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## Bus Terminal Planning and Operation at the 1982 World's Fair

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The design and operation of charter and tour bus and shuttle bus terminals at the 1982 World's Fair in Knoxville, Tennessee, are described. Constraints governing the design principles are discussed and operation policies are defined. Each terminal required a different type of layout and operating concept because of land availability and differences in the loading and unloading requirements of users of the types of services offered. Operating labor requirements, other factors influencing cost, and flow rates actually achieved at each terminal are discussed.

The 1982 World's Fair in Knoxville, Tennessee, was planned to attract 11 million visitors during its six-month duration. A modal split of 30 percent by public transit was predicted for the designed day volume of 80 000 persons. The public transit component of the Fair's planned transportation system included provisions for charter and tour buses; shuttle buses from local hotels, motels, and nearby communities; shuttle buses from parking lots included in the official World's Fair parking system; and the local bus service provided by the Knoxville Transit Authority through its operating arm, K-TRANS. Early estimates were that, on peak days, 700-800 charter buses might arrive, carrying some 30 000 Fair visitors. The local hotel and motel shuttles were predicted to carry a maximum of 5000 visitors/day, and the official parking lot shuttles an additional 10 000 visitors on peak days. (The parking lot shuttles, both official and unofficial, were counted as part of the automobile modal split and thus were not included in the 30 percent forecast.)

The World's Fair site (see Figure 1), which is bounded by the Knoxville central business district (CBD) to the east, the Tennessee River to the south, the University of Tennessee campus to the west, and an Interstate highway and local arterial streets to the north, posed many challenges to the transportation planners. The overall goal was to get visitors to and from the Fair as efficiently as possible while imposing a minimum of added congestion on the Knoxville street and highway system. Planners for the Fair's transportation system had to work within the following constraints:

1. Land adjacent to the Fair was scarce and costly,
2. The Fair management wished to invest the minimum amount possible in transportation facilities consistent with the goals stated above,
3. Charter and tour buses required parking for the day as well as terminal facilities for loading and unloading,

4. Terminal plans had to be compatible with existing or achievable highway capacity on the adjacent streets, and

5. The terminal system and traffic-flow rates had to mesh with the Fair's entrance gate designs and capacities.

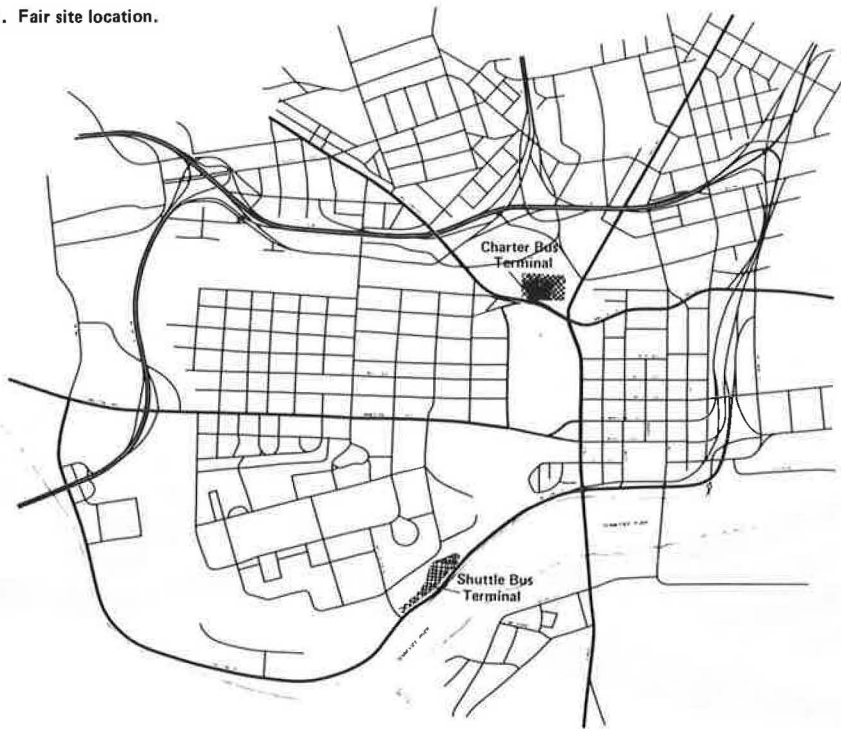
The solution adopted was to assign the different types of bus traffic to terminals at the various Fair gates, thereby distributing the volumes and enabling the most appropriate type of facility to be designed for each kind of service. The design and operation of each of the three bus terminals are described in the remaining sections of this paper. Information on operating labor requirements and flow rates achieved is included for each type of terminal.

### CHARTER AND TOUR BUS TERMINAL

A charter or tour bus was defined as a bus that transported a group to the Fair, dropped off the passengers, and then picked them up at a designated time. The buses used were typically standard intercity coaches or school buses with one front door for loading and unloading.

The area designated for the charter terminal was a triangular piece of land immediately adjacent to the Fair's north gate. It was selected because of its proximity and ease of access to the Interstate highway system that serves Knoxville, which made it possible to keep most of the long-haul bus traffic off the downtown Knoxville streets en route to and from the Fair. A policy decision was made that charter and tour buses would unload at a Fair gate, but that no attempt would be made to provide all-day parking for the buses in the immediate vicinity of the Fair due to lack of land. Hence, buses would have to deadhead to a parking area immediately on unloading and return to the bus terminal only to pick up their passengers and depart for the next destination. Anticipating the need for fueling, dumping station, and cleaning services, as well as minor maintenance, Fair management entered into an agreement with a local entrepreneur to provide parking for a minimum of 175 buses, with room for an additional 250 to be provided if demand warranted. Servicing and minor maintenance were to be available at the same location, which was approximately 4.5 miles from the north gate. Proposals were solicited from existing bus facilities to provide the layover area based on services available and acreage.

Figure 1. Fair site location.



#### Terminal Layout

With the terminal being used solely for loading and unloading, maximizing the capacity of the facility to handle the movement of people and buses to and from the Fair was the primary design criterion. Several alternative configurations for the terminal were drawn up and analyzed, and the one selected is shown in Figure 2 (note that dark areas are pedestrian islands). The capacity of the terminal was maximized by using a layout that would allow the greatest number of buses to unload or load at a given time. This meant locating the loading berths in long rows and operating the terminal in a manner that would prevent bottlenecks from occurring on the platforms. Passing along the loading berths was not permitted due to space constraints. Arrivals at the Fair were handled on a first-come, first-serve basis, and a reservation system for departures from the Fair was established. The reservation system was widely publicized through the American Bus Association, the National Tour Brokers Association, and the Fair's group sales office. Brochures were distributed that outlined the terminal operating procedures, and site tours were conducted in March to familiarize tour operators with the terminal facility.

Two loading berths were provided for buses carrying handicapped persons along the west pedestrian walkway. These buses were permitted to park in the terminal; however, only one bus operator used the facilities throughout the course of the Fair.

#### Operating Plan

Greyhound, as official motor coach carrier of the World's Fair, was permanently assigned platforms A and B, with a total of 15 loading berths. The Trailways organization was assigned platform E, with eight berths. These platforms were operated by dispatchers from the respective carriers who were responsible for managing their traffic so as to avoid delays and to accommodate their scheduled departures. Greyhound chose to marshal their departures

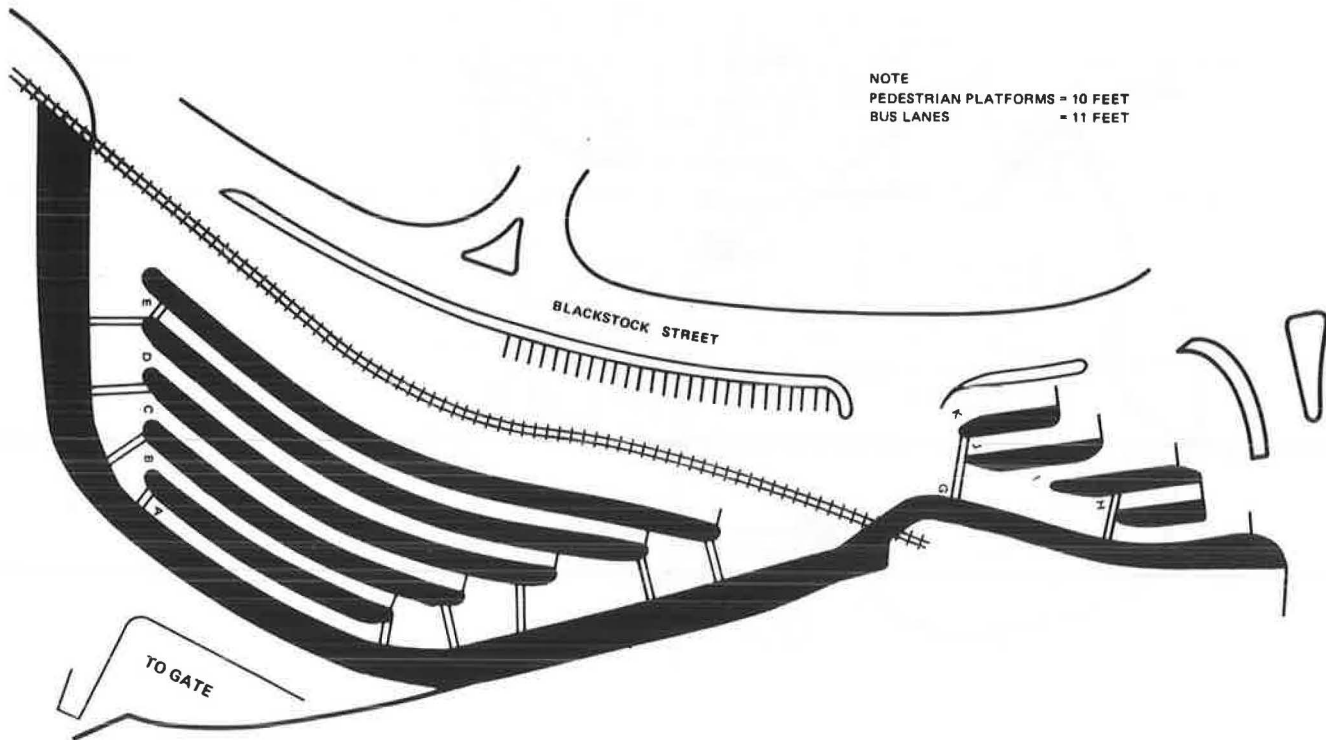
at their parking and layover area several miles from the Fair and to convoy the buses from there to the Fair in departure sequence. They were able to assign each bus a specific loading berth in this way and to tell the passengers where the bus would be along the platform. Trailways, which is an association of carriers rather than a wholly-owned operation, assigned their departures to the requested hour and used two-way radios between the terminal and their Knoxville garage to regulate flow during busy hours.

The remaining 31 berths in the terminal were operated by Fair staff. Fair dispatchers were stationed on platforms C, D, and F through J to greet incoming buses and assign or verify the departure time. Buses were assigned a sequence number for the day, which matched the number of the reboarding checks given the driver or tour escort to hand to the passengers. Passengers were told at which platform the bus would load and the departure time. The bus also was issued a windshield card that served as the pass to allow the bus to reenter the lot for loading. This card indicated the sequence number, the departure hour, and the platform assigned for loading. By recording the sequence number in the day's log, the dispatcher also could assist passengers in locating their bus; the log indicated which sequence numbers would be loading at each platform by time of day. Charter operators originally estimated boarding and alighting times of 10-12 min. Actual boarding and alighting times were 4-8 min. This was partly due to limited use of under-the-floor luggage compartments. Wheelchairs were generally the only items stored in the luggage compartments.

It was planned to provide a departure schedule board for the terminal; however, it proved to be unnecessary. With the reboarding checks issued, uniformed Fair staff and Greyhound and Trailways dispatchers assisted passengers in locating their buses.

Buses that arrived at the Fair without an advance departure reservation requested a departure slot from the Fair dispatcher who met the bus on arrival

Figure 2. Charter bus terminal.



in the morning. The dispatcher would confirm the slot at the desired hour, if available, or offer the group a choice of the first available time before and after the desired hour. Originally, departures were scheduled only for the hour and half hour. As operating staff gained experience with the terminal, it proved feasible to schedule departures at 15-min intervals.

Several bus companies operated daily charter service (one round trip) daily. These firms were permanently assigned to platform J. Under the reservation system, buses would be allowed to enter the terminal no sooner than 10 min before their scheduled departure time and would have to leave 10 min after the scheduled time. (The 10-min grace period was established to allow for stragglers.) Bus companies were encouraged to write in for departure reservations well in advance, and written confirmations were returned to the companies where time permitted. For touring groups that had, for example, scheduled a meal at a restaurant in the area at a specific time, the ability to receive confirmation of a guaranteed departure time from the Fair was important to the smooth functioning of the tour as a whole.

#### Staffing Plan

Simulation studies conducted before opening indicated that the transaction time for an incoming bus without an advance departure reservation could exceed 1 min. Bus companies had indicated their preference for a 10:00 a.m. arrival hour (the opening hour for the pavilions and exhibit areas), and it soon became apparent that intensive staffing would be required in the morning hours to prevent bus traffic from queuing up for a mile or more. Greyhound used as many as six dispatchers to handle their traffic on busy mornings; Trailways frequently had four or five dispatchers on their platform.

Initial staffing for the Fair-operated portion of the terminal was nine dispatchers and seven traffic controllers. The traffic controllers were positioned at strategic locations within the terminal to direct traffic. Their task was to assign incoming buses to platforms in an efficient manner, to keep the flow of traffic moving, and to ensure pedestrian safety in the terminal. Although the platforms were fenced to prevent passengers from walking between buses when heading for the gate, there was a general tendency to ignore the marked crosswalks and oncoming buses.

After dispatchers and drivers became more familiar with the terminal and the routine, it proved feasible to operate the terminal with a crew of 10 Fair staff in the mornings. Transaction times dropped, thereby making it possible to function effectively with only six or seven dispatchers and three or four traffic controllers.

The evening staffing requirements were substantially lower, requiring only four or five Fair staff once the initial shakedown period was over. These people functioned mainly as traffic controllers, directing the incoming buses to the proper platform, separating pedestrian and vehicular traffic, and expediting the departure of buses when loaded and/or scheduled to depart.

#### Terminal Capacity

Before the fair opened, the capacity of the terminal was estimated to be 180 buses/h for unloading and 100 buses/h for loading. The figures were calculated on the basis of the bus industry's claims that it took 15-20 min to load a bus and slightly less to unload a full one. Therefore, it was determined that the lot could only turn on a half-hourly schedule for departures, which indicated an hourly capacity of roughly 100 buses. Because arrivals did not have to be scheduled, it was assumed that the turn-

over would occur approximately 3.5 times/h, allowing for about 180 buses/h on the arrival side.

In practice, the terminal proved able to handle more traffic than predicted. On busy May mornings, once the routine had been perfected and drivers were returning for their second and third trips, it was possible to unload 250 buses/h for a 2- to 3-h morning rush period. In the evenings, in general, the turnover period was shortened to 15 min, which enabled a departure rate of 175-180 buses/h to be achieved when necessary. This was partly due to the promptness of Fair visitors in returning to the terminal at departure times.

#### Other Features

Several features of the north terminal operation were crucial to its success. One, not previously mentioned, was the stationing of a uniformed police officer at the terminal entrance. This officer, who was hired and paid by the Fair, was responsible for keeping unauthorized vehicles out of the bus terminal--a major problem at some periods of the day--and keeping traffic moving smoothly on the street in front of the terminal. Because several major parking facilities were adjacent to the terminal, this task was substantial.

Discipline was enforced in the terminal, and bus drivers and tour guides came to recognize and respect the need for that discipline. Buses that attempted to linger in the terminal waiting for stragglers past the grace period were requested to leave, although they were permitted to reenter immediately for the next departure time if room was available on that platform (otherwise the bus had to go to a "penalty box" on the street near the terminal to wait for the passengers who were late). A strict no-passing and no backing-up rule was enforced in the platform areas; drivers who violated it were stopped on the spot and informed about the rule. Speeding in the terminal was also cause for swift corrective action. Once drivers understood that passenger safety was paramount, and the necessity for strict safety rules in a terminal handling up to 250 buses and 10 000 passengers/h with no vertical separation of buses and passengers, cooperation was usually obtained. In general, it can be reported that the bus industry exhibited the highest standards of professionalism, working closely with Fair staff to ensure the smooth operation of the terminal and the safety of its users.

Bus platforms were marked with letters on the pavement for the drivers entering the terminal. Signs 2 ft<sup>2</sup> were posted on the ends of each platform for the passengers.

#### HOTEL AND MOTEL SHUTTLE BUS TERMINAL

The characteristics of shuttle bus operation suggested the need for a terminal design quite different from the charter and tour terminal. Charter and tour buses typically arrived at the Fair only once a day and transported the same group they brought to the Fair. In contrast, shuttle buses returned to the Fair several times a day, and the passengers on an outbound bus were not necessarily the same group that traveled inbound together. Charter buses from a given firm might or might not be using the terminal on successive days; virtually all shuttle services planned to operate each day of the Fair. Hence, while it was not practical to assign permanent loading locations in the charter bus terminal to specific carriers (except for Greyhound, Trailways, and a few regulars with daily departures), it was necessary to assign permanent locations in the shuttle bus terminal so that pas-

sengers would know where to find their bus on leaving the Fair, keeping in mind that the outbound bus would be from the same company, but not necessarily the same vehicle, as the inbound one.

#### Terminal Layout

A location for the shuttle bus terminal was established near the Fair's southwest gate. Again, the principle was that bus passengers would be brought to the gate, but that buses would have to park elsewhere. This was less of an issue for shuttle carriers, since the majority of them were operating several trips with the same piece of equipment and had no desire to leave it near the Fair. The terminal, shown in Figure 3, accommodated 34 buses and 10 vans at a time (note that dark areas are pedestrian terminals). Its layout and location were dictated by land availability and topography. In effect, the terminal was created on land leased by the Fair from the University of Tennessee (UT) adjacent to an existing UT commuter student parking lot. Because the parking lot was to be used by the Fair for revenue parking weekdays from June 10 to September 18 and on all weekends during the run of the Fair, it was desirable to preserve as much of the lot for automobile parking use as possible. As ultimately configured, the terminal combined loading zones all around its perimeter with a minimum-radius turnaround area adjacent to the walkway to the southwest gate of the Fair. (The walkway's purpose was to accomplish a grade change some 20 ft vertically from the terminal to the gates.)

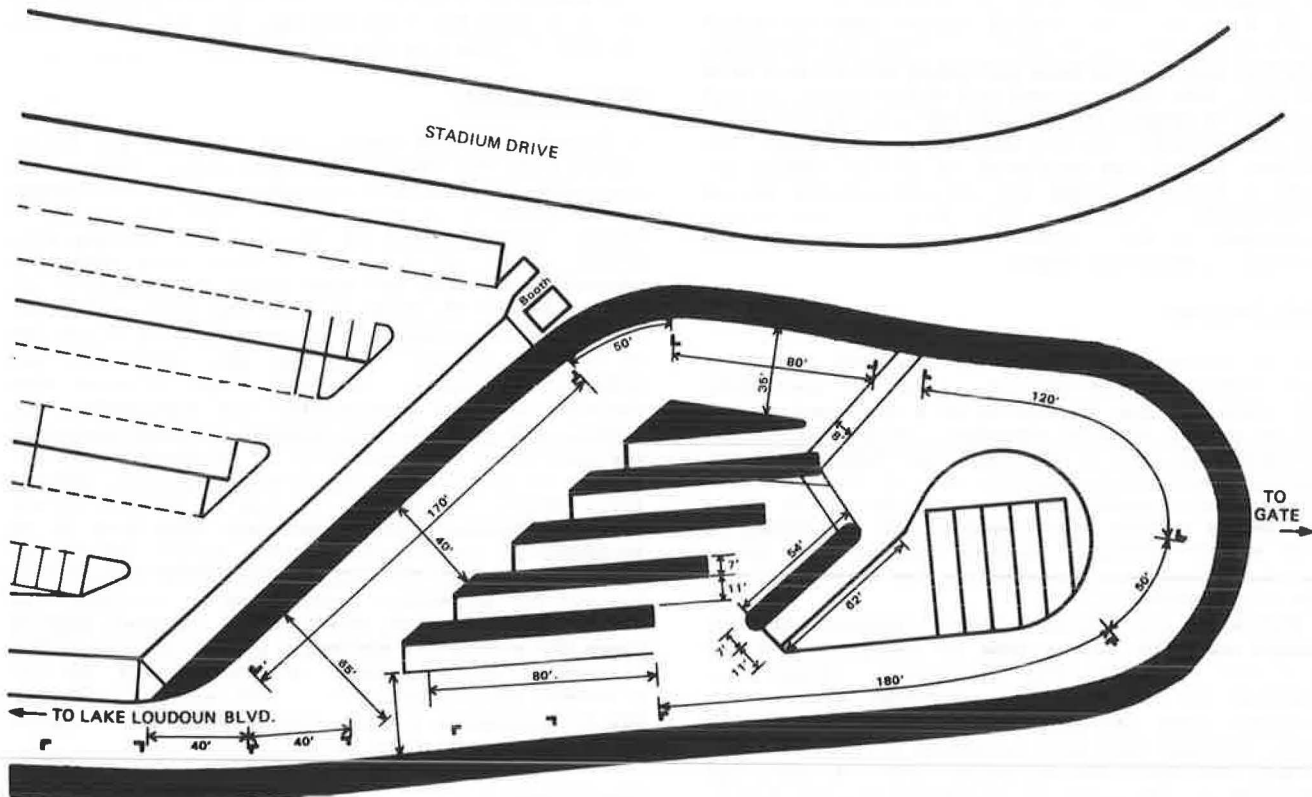
#### Operating Plan

Shuttle operators were authorized to use the southwest terminal on the basis of individual discussion with Fair transportation services staff pertaining to expected frequency of operation, possible interchange of passengers with other carriers, and other relevant factors. Fair staff assigned carriers to loading positions or zones so as to maximize capacity of the terminal and minimize walking distances. Where several carriers were to use the same loading zone, individual berth use was limited to 4 departures/h. Where the same carrier had routes leaving for various destinations, 6 departures/h were scheduled when necessary. Carriers that indicated that they would be operating more than 6 departures/h were assigned multiple loading berths adequate for their needs.

The terminal layout was based on an operating policy that any bus should be able to pull in, load, and depart without interference from any other bus operated by another carrier. Loading berths were spaced every 40 ft along the south side of the terminal, with 40 ft between berths to allow free movement. These loading berths were grouped into zones, with a given carrier entitled to use any berth within its assigned zone. Fair staff that monitored the terminal prevented carriers from entering the terminal if their loading zone was full and ensured that carriers departed promptly after their allotted layover time when the space was needed for others.

The loading zone and berth operation was only intended for evening use when visitors would be departing the Fair and would need to know exactly where to find their shuttle. For arrivals, the original intent was to have buses unload as close to the gate as possible rather than insisting that all carriers use their assigned berths. Fair staff were to indicate to drivers where to stop and to ensure that a one-bus-length space was left between groups of three or four buses. Four such unloading zones were established. It was estimated before the Fair

Figure 3. Shuttle bus terminal.



opened that, by the time the fourth group of buses had arrived during a busy morning hour, the first group would be ready to leave. Thus, the first unloading zone could be used over again, and buses in the second group could leave while the first group was unloading.

In practice, it proved feasible for the major carriers (those allotted more than one bus length for their loading zone) to use their own zone for morning unloading, and most other carriers preferred to discharge passengers at their loading zone. In that way they could show the passengers just where they would find the bus for the return trip that evening.

#### Staffing Plan

The southwest terminal was staffed with three Fair dispatchers during the busy hours (4:00-11:00 p.m.) and two at other times. First bus arrivals began at around 8:30 a.m.; last departures varied, with many of the smaller operators making their last run after the nightly fireworks display ended at 10:45 p.m., and some of the larger operators scheduling late departures at 11:30 p.m. or midnight. Inbound passenger and bus volumes peaked between 9:30 and 10:30 a.m.; outbound departures peaked around 6:00-6:30 p.m. and again after the fireworks display (10:30-11:30 p.m.). One dispatcher was stationed at the terminal entrance to allow buses in when their space was available; the others were stationed near the gate to help keep the buses flowing smoothly, answer visitors' questions, and keep pedestrians from walking in the bus lanes. A sheriff's deputy was stationed at the terminal entrance to prevent unauthorized vehicles from entering the lot. (Some charter bus operators attempted to use the southwest terminal and were directed to the north terminal.)

#### Terminal Capacity

The Fair staff was faced with an apparent imbalance between terminal space supply and demand before the Fair opened. Over 100 applicants for authority to transport passengers to the Fair from points within Tennessee had been heard by the Tennessee Public Service Commission (which had jurisdiction over service outside of the immediate Knoxville area) or the Knoxville Transportation Authority (which had jurisdiction over service from points in Knox County within seven miles from the Knoxville city limits). Virtually all applications that were completely and correctly filled out were granted, and most of those carriers wanted to use the southwest terminal. Many of the carriers had forecasted their ridership on the basis of a 30 percent modal split for their service, with 3.5 persons/hotel or motel room, and thus predicted a daily passenger volume roughly equivalent to one passenger per room served. Fair staff felt confident that the terminal could handle 135 buses/h for loading by using a 15-min turnover for each space, plus more than 60 vans/h. However, the initial carrier projections were for more than 200 bus departures/h. The Fair asked carriers to cooperate during the first few weeks of operation and accept a reasonable share of the available space, with the understanding that a reallocation would occur as carriers changed schedules or withdrew from the market. Dropouts were expected because the total capacity initially offered would have implied a daily ridership of 20 000-30 000 on shuttle buses, which was simply not plausible.

By late July, the terminal was handling 55-60 buses inbound in the morning peak hour (between 9:00 and 10:00 a.m.), which served approximately 1000 passengers/h. The outbound peak occurred between 10:00 and 11:00 p.m., with the same number of buses

handling somewhat more passengers. A typical peak half-hour served passenger volumes in the 650-800 range, although on one evening in mid-July the terminal loaded 1400 passengers between 10:30 and 11:00 p.m. on 53 buses. Daily terminal passenger volumes ranged between 3000 and 5000. Van arrivals were not included in these totals.

#### Other Features

Because of the layout of the loading area, it was possible to use ropes and stanchions for crowd control and pedestrian-vehicle separation in a few locations. However, passengers leaving the Fair and seeing their buses waiting in the center loading islands tended to walk directly across the bus drive. Terminal staff devoted a large portion of their effort in the outbound peak periods to pedestrian control and safety.

An early tendency on the part of some carriers to dispatch more buses during the evening pickup hours than their allocated space could accommodate was solved by direct discussion with the carriers. Major carriers had dispatchers at the terminal and could take swift corrective action. Other carriers were contacted by telephone when necessary. It was generally understood that Fair dispatchers were the final authority in the terminal, and they had the right to bar a carrier's vehicles from the terminal. Fair staff developed the practice of giving the carrier the option of sending the first bus out immediately when an extra bus appeared in the terminal or sending the extra bus out of the terminal to circle the block until space was available. Eventually, carriers were able to adjust their schedule to more closely fit running times and available terminal space as they gained experience with the requirements of their routes. This enabled them to instruct drivers to take layovers at the end of the line away from the Fair or to arrange for en route staging areas and time points. No layover and staging area was provided by the Fair. Each shuttle service was responsible for its own staging areas and schedules.

A number of local school bus operators entered into individual contracts to serve a variety of hotels, motels, parking lots, and campgrounds. Working through the Knox County Bus Owner's Association, they scheduled their own vehicles to avoid conflicts and agreed to use one 2-bus tandem loading location, which operated at much closer headways (as little as 4 min in some cases, according to their original schedules) than the Fair would have scheduled.

The Fair asked all carriers to provide a bus stop sign giving the name of the carrier, the locations served, and the scheduled departure times. These were mounted at the loading zones for passenger information. With only two exceptions, it proved possible to leave carriers in their original loading locations; attrition occurred in a way that seemed to resolve vehicle capacity problems without need for massive relocations.

Several carriers were granted authority to serve the Pigeon Forge-Gatlinburg resort area, approximately a 1-h drive from the Fair. Although there was substantial excess capacity, the carriers were unable to agree on any type of pool service or other arrangement to reduce operating costs while still generating the same amount of revenue. The Public Service Commission chose to allow the rigors of the competitive marketplace to sort out the economics of the situation, and the Fair felt it could not go beyond making suggestions for cooperative ventures.

The alternative to shuttle bus service for many visitors to the Fair was to drive their own cars.

Although concrete evidence was lacking, some shuttle operators theorized that first-day visitors would ride the shuttle because they did not know the route to the Fair, the availability of parking, or the severity of traffic problems. Having taken the bus on their first visit and finding parking space available right next to the shuttle bus terminal with no significant traffic congestion, they would drive on subsequent visits. With shuttle fares ranging from \$2.75/person for round trips within Knoxville to \$6.50 and up (for trips in the 20- to 30-mile range) and \$10.00 for the round trip to Gatlinburg, the \$6.00 daily parking fee appeared to be a relative bargain to many families, even after including the cost of gasoline. In a sense, the success of other elements of the Fair's transportation system may have created problems for the shuttle operators.

#### OFFICIAL PARKING LOT SHUTTLE TERMINAL

The Fair provided shuttle bus transportation from those parking lots that were part of the official parking system and were located more than 0.5 mile from the Fair. These routes terminated at an on-street terminal (the Locust Street terminal) a block from the Fair's east gate. A pedestrian overpass was constructed that began at the terminal and ran straight west, crossing Henley Street, to the Fair gate. Two Fair ticket booths were placed at the terminal end of the overpass to reduce congestion at the gate itself. The terminal was originally planned to serve four bus routes, which in turn served five remote parking lots. Lot locations and capacities are given in Table 1. Three of the four routes were planned to load and unload along the west curb of Locust Street; the fourth was to stop westbound on Clinch Avenue. Because street widths precluded long layovers, it was decided that buses would have to unload, load, and leave the terminal without delay, taking layovers at the remote parking lots.

The sidewalk at the Locust Street terminal was occupied by a variety of street furniture; planters and Fair ticket booths took up a significant amount of square footage that might have been needed for pedestrian queuing areas. The pedestrian bridge was only 8 ft wide; it was predicted that several buses unloading in rapid succession could cause the foot traffic on the bridge to back up into the unloading space. During evening hours, a gap in bus service at a time of peak outbound flow from the Fair also could have caused congestion problems.

In fact, a surplus of close-in parking spaces helped prevent the anticipated difficulties from arising. The Coliseum parking garages never handled more than 15 percent of their capacity, and their use as part of the World's Fair parking system ended in July. The other remote lots fared somewhat better, but never realized their full potential. By mid-July, peak-hour bus volumes were down to 18 trips for the three remaining routes, and service was cut back even further in the off-peak afternoon hours, when there might be as few as two trips per hour per route. (Other remote lots, outside the official system, also had problems; a major development of 2500 spaces near the Coliseum garages ceased operation at the end of June.) The capacity of the terminal was challenged only on a few evenings after the fireworks show, when the arrival rate of departing visitors exceeded the available bus capacity for brief periods. The Fair and the shuttle operators ultimately worked out a system for stockpiling capacity near the terminal by shortening headways just before the end of the fireworks and virtually eliminating layovers, thus shortening the round-trip cycle time. This solved the problem.

Table 1. Lot locations and capacities.

Lot Name	Direction from Fair	Capacity (no. of automobiles)	Maximum Peak-Hour Demand (passengers)	Bus Trips per Hour	Avg Automobile Occupancy
Coliseum	East	1850-2350	2140	39	3.80
Willow	East	360	330	6	3.78
Baxter	North	600	330	10	3.65
Martin Hill	South	360	330	10 <sup>a</sup>	3.60 <sup>a</sup>
Hawthorne	South	230	210		

Note: There were 65 bus trips/h and the average automobile occupancy was 3.75.

<sup>a</sup>Martin Hill and Hawthorne operated as one route (in regard to bus trips per hour and automobile occupancy statistics).

Table 2. Cost factors for terminal operations.

Item	No. and Description
North Terminal—Charter and Tour Bus Operation	
Employees	
Operating labor	15 full-time equivalent
Reservations staff	4 full-time equivalent
Police	2 full-time equivalent
Supervision and overhead	2 full-time equivalent
Total	23 full-time equivalent, for 8:30-12:30 a.m. terminal operation, 7 days/week
Reboarding checks	70 sets of 50 checks, each of 900 numbers
Windshield cards	60 000 for fair dispatcher use only; Greyhound provided own stock and Trailway's did not use them
Printing	400 pages/day of daily log sheet (10 sets, 40 pages each) 30 000 confirmation copies of reservations 5000 copies of reservation form and information for operators and groups
Southwest Terminal—Hotel and Motel Shuttle Bus Operation	
Operating labor	6 full-time equivalent
Police	2 full-time equivalent
Supervision and overhead	2 full-time equivalent
Total staff	10 full-time equivalent

The Fair had planned to staff the Locust Street Terminal with a roving inspector, but in fact found this unnecessary. Both shuttle operators provided adequate supervision to ensure proper operation of the lines and the terminal, and the diminished volume of bus traffic eliminated the need for additional staffing. For all practical purposes, the terminal operated much as any downtown multiline bus stop would.

#### COST FACTORS IN TERMINAL OPERATIONS

As noted above, the short-term nature of the Fair dictated terminal designs and operating plans that were relatively labor intensive with low capital requirements. Table 2 lists the major elements of the terminal operating costs.

In addition to the capital expenditure required for the bus terminals (grading, paving, lighting, and striping), and for crowd-control fences, ropes, and stanchions, a number of minor capital equipment items were found necessary. Both terminals were equipped with bullhorns for crowd control and two-way radios linked to a base station in the Fair's operations center. Low-power walkie-talkies also were used for communications within the terminals to a limited degree. Extensive signing was required to direct passengers to the appropriate platforms in the north bus terminal: approximately thirty 2-ft<sup>2</sup> signs (three per platform) were used to

identify the platforms, along with additional signs that carried instructions for bus drivers. The individual bus lines furnished their own signs, which were manufactured to Fair specifications regarding design for the shuttle bus services.

#### STAFF TRAINING

Two weeks before the Fair opened, the operating staff was on board for training and familiarization with terminal operations. All staff were trained to work both the charter and shuttle bus terminals to enable staff flexibility. Classroom training covered lectures on safety, operation of each of the terminals, procedures for use of two-way radios, and proper traffic-control hand signals. Field training in terminal operations and two-way radio communication was conducted. Because the same personnel would be using the terminal daily, shuttle bus operators were encouraged to participate, with their buses, in the simulation of southwest terminal operations. Arrival and departure operations were enacted and loading and unloading zones were assigned. This was effective in familiarizing shuttle operators with the terminal layout and operation as well as giving the Fair staff hands-on experience before the opening of the Fair.

Simulations of the charter and tour bus terminal operations were conducted by using automobiles and Fair staff employees only, since the majority of bus drivers were long-distance haulers and many would be one-time-only visitors to the Fair. The dispatchers practiced greeting and processing buses with and without departure reservations as well as handling typical inquiries on bus parking locations, group ticket sales, and so on. Simulations were timed to estimate staffing needs and to streamline operations.

#### CONCLUSIONS

Given the limited land available for terminal operations, the strategy of bringing high-occupancy vehicles directly to terminals at the Fair gates and relying on remote parking areas operated by the private sector worked very well. The passenger volumes handled in the charter and tour bus terminal place that operation well within the top 10 bus terminals in the United States in terms of hourly flow rates. The temporary nature of the facility and the typical visitor's unfamiliarity with the surroundings (as contrasted to a daily commuter terminal) suggest that the labor-intensive design actually expedited passenger flows. It seems fairly clear to those who operated the terminal that a more highly capitalized and automated operation would have functioned at reduced capacity, thereby increasing delays and lowering the number of passengers who could depart at precisely the hour they desired. (Once the initial shakedown period was completed, virtually all departures were accommodated at, or within 15 min of, their desired time.)

The bus industry, once convinced that there was no way to enlarge the terminals, cooperated extremely well in making the terminals function efficiently. Advance discussion with charter, tour, and shuttle bus operators paid off, as their drivers were prepared for what they encountered and did their part to make the system work. The initial tendency of tour operators to cluster their arrivals directly around the 10:00 a.m. opening hour diminished for several reasons: The Fair opened the north gate turnstiles as early as 9:00 a.m. on busy days, thereby enabling early arrivals to be accommodated, and the carriers realized that there was no point in rushing to take their place in a 10:00 a.m.

queue when an 11:00 a.m. arrival could be accommodated without delay on most days.

Unfortunately, it is not possible to generalize from the Knoxville experience about the relative merits of terminals with remote parking areas versus on-site parking. Such an analysis of cost-effectiveness must be site specific. Cost of land and improvements, minor capital item and equipment costs, and operating expenses for alternative configurations are the key variables in the equation, along with the demand to be accommodated. In the

present case, the deciding factor turned out to be the unavailability of sufficient land adjacent to the Fair gates to even permit consideration of on-site bus parking. The terminal designs and operating plans used, although born of necessity, proved highly effective and are replicable.

*Publication of this paper sponsored by Committee on Intermodal Transfer Facilities.*

## Assessment of Low-Cost Elevators for Near-Term Application in Transit Stations

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An assessment of low-cost elevators for use in existing transit stations, the supporting data for selecting the screw-column elevator for further evaluation, and an evaluation and assessment of the screw elevator design and operation are presented. This information provides data to authority representatives to enable them to make informed decisions regarding application of the screw-column elevator. The assessment team investigated screw-column elevator design, construction, maintenance costs, and actual use. On-site inspections were conducted at a manufacturing plant and at elevator installations. It was determined that screw-column elevators offer a low-cost alternative for vertically moving elderly and handicapped patrons in transit stations. Low capital expense, minimum time for installation, low cost for standard site preparation, and maintenance costs make the screw-column elevator attractive.

To comply with Section 504 of the Rehabilitation Act of 1973, which states that "no otherwise qualified, handicapped individual shall, solely by reason of his handicap, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance," transit authorities must make efforts to provide transportation that handicapped people can use. This may include providing access to existing systems. One element of accessibility is that of vertical movement in rapid transit stations. As past studies have noted, the problems and issues of providing vertical movement accessibility for transit are multifaceted.

To meet the significant problems imposed when locating an elevator in an existing station, the optimal unit will require minimum space, be relatively easy to install, and have an overall low cost. This study analyzed current elevator types to determine which type or types best satisfy these constraints and presents data for the screw-column elevator, which appears to offer important advantages. [The investigation is reported in its entirety elsewhere (1).]

### ELEVATOR COMPARISON AND SELECTION

The issues and problems that surround the vertical movement of patrons in transit stations call for certain requirements in the design of an elevator. Issues associated with selecting a unit that will result in an overall low cost and satisfy structural, spatial, and security needs pose design problems for elevators. Each of these problems has been

addressed, and a list of important requirements has been developed. These requirements pertain to elevator and station problems generally, but do not attempt to address site-specific problems that face the transit authority and architect or engineer at the time of planning and designing a specific installation.

The following requirements have been identified as necessary to evaluate elevators for transit use. The elevator should

1. Be capable of use by both the elderly and the handicapped and other transit passengers;
2. Have a capacity of no less than 2000 lb;
3. Be sized for wheelchair turnaround, which results in a net car dimension of 80x51 in or 68x51 in, depending on the location of the elevator door opening;
4. Be able to meet the expected vertical rise (nominally 20 ft);
5. Have a low life-cycle cost, which includes capital expense, installation, operations, and maintenance;
6. Be easily installed in existing locations;
7. Provide for passenger safety;
8. Provide for passenger security (such as against malicious attacks);
9. Give reliable service;
10. Meet and satisfy prevailing codes and standards; and
11. Be capable of operating in a transit environment.

These specific requirements set the conditions for any technical analysis of elevators. In addition, for purposes of this report, a nontechnical requirement has been identified: Material should be available that provides information needed by transit authorities to select, purchase, and install elevators that result in the lowest overall cost.

Discussions with manufacturers were conducted and elevator specialists were interviewed to select initial elevator candidates. Five types of elevators were identified and compared with the requirements: conventional electric traction, conventional hydraulic, holeless hydraulic, screw column, and vertical wheelchair platform lift. This comparison is