANS was built to serve a total of 53 station stops at the airport. Trash, supply, baggage and mail stations have been described above. The passenger stations and waiting rooms are on a single siding and feature a glass enclosed platform with bi-parting doors which open with the vehicle doors when a train comes to a stop and the vehicle leveling system has leveled it with the station platform. The stations originally contained fare collection turnstiles (which were removed early in the airport history), a route map, station TV surveillance cameras, above-door graphics showing the destination of the vehicle currently in the station, a public address system, and seats. Two doors were installed originally with provisions for a third if two-car trains were used.

The employee stations are across from the passenger stations on separate sidings and are screened from the passenger stations. An open platform is provided. It contains destination graphics, a route map and public address system. All stations in the north and south parking lots are on line because traffic there is relatively low. Throughout the system, passengers enter vehicles from the right, and employees from the left, in the direction of traffic. Station locations are shown on the *Guideway Configuration illustration*. The hotel station is an elevated station for both passengers and employees.

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Maintenance

Maintenance takes place in the transportation center. This center contains the post office, the trash dump, the supply depot, an on-line vehicle wash station, and the maintenance building. Also in this center there is a departure test track, used to ensure that vehicle safety features are functioning, and a ready track for vehicles awaiting dispatch into service. For layout, see the Transportation Center illustration.

The maintenance building contains ten stalls for servicing vehicles, the control room for the departure test and offices. The building is surrounded by a paved area. Another very important innovative feature of AIRTRANS is that the vehicles have off-guideway capability in that they may be moved over any smooth surface with a standard commercial tug. These tow tugs can move the vehicles around the maintenance area and can recover a stalled vehicle from the guideway. The departure test track automatically checks the vehicle systems and in particular the safety systems before a vehicle enters the guideway to run unattended throughout the system. A commercial-type guideway sweeper was also provided. LTV also developed a complete plan and schedule of maintenance. The ability of the vehicles to be moved outside the guideway, while still operating under full automatic control when inside it, resulted in tremendous cost savings and system flexibility which have contributed to a long service life.

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AIRTRANS 1998

On June 1, 1998, AIRTRANS was still in operation without modification to the basic design, making it, 25 years after installation, the automatic system with the longest record for providing service without undergoing major modifications. Numerous operational, usage, and maintenance changes have been made by the Transportation Department staff at the Dallas/Fort Worth Airport, including the addition of guideway and increasing the number of passenger vehicles. The longevity, safety, and reliability of AIRTRANS are a tribute to the Vought designers, the builders, and the D/FW Airport operators and maintenance personnel. The system operates 24 hours per day, 7 days per week, 365 days per year.

Following are some of the current operational data reported by the staff at the airport:

- Guideway length: 15 miles
- Stations for employees and passengers: 33
- Personnel vehicles: 68
- Average vehicle mileage: over 1,000,000 miles
- High-mileage vehicles: six at over 1,500,000 miles
- Total system mileage as of 12/31/97: 74,529,310 miles
- Current riders per year: 9,000,000