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Urban Mass
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Administration

Accelerating Walkway Systems Phase III Summary Report

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16. Abstract

The Accelerating Walkway System (AWS) Demonstration Program was originally phased to lead to a public use demonstration. The report summarizes Phase III of the Project series and contains descriptions of the work performed by the Port Authority, and passenger and equipment tests performed by the licensee manufacturer of the TRAX variable speed accelerating walkway system. The TRAX system is a 4:1 speed ratio, loop configuration AWS with a treadway comprised of grooved, overlapping and intermeshing pallets. The handrail consists of individual handgrasps connected by a covered chain. Except for the variable speed capability, the walkway resembles conventional single speed passenger conveyors in use at many airports.

Passenger tests of the TRAX AWS with a range of users showed favorable acceptance of the system at speeds of 360 and 480 fpm (1.8 and 2.4 mps). Some user problems were experienced at higher speeds. Equipment problems surfacing during debugging runs were satisfactorily resolved, but further design changes are recommended to improve compliance with the ANSI A.17.1 Code, and to increase system reliability. Tests showed that AWS maintenance can be accomplished by typical escalator mechanics. Installed cost of the TRAX loop AWS is 7-10 times that of conventional one-way walkways, power consumption is greater due to the higher speed, and overall operations cost would be dependent on applications context.

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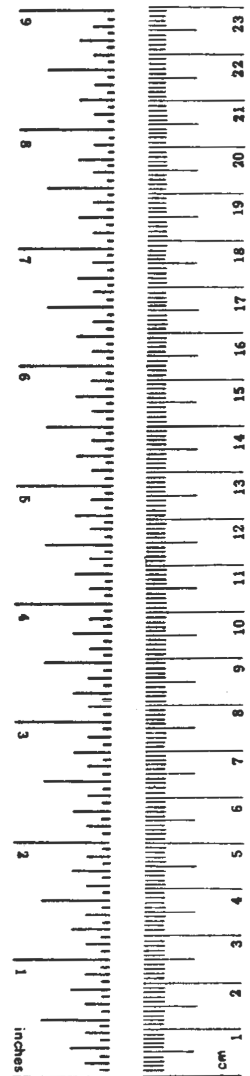
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

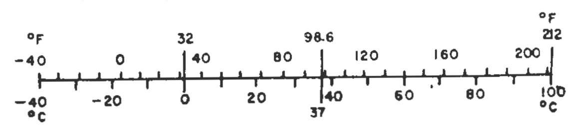
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounce	
kg	kilograms	2.2	pound	
t	tonnes (1000 kg)	1.1	short t	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



AWS PHASE III SUMMARY REPORT

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Executive Summary

The Accelerating Walkway System (AWS) Demonstration Program is a phased Project funded by the Urban Mass Transportation Administration under a grant to the New York Metropolitan Transportation Council (NYMTC). As originally planned, Phase IV of the Program would have culminated in a public use demonstration of the new technology. Program Phase III summarized in this report, consists of a major passenger and equipment test series of the TRAX variable speed Accelerating Walkway System (AWS), designed by the Paris Transit Authority (RATP), and currently under a manufacturing license to Ateliers et Chantiers de Bretagne (ACB), of Nantes, France. Because of changes in Program directions, the Phase IV public demonstration of the AWS technology is not currently planned, and the Program will effectively end with Phase III. The Port Authority of New York and New Jersey as sponsor and manager of the Program has monitored the ACB test program, evaluated ACB test series and program of work, and performed certain preparatory studies for the public demonstration which are summarized in this report.

Accelerating walkways are an evolutionary step in more than a century of development of continuous service passenger conveyor systems. Five different AWS technologies were evaluated in the course of the demonstration program, with TRAX, a 4:1 speed ratio system, remaining as the only fully developed example of the technology available.

The TRAX system is an "in-line" accelerating walkway with the treadway and synchronous handrail gradually expanding to accelerate, and contracting to decelerate. The treadway consists of overlapping, sliding and intermeshing pallets forming a continuous loop and the handrail a series of interconnected handgrasps linked by a covered chain, also in a loop configuration.

Technical Evaluation Team observations of passenger and equipment tests of the TRAX AWS indicate that a number of equipment modifications would be desirable for U.S. applications to assure compliance with ANSI code requirements, to improve passenger ride quality and acceptability, and to increase system reliability and availability.

In general, passenger acceptance of the TRAX AWS was good. Passenger test participants represented a range of ages, and included disabled persons. Two falls were observed during the test series, neither resulting in injury. One involved a disabled person. Based on the evaluaton of equipment characteristics and the passenger tests, the level of safety of the TRAX AWS is anticipated to be about the same as an escalator.

Estimated deployment costs of a TRAX AWS in a loop configuration are approximately $6,300 per foot ($20,700 per meter) (one direction only) for furnishing and installation of the equipment, $1,100 per foot ($3,600 per meter) for site preparation at an existing covered site, and $10 per running hour for power, for a typical 1000 ft. (305 m) long unit. Maintenance and repair could be performed using typical escalator mechanical skills, and cost of maintenance personnel dependent on the application's context. Where there is already a large passenger conveyor installation, for example at an airport, only supplementary staff would be necessary.

1.0 Introduction

Accelerating Walkway Systems (AWS) are an evolutionary step in more than a century of development of continuous service passenger conveyor systems. Resembling conventional moving walkways seen at many airports, accelerating systems have the capability of accelerating passengers up to 5 times the entry speed after boarding, and of decelerating before exiting.

In the 1970's a number of variable speed accelerating walkways were developed, with several reaching the prototype stage. As with any new technology, there are difficult questions relating to costs, public acceptance, and safety, which are only answerable through experience. Recognizing this, in 1976 the United States Department of Transportation, Urban Mass Transportation Administration (UMTA), funded a program for a public use demonstration of the accelerating walkway technology. This program was sponsored by the Port Authority of New York and New Jersey, with the cooperation of Metropolitan Transportation Authority and New Jersey Department of Transportation. The New York Metropolitan Transportation Council, (formerly the Tri-State Regional Planning Commission), is the UMTA grantee and the administrator of the Demonstration Program, under Section 6 of the UMTA Act.

1.1 General Program Description

The Accelerating Walkway System (AWS) Demonstration Program was originally planned as a phased project leading to a public use demonstration of the variable speed AWS technology. Phase I of the Program consisted of a series of studies to determine the state-of-the-art of AWS technology, potential applications and market, and user acceptability and safety. (See Appendix pages A-1 to A-7 for - abstracts of Phase I reports).

Five prototype variable speed accelerating walkway systems were identified in Phase I. Brief descriptions and photos of a 4 of these prototypes, developed by the Boeing Company, Dean Research Corporation, Dunlop Limited, and Johns Hopkins Applied Physics Laboratory, are contained in the Appendix of this report. The TRAX accelerating walkway, the only system selected for Phase III passenger and equipment tests, under a manufacturing license to Ateliers et Chantiers de Bretagne (ACB) of Nantes, France, a division of Alsthom Atlantique, is described in more detail in Section 1.3 of this report.

Phase II of the Program involved the design development of four of the prototype systems, with the objective of obtaining the type of detailed operating and cost data needed for the evaluation and selection of candidates for program Phase III. (Appendix page A-8 - abstract Phase II Summary Report). The four developers selected for Phase II design development contracts were the Boeing Company, Dean Research Corporation, Dunlop Limited, and ACB-TRAX.

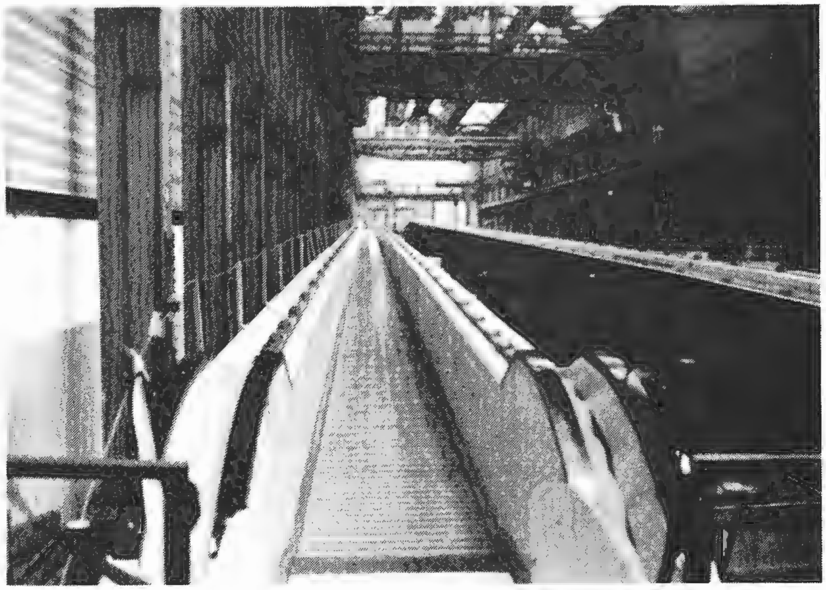
temporarily suspended during the period of the equipment redesign and hailstorm cleanup because the contractual agreement with ACB provides payment only for equipment rental, performance of passenger and equipment tests, and preparation of a series of reports on these tests and the TRAX system.

1.3 General Description of TRAX

The ACB-TRAX variable speed accelerating walkway is a two-directional loop system with a continuous treadway comprised of intermeshing and overlapping, grooved aluminum plates (see Figures 1.1 and 1.2). The intermeshing of the treadway plates provide a "combing" action, an important safety feature to prevent entrapment of footwear between the sliding treadway elements. The grooved treadway also moves beneath combplates at system ends, similar to the combplates used on escalators, as the treadway makes its return circuit on the loop (see photos Figure 1.1).

Acceleration and deceleration of the treadway is accomplished by the shifting of the sliding plates relative to each other, gradually lengthening the exposed treadway to accelerate passengers at entry and shortening it to decelerate passengers for exiting. The overlapping treadway plates are supported by rollers running on guideway rails beneath the treadway (see Figure 1.3). The lateral spacing between the guideway rails, or gauge, controls the longitudinal shifting of the treadway plates, and the rate of acceleration and deceleration of the treadway surface. The individual plate assemblies forming the treadway are interconnected by a series

FIGURE 1.1

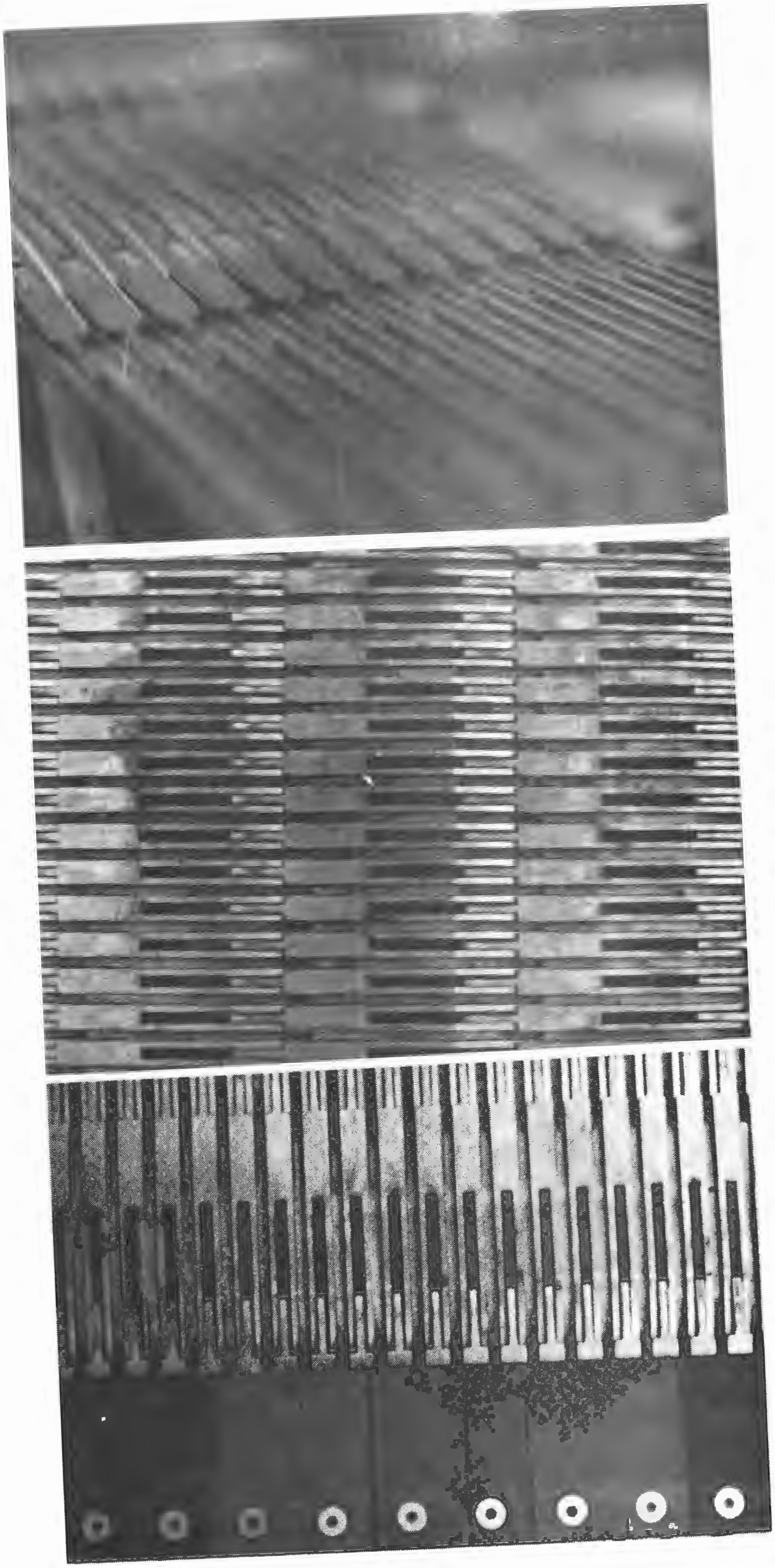


TRAX ACCELERATING WALKWAY SYSTEM

Upper - General view of ACB factory installation - Nantes, France

Lower - Turnaround section of loop, showing treadways in lift position, handrail bogies and chain.

FIGURE 1.2



TRAX AWS

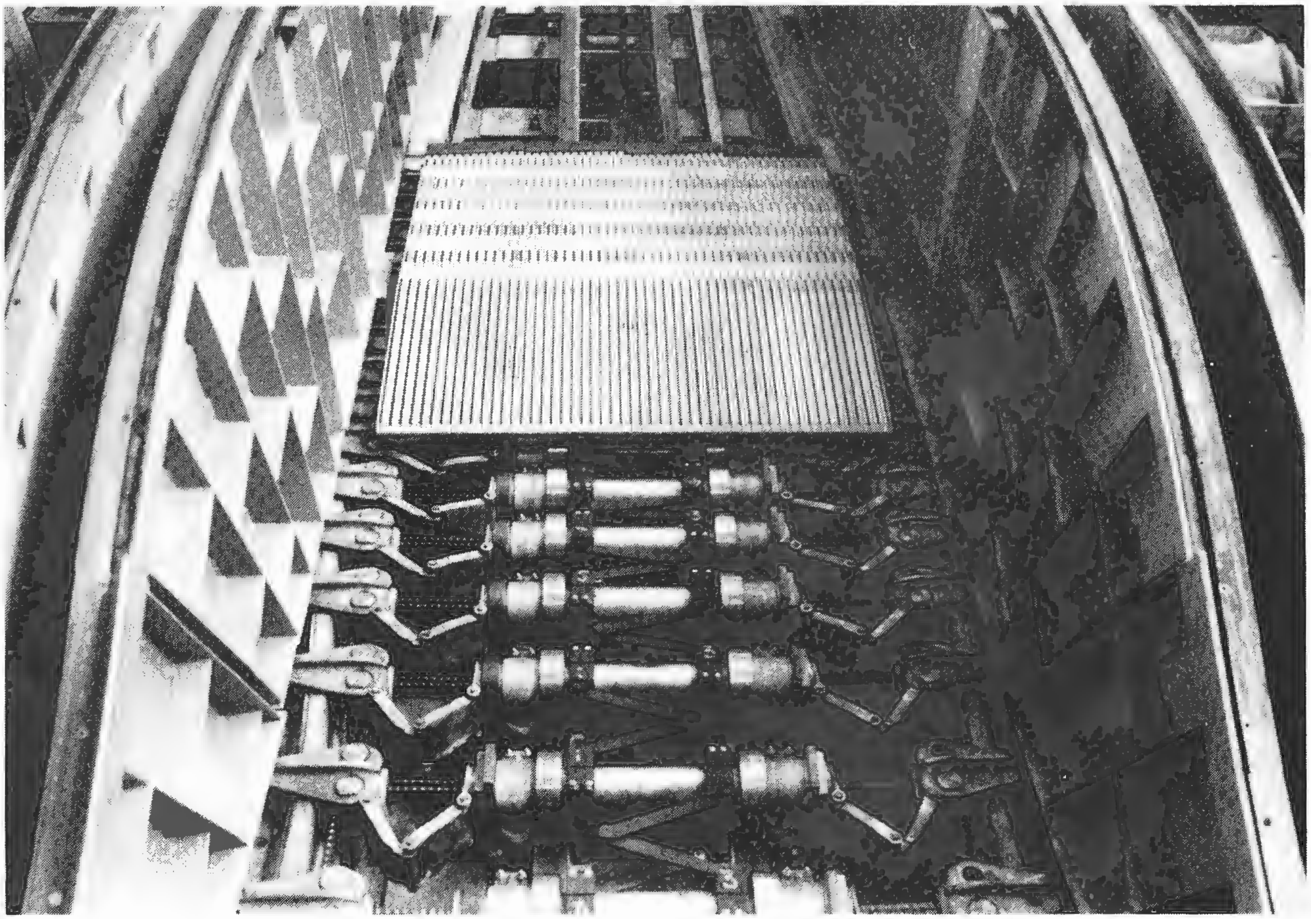
Views of Treadway

Upper - Intermeshing of Treadway combs

Middle - Treadway pallets in contracted position, low-speed zone

Lower - Stationary comb-plate at exit portal

FIGURE 1.3



TRAX Entrance - Undercarriage, Pallets,
Safety Scissors.

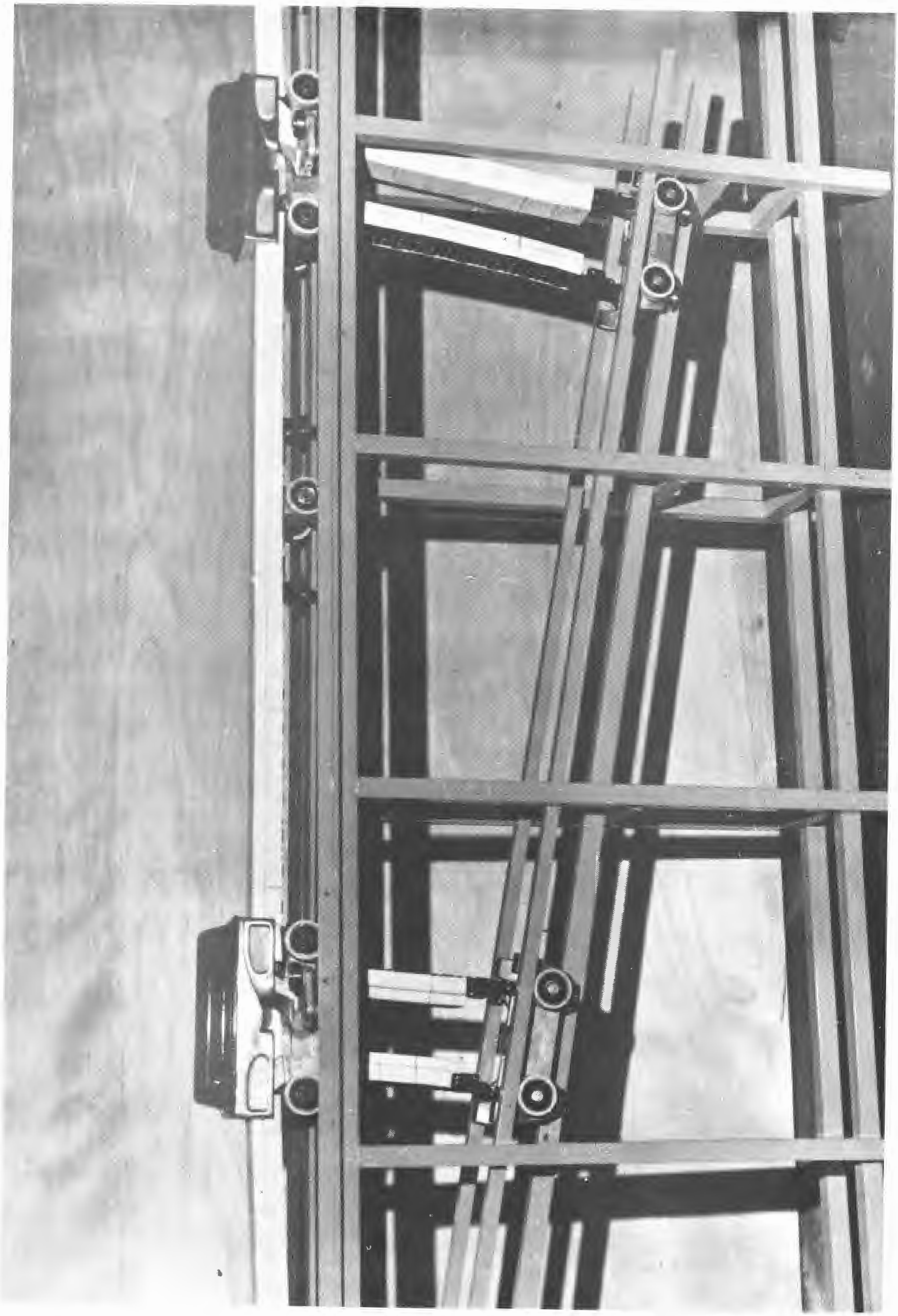
of quadrangular chains of constant length, and an added safety scissor arrangement to prevent separation of the sliding plates which could cause dangerous gaps in the treadway surface in the event of chain breakage.

In the acceleration zone the gauge between the supporting guideway rails narrows, changing the geometry of the connecting quadrangular chain by reducing its width and increasing its length. This elongation of the connecting chain quadrangle shifts the sliding pallets and increases the length of the exposed treadway surface. The process is reversed in deceleration zones by increasing the guideway rail gauge and decreasing the length of the chain quadrangle.

The concept of the variable gauge guide rail and constant length quadrangular chain assembly is also used for the TRAX handrail (see Figure 1.4). The connecting chain itself, with a protective cover, actually becomes part of the handrail. The chain moves through a handgrip, which is the preferred means of passenger support, although the chain cover can also be grasped for support. Syncronicity of treadway and handrail movement is a safety consideration, with differentials in these two speeds potentially upsetting riders. Syncronicity of the handrail and treadway on TRAX is obtained by coordination of the respective guiderail geometries and propulsion systems

The width of the TRAX treadway pallets is 41 inches (1.04 meters), and spacing of handgrips 19.7 inches (0.5 meters). The TRAX profile in the middle high speed zones of system requires a running

FIGURE 1.4



TRAX Handrail, Handgrasps and Covered Chain equipment pit about 3-4 feet (1-1.2m) in depth. Equipment pits about 10 feet (3m) in depth are required in the end "turnaround" sections of the loop system as the continuous treadway and handrails move below grade. Deeper machine pits are also required for propulsion units, placed near each end of the system. In longer walkway applications additional intermediate propulsion units may be required.

The TRAX accelerating walkway is a 4:1 speed ratio system, with a high speed 4 times the entry and exit speed. The TRAX unit in Nantes, France, which is destined for installation in the Paris Metro subway in the Invalides station complex, is designed for a top speed of 650 fpm (3.3 mps) and an acceleration and deceleration rate of 3.6 ft/sec/sec or 0.11'g', (0.8 m/sec/sec). Although the United States codes permit speeds of 180 fpm (0.9 mps) for conventional single speed walkways based on human factor considerations at entry and exit, the common practice is not to exceed a constant speed of 120 fpm (.61mps). At the 4:1 speed ratio, a U.S. system would run at a top speed of 480 fpm (2.4 mps), about twice normal pedestrian walking speed.

2.0 ACB Program of Work

Ateliers et Chantiers de Bretagne (ACB), of Nantes, France, licensed manufacturers of the TRAX AWS, contracted with the New York Metropolitan Transportation Council to perform the following work tasks:

A. Equipment Test Series - including failure mode and life cycle testing; maintainability, serviceability and reliability tests; environmental testing; system operating and life-cycle costs; endurance tests.

B. User Test Series - rider tests for representative population sub-groups including elderly, juveniles, and handicapped to establish equipment acceptability, safety; passenger adaptability to system operating characteristics; estimated system passenger capacity; assessment potential risks of product and owner liability.

C. Final Reports - The ACB Final Reports consist of the following:

Report A - Summary of TRAX Test Program. (UMTA-IT-06-0126-85-01)

Report B - Passenger Test Series. (UMTA-IT-06-0126-85-02)

Report C - Program Implementation Plan. (UMTA-IT-06-0126-85-03)

General installation requirements, schedules.

Report D - TRAX Equipment Manuals - Mechanical (UMTA-IT-06-0126-85-05)

- Electrical (UMTA-IT-06-0126-85-06)

Maintenance and operations procedures.

Report E - Equipment Test Series (UMTA-IT-06-0126-85-04)

(distribution limited, contains proprietary information)

2.1 Equipment Test Series

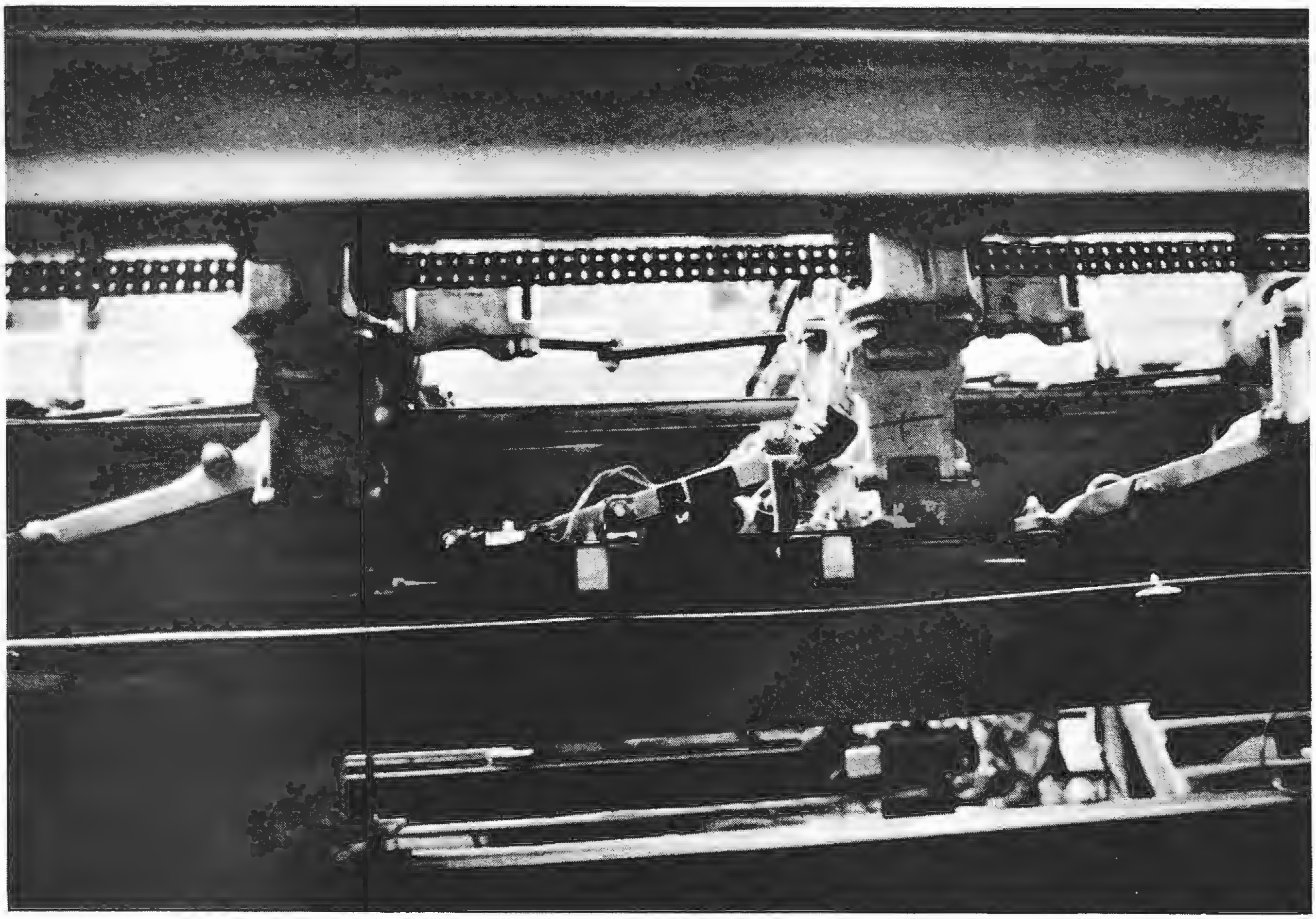
As part of the equipment test program, ACB conducted a series of bench tests of critical equipment components, and performed other tests at the Nantes, France factory site for Project Technical Evaluation Team members during the March and December 1983 inspection visits. The bench test results are summarized in the report: Tests on Isolated Components, completed by the Contractor in May 1982. In addition, ACB was required in Task II of the contract to complete a report on the full test series.

2.1.1 Bench Tests

The interim report titled Tests on Isolated Components, produced as part of the equipment test series, contains the results of breaking tests performed on TRAX system lift arms, guide arms and treadway and handrail chain linkages. In addition to establishing the maximum breaking strengths of these components, the tests were useful for determining the points where strain gauges should be placed during dynamic testing of the fully-assembled unit (see Figure 2.1). The maximum breaking strengths provide means of determining component factors of safety through comparison with working stress measured under actual operating conditions. The relationship of working stress to maximum breaking stress are also used to estimate the fatigue characteristics and projected working life of equipment components under actual use.

The test confirmed theoretical calculations of the assumed failure sequences which by design were intended to occur in a manner

FIGURE 2.1



TRAX AWS - NANTES FACTORY UNIT - BOTTOM VIEW OF TREADWAY UNDERCARRIAGE

(Strain Gauge Attached to Lift Arm for Dynamic Tests) that would not endanger passengers. The failure sequences were further confirmed during the March 1983 system dynamic tests when there were a number of component failures related to unanticipated operating characteristics of the treadway and handrail drive assemblies.

2.1.2 Dynamic Tests

Dynamic testing of the TRAX system, in conjunction with passenger tests, were observed by Project Technical Evaluation Team members at ACB's Nantes, France factory during the period March 19-28, 1983, and December 4-9, 1983. The dynamic test program included observations of the running of the TRAX AWS at high speeds of 360, 480, 653 fpm (1.8, 2.4, 3.3 mps), continuous monitoring of running stresses on selected equipment components, continuous recording of sound levels and power consumption, emergency stops, and a full-load test.

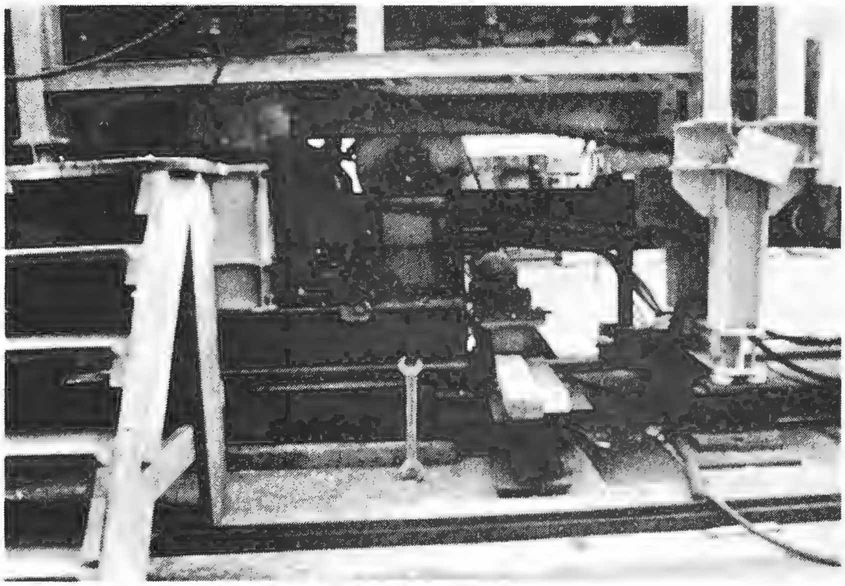
As it turned out, the March series of tests were premature because ACB was still engaged in "debugging" the TRAX AWS. A number of unanticipated equipment breakdowns caused interruptions of scheduled tests, but provided valuable information on failure modes, passenger safety during failures, repair procedures, and identification of components requiring readjustment and possible redesign to increase system availability and reliability.

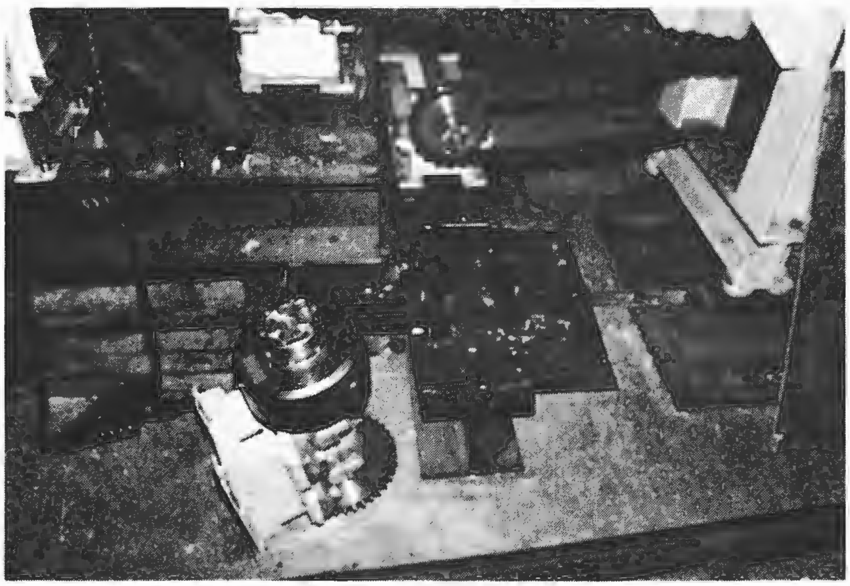
The operational failures that occurred during the March test program were virtually all attributable to the handrail and its propulsion system (see Figures 2.2 and 2.3 following). Several minor

FIGURE 2.2

TRAX AWS - Upper - TRAX soft drive belt and rubber cleat "deltas", (horizontal line and rollers, top of photo).
Lower - Handrail failure, in this case due to sheared set pin and bolt. Other failures related to tension differentials causing sag of chains (at right) and collision of bogie (center) with balustrade support.

FIGURE 2.3





TRAX AWS - Upper - Treadway and handrail drive unit.
Lower - Torque limiter failure related to handrail chain problems. Collision of handrail bogie with balustrade overloaded drive unit and resulted in this failure. None of these failures would endanger passengers.

stoppages were related to the adjustments of the AWS fault detection system. The treadway design was found to be very rugged. Handrail related failures of different types resulting in automatic shut down of the system occurred every day of the March test series. None of these failures occurred in a manner that would endanger passengers. The basic problems with the handrail are summarized as follows:

a. Quality Control - an initial system failure was traced to the shearing off of an anti-rotation set pin excessively tightened during fabrication of the handrail assembly.

b. Variations in Chain Tensions - The drives located at the high speed zones caused differences in chain tensions and sagging of the handrail along sections of the handrail loop. In areas of low tension, the chain assembly and lower handrail assembly dropped below its normal running position and impacted balustrade spacers. The impact resulted in a failure of the handrail bogie and triggered an automatic system shut down. The breaking strength tests discussed in 2.1.1 showed that the ratio of handrail chain strength was much higher than handrail bogies, and this type of failure of the bogie before the drive chain, purposely designed into the system for safety reasons, was observed several times during actual system failures.

c. Hand Grasp Clearance - Rubbing between the hand grasp bogie and balustrade was observed all along the handrail loop, increasing the friction load on the handrail drive. This problem added to the handrail sagging problem.

d. Handrail Drive - The 370 ft. (112 m) long Nantes test unit has four drive assemblies located at the high speed section of the system. The longer, 575 ft. (175 m) Invalides Station unit will have two additional drives. The present "soft-drive" system incorporating cleated rubber belts propelling both the treadway and handrail was designed with the objective of reducing system noise, but noise levels were still observed to be high with the open-sided factory unit.

The driving cleats on each of the belts consists of approximately 20 triangular rubber teeth or "deltas", as they are called by ACB, which simultaneously intermesh with elements of the treadway and handrail to synchronously drive these systems (see Figure 2.4). The soft drive is purposely designed to slip and to cause an automatic system shut down in the event of an overload or jamming and loss of synchronization of the handrail or treadway. These rubber teeth proved to be too flexible and this was responsible for a number of system shut downs.

A redesigned handrail sub-system is now under development to provide the same level of reliability and ruggedness as the treadway sub-system.

2.2 Passenger Test Series

ACB, in conjunction with its sub-contractor Dorset Development Corp., a human factors and public opinion consultant, conducted the passenger test series in March and December 1983. The March passenger test series was interrupted by unanticipated equipment

FIGURE 2.4

TRAX AWS - NANTES FACTORY UNIT

Close-up View of Delta Block
Treadway Propulsion Gear

breakdowns as previously discussed, allowing completion of only about 25% of the passenger test series. The full program of tests was completed during the December inspection.

The plan for the passenger test series called for riding tests at entry speeds of 90, 120 and 163 fpm (0.45, 0.6, 0.8 mps), with high speeds four times entry. Passenger groups were divided into 5 categories: (1) adolescents, (2) adults, (3) mixed age group, (4) elderly, and (5) handicapped. The mixed group included a subgroup of smaller children accompanied by adults. The daily testing routine involved 4 to 5 groups of about a dozen person each. As planned, a typical 90 minute test session included a series of rides by each participant, an emergency stop, a bunching test, and variations such as the carrying of baggage and packages. Every test participant was interviewed before and after each series of rides at the different speeds to determine their perceptions of riding comfort, and other opinion factors.

Passenger rides were videotaped by 4 TV cameras located on platforms approximately 12 feet (3.7 m) above the two ends of the TRAX AWS. One camera was aligned with each entry and exit portal. The cameras were equipped with telephoto zoom lenses so that passengers could be tracked through a complete ride cycle. Figure 2.5 illustrates testing procedures.

Riding tests were cut short the first day of the March test series by a system failure at the highest speed of 163/653 fpm (0.8/3.3 mps). This failure resulted in an emergency stop which

FIGURE 2.5

TRAX AWS - NANTES PASSENGER TESTS

Upper - Staging area for passengers at upper end of AWS loop.

Left - Passenger tests run at different speeds, individual and group rides, with and without carried articles.

Right - Passengers interviewed before and after test rides at different speeds.

caused no difficulties for the one passenger on the system at the time. Observations of passengers at the three test runs before the failure indicated few rider problems at the two lower speeds (90/360 and 120/480 fpm) and relatively minor problems at the highest speed (163/653 fpm). Deceleration rates, including emergency stop were acceptable at the lower speeds more likely to be used in the U.S. Decelerations at 90 fpm (0.45 mps) were .03 "g" and at 120 fpm (0.6 mps) .05 "g". Deceleration at the top speed is 0.1 "g", the maximum allowed in Project specifications.

After the first major equipment failure occurred at the highest speed, further passenger tests in the March series were run at the lower speeds more likely to be applied in the U.S. This was done in the interests of minimizing further equipment downtimes and to increase the probability of completing the test series. Tests were subsequently run with a limited number of elderly persons and handicapped passengers, including wheelchair users. Tests were also conducted with passengers using shopping carts and carrying various types of articles such as luggage and shopping bags. Bunching tests were conducted with passengers being specifically instructed to move forward in the deceleration zone to create crowded conditions.

The December tests series, in addition to replicating some of the March tests to increase the data base, included a full load test involving 260 passengers. This test served a two-fold purpose, on the equipment side to determine the adequacy of system propulsion and braking, and on the passenger side to provide an estimate of system capacity and to further evaluate the bunching problem.

2.3 ACB Final Reports

2.3.1 Executive Summary

The Executive Summary reports on the organization, execution and results of the ACB performed tests on the TRAX AWS to assess equipment performance and passenger acceptability. The resulting equipment test data and observations provided the basis for estimating system availability, reliability, maintainability, life cycle costs and readiness for public operation. The passenger test data provided the basis for assessing safety code compliance and user acceptability. Areas requiring equipment improvement and modification were identified and an implementation plan developed for a public use installation of the TRAX AWS. Capital and operating cost data was developed.

2.3.2 Passenger Test Series

The Passenger Test Series report describes in detail the design, organization, operation and results of the passenger tests conducted on the factory TRAX AWS unit by ACB. The tests were run at speeds up to 653 fpm (3.3 mps) using 260 passengers representing the young, adult, elderly and handicapped of both gender. Potential safety and hazard areas were investigated at loadings equivalent to 6600 passengers per-hour and the results related to safety code requirements. The tests demonstrated a high degree of passenger adaptability to the AWS characteristics and substantial compliance with proposed AWS safety code requirements. The handrail grasp design, lengthening of the deceleration zone and noise reduction were identified as areas requiring improvement prior to operating a public installation.

2.3.3 Program Implementation Plan

The Program Implementation Plan report describes the manufacturing, delivery, installation and test procedures for a TRAX AWS public use installation at a U.S. site. It is estimated that more than 50% of the TRAX components would be manufactured and assembled in the U.S. with site installation work performed by a U.S. contractor under ACB supervision.

A 1000 ft. (305 m) long TRAX unit is estimated to cost $5.6 million (at 8 French Francs to the U.S. dollar exchange) and the installation work and check testing to require 11,500 man-hours. Site acquisition and site preparation costs are location dependent. Approximately one year is required to complete the installation from contractual go-ahead. Operating cost and spares holding data were developed.

2.3.4 TRAX Equipment Manuals

The TRAX Equipment Manuals describe the function and operation of mechanical and electrical systems and components in separate reports (Volume I - Mechanical, Volume II - Electrical). Maintenance and service procedures for both systems are detailed. The Mechanical volume addresses the drive systems, treadway, handrails, frames and balustrades. The Electrical volume addresses control systems, safety systems and the electrical components of the drive system.

2.3.5 Equipment Test Series

The Equipment Test Series report describes the development of the TRAX AWS starting with the early RATP studies in the mid 1960's, progressing through experimental testing in the 1970's to the present level of development with the ACB factory test unit. The substantial degree of compliance with safety codes is outlined, minor waivers detailed and the areas requiring further development described (primarily the handrail, deceleration zone lengthening and noise reduction). A detailed description of the test unit is given. A failure mode analysis and maintenance schedules are detailed. Reliability, maintainability and availability analyses are presented. The environmental impact of TRAX is examined. Investment and operating cost data is developed. The Port Authority safety inspection report on the TRAX test unit is reproduced.

3.0 Sponsor Program of Work

The Port Authority of New York and New Jersey (PANYNJ) as sponsor of the AWS Demonstration Program and under its contract with the New York Metropolitan Transportation Council, (NYMTC), the program grantee/administrator, performed as the Program Manager. This role included review of ACB's work, approval of payment requests and assessment of technical aspects of the AWS passenger equipment and equipment test series. In addition, under its contract with NYMTC, the PANYNJ produced a series of reports relating to the planned demonstration site. Although this demonstration was subsequently cancelled, abstracts of these reports are contained on pages A-9, A-10 and A-11 of the Appendix. Summaries of two of the reports, the Pre-Demonstration User Profile and Demonstration Site Engineering Report , follow.

3.1 Pre-Demonstration User Profile

The Phase III contract required the development of "before" data on the characteristics of users of the proposed Hoboken railroad terminal demonstration site, for purposes of evaluating the "after" effects of an AWS installation (Report No. UMTA IT-06-0126-83-1, abstract, Appendix page A-10). The report is summarized below.

3.1.1 Interface Description

The Hoboken terminal consists of two parallel, grade separated stations, one serving PATH subway transit trains. The railroad commuter station is a stub-end terminal at street level, with 17 parallel tracks capable of handling 8 to 12 cars apiece. It is covered by a column-supported train shed which is open on the south and west sides. A street-level bus terminal adjoins the train shed on its north side. Figure 3.1 the general site plan, shows the NJ Transit commuter railroad terminal, and the approximate alignment of the proposed AWS installation. The PATH subway terminal is a three-track, stub-end terminal, which is below grade level immediately north of the commuter terminal. Each of its three tracks is capable of handling 6 or 7 car rapid-transit-type trains. As shown on Figure 3.1 the PATH station has two entrances connecting it with the railroad terminal. An east entrance close to the discharge end of the suburban rail platforms, and a west entrance approximately 300 ft. (91.5m) away. The demonstration AWS passengers diverting from one entrance to the other would provide valuable insights into user perceptions of the convenience and acceptability of the new technology.

3.1.2 Pedestrian Activity

Fifty-seven trains arrive at Hoboken during the peak hours of 7-10 A.M. weekdays. The morning has two 15 minute peaks, 8:15-8:30 A.M. and 8:30-8:45 A.M. Nine trains arrive during each peak, and 31 trains arrive during the peak hour, 7:45-8:45 A.M. Fifty-four trains leave Hoboken during the peak afternoon hours of 4-7 P.M. weekdays. Of these, 9 trains leave during the peak 15 minute period, 5:30-5:45 P.M., and 28 trains depart during the peak hour between 5 and 6 P.M. Afternoon peaking is less pronounced because the station handles fewer trains during the PM rush period.

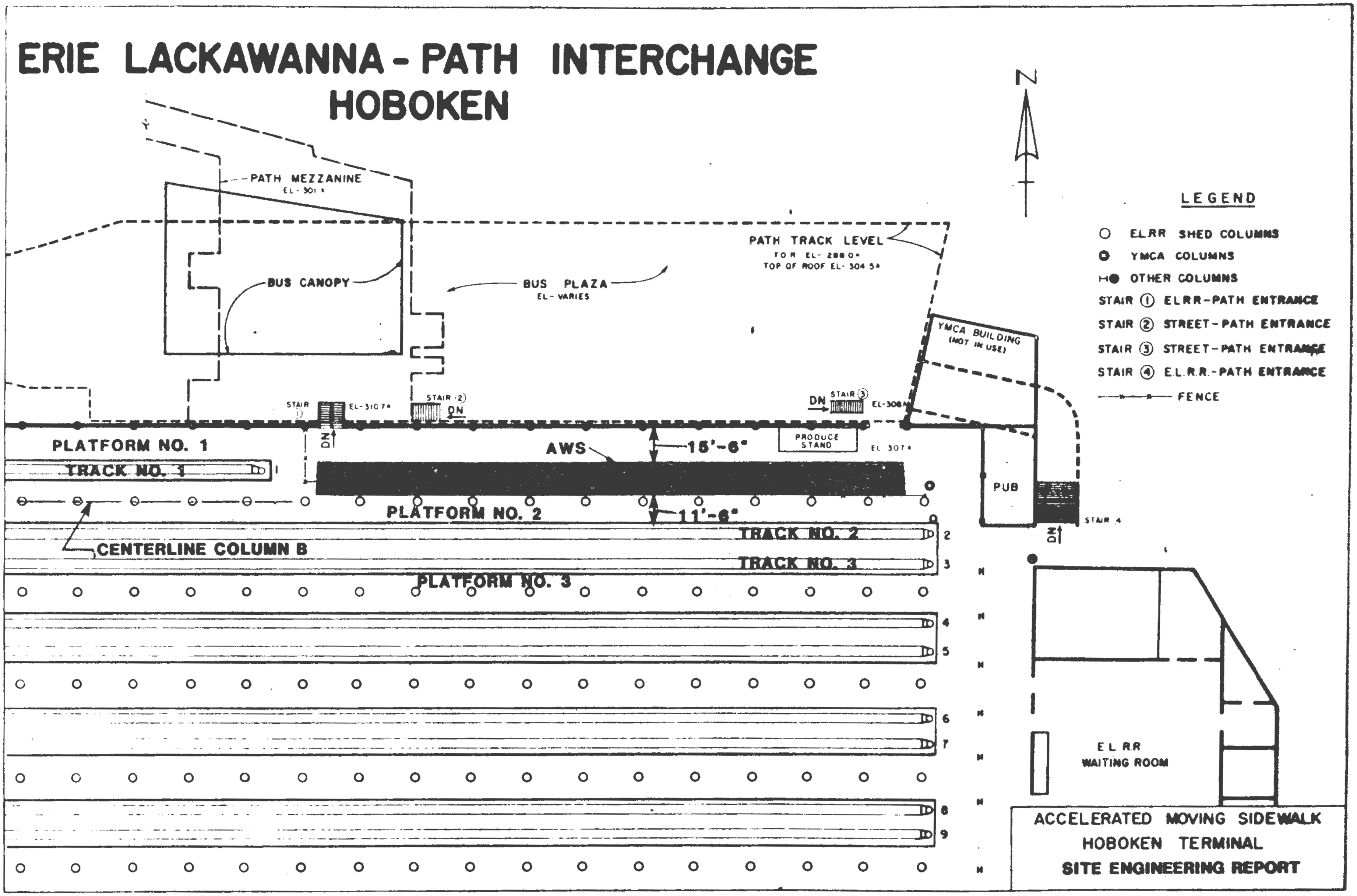

ERIE LACKAWANNA - PATH INTERCHANGE
HOBOKEN
N
PATH MEZZANINE
BUS CANOPY
BUS PLAZA
EL - VARIES
PATH TRACK LEVEL
YMCA BUILDING
(NOT IN USE)
LEGEND
EL RR SHED COLUMNS
YMCA COLUMNS
OTHER COLUMNS
STAIR (1) EL RR-PATH ENTRANCE
STAIR (2) STREET-PATH ENTRANCE
STAIR (3) STREET-PATH ENTRANCE
STAIR (4) E.L.R.R.-PATH ENTRANCE
FENCE
STAIR (1)
STAIR (2)
STAIR (3)
DN
PLATFORM NO. 1
TRACK NO. 1
AWS
15'-6"
PRODUCE STAND
PLATFORM NO. 2
11'-6"
PUB
STAIR 4
CENTERLINE COLUMN B
TRACK NO. 2
TRACK NO. 3
PLATFORM NO. 3
2
3
4
5
6
7
8
9
E L RR
WAITING ROOM
ACCELERATED MOVING SIDEWALK
HOBOKEN TERMINAL
SITE ENGINEERING REPORT

FIGURE 3.1

Passengers transferring from NJ Transit trains to PATH may enter the PATH station from either the east or west end entrance. During the morning peak, passengers discharged from these trains form dense platoons heading toward the PATH entrances. This causes considerable crowding in the pedestrian passage at the east entrance and queues at PATH turnstiles. Passenger flows to the west end mezzanine entrance are less dense due to the smaller number of passengers choosing this alternative, and because of this, no queuing occurs at west entrance turnstiles. (See Figure 3.2.)

In the evening, the peak direction of flow is from the PATH trains to the commuter trains. Passenger activity peaks around PATH train arrivals, with exit queues forming inside the lower level mezzanine. Since PATH train arrivals are relatively frequent (around every two minutes in the peak hour), the resulting platoons are not as dense as those formed in the morning, but the period of dense flow is more prolonged. Due to the "metering" effects of the turnstiles which act to control pedestrian flow, less crowding is observed in the pedestrian passage and connecting corridor in the evening.

3.1.3 Passenger Characteristics

A survey of PATH passengers taken by the Port Authority in 1980 provided information about passengers boarding at stations west of the Hudson River. The data collected in this survey includes origin and destination (O&D) information, demographic data, and perceptions of level of service. Additional data were obtained from turnstile count surveys.

FIGURE 3.2

HOBOKEN RAIL TERMINAL - A.M. Passengers Approaching West Entrance to P.A.T.H.

Turnstile count surveys show that in the morning peak period 7-10 A.M., 5,650 (26%), of the rail transfer passengers use the west entrance to PATH, and 16,030, (74%) use the east entrance. In the evening peak period, 4-7 P.M., 4,030 (21%) use the west entrance and 15,150, (79%) use the east entrance.

The O&D data shows that approximately three-quarters of the passengers transferring from rail to PATH during the peak period were male. However, the percentage of women using the west entrance was higher than the percentage of men, possibly due to negative perceptions of crowding at the east end entrance, and the desire to obtain a seat on the train. Age group data indicates that 83% of the rail passengers are between 25 and 61. The lowest percentage of west entrance users was the 35-42 age group and the highest, the 18-24 group. Surprisingly, passengers over age 61, who might be expected minimize walking, showed the second highest usage of the more distant west entrance.

Income data indicates that almost 60% of the rail transfer passengers had an annual income of over $35,000 (1980 dollars), and that the use of the more distant west entrance decreased with increasing income. This probably indicates a greater valuation of personal time savings, as weighed against the increased crowding of the closer east entrance.

3.1.4 Estimated Use - Demonstration AWS

Based on analysis of turnstile counts, passenger origin and destination data, and evaluation of user time savings, a demonstration

AWS would attract 10,270 daily peak period rail transfers, or 2,567,500 users annually. This translates to 736 passengers in a peak 15 minute period. Annual time savings are estimated 718,750 person-minutes. Diversions of pedestrians from the more crowded east entrance of PATH will result in improved level of service.

An AWS installation would be capable of accomodating the predicted volume of users with few problems. Its rated practical capacity 100 passengers per minute is considerably higher than the predicted average peak rate of usage of 49 passengers per minute, minimizing queueing except or very short-term peaks.

3.2 Site Engineering Studies

As part of the Phase III program of work, the Port Authority Engineering Department prepared plans and a descriptive report covering the preparation of the demonstration site for an AWS installation. The report includes excavation, foundation, AWS installation, and site restoration plans, as well as related cost data, scheduling, and specifications. An abstract of the report (UMTA-IT-0126-83-2) is shown on Appendix page A-11. The report summary follows.

3.2.1 Structural Data

The alignment of the proposed demonstration unit is along the trackbed of what was once the eastern end of Track 1. This track was cut-back and covered with compacted fill and an 8 in. (200 mm) concrete slab. Round, cast-iron columns, spaced at 27 ft. (8 m) centers along the centerline of each 20 ft. (6 m) wide platform support the train shed's steel arch roof. The column foundations consist of concrete piers approximately 7 ft. (2 m) deep, underpinned by four timber piles (the primary piles). The platform support piers are supported by single timber piles (the secondary piles). The primary piles support the roof and the secondary piles support the platform. Removing a portion of the platform north of the columns and one line of secondary piles, as planned for the AWS installation, will therefore have no effect on the stability of the train shed roof.

3.2.2 Geotechnical Data

Geotechnical conditions at the demonstration site were determined from subsurface boring data colled as part of this study, and known geologic conditions in the general area of the Hoboken terminal. Tests were performed on the boring samples to predict allowable soil bearing values to support the AWS equipment and foundations. Surface soils at the site were found to be composed of fill extending to a depth of approximately 17 ft. (5 m). Below the fill is a thick layer of soft organic silty clay ranging in depth from 50 to 70 ft. (15-21 m). Groundwater observations show the water level to be 5 ft. (1.5 m) below ground surface.

The geotechnical data was used to evaluate three foundation alternatives for supporting the AWS: (1) continuous or spread footings, (2) existing platform piles, and (3) existing pavement. Based on a geotechnical analysis and site conditions, continuous spread footings were recommended.

The foundation recommendations, test data, and a descriptive report of the geotechnical work performed by the Port Authority Engineering Department is contained in the report UMTA-IT-0126-82-2. An abstract is shown on Appendix page A-9.

3.2.3 Basic Installation Assumptions

The AWS installation program included provisions for public safety and maintenance of commuter rail operations and pedestrians movement. All construction activity was to be coordinated with the New Jersey Transit Corporation, the terminal's owner and operator.

Movement of contractors' equipment, the disposal of excavated and waste materials, and deliveries of construction materials would be performed during low traffic hours. Safety barriers and signing were envisioned to separate construction and passenger activities.

3.2.4 Foundation Design

Analysis of existing structural elements and the bearing capacity of the soil at the site resulted in the selection of a U-shaped reinforced concrete slab foundation design.

Alternatives incorporating existing pavement or secondary piles for support of the AWS would have transmitted additional load to the primary piles supporting the roof load. In supporting the AWS at grade on the existing pavement would have raised the treadway surface 4-5 ft. (1.2-1.5 m) above platform level, requiring ramped approaches and discouraging the system's use. Another consideration in the use of a concrete slab foundation is that the weight of the soil to be removed is greater than the weight of the AWS, it's live load, and foundations. Due to the natural surcharging of the soil caused by the weight of the material to be removed, the soil pressure is 400 psf (19,152 Pa) at a depth of 4 ft. (1.2 m), and greater at the depths of equipment pits. The foundation slab and the full load of the AWS imparts maximum pressures of approximately 320 psf (15,322 Pa), or less than the existing surcharge at the minimum equipment pit depth.

3.2.5 Foundation Depths

The continuous reinforced concrete foundation supporting the AWS needed to be recessed at several points to accommodate the system's propulsion units and turnaround sections. The 4:1 ratio TRAX AWS requires a 3 ft., 4 in. deep (1 m) recess for fitting typical walkway module units, a 5 ft., 4 in. deep (1.6 m) recess for the propulsion motors, and an 11-1/2 ft. (3.5 m) depth at the end turnaround sections. The respective excavation depths required for these recesses are 4 ft. (1.2 m) for typical walkway sections, 6 ft., 4 in. (1.9 m) for the driving motor recesses, and 12 ft. (3.6 m) for the end equipment pits.

3.2.6 Electrical Requirements

The demonstration unit required a 120/208 Volt, 3 Phase, 4 wire electric service. A service entrance pedestal comprised of a 600 ampere fused service switch, current transformer cabinet, and utility meter shall be furnished and installed by the site preparation contractor. A 4 in. (102 mm) steel conduit with eight 250 mcm cables shall be extended overhead from the 600 ampere switch to a 3 ft. x 2 ft. x 8 in. (914 x 610 x 203 mm) junction box at column 5 in the transit shed. The AWS equipment installation contractor was to furnish, install, and connect propulsion motors, security and alarm panels, the motor control center, circuit breaker and power supply panels, all safety and control devices, and associated electrical connections and conduit for the AWS.

3.2.7 Construction Procedures

A 6 ft. high (2 m) safety partition was to enclose the AWS installation area as a precaution against injury to pedestrians. Then the 8 in. thick (203 mm) concrete slab on grade along the AWS alignment would be removed using jackhammers. Debris would be of a size small enough to be carted away from the work area by wheel barrow and conveyor belt. Sheeting was to be placed along the sides of the excavation in order to prevent settlement along the perimeter of the modified area. Dewatering was specified at the end equipment pits, since the excavation for these pits will go below the water table.

A 6 in. (152 mm) layer of dense graded aggregate base course would be placed over the bottom of the excavation. The foundation slab would be cast in place by pumping in concrete and/or the use of a conveyor belt and wheel barrows. Expansion joints would be provided where the end equipment pits meet the typical AWS foundation and at the inner termination of the 5 ft., 4 in. deep (1.6 m) driving motor areas. A dense concrete with a compressive strength of 4,000 psi (27.6 MPa) would be used for all foundation work. Equipment pits would be fitted with sumps and pumping equipment to remove occasional water accumulation. In addition, water stops at joints and waterproofing would be used where the foundation level goes below the water table. Pedestals and support pads for the AWS modular units and propulsion motors would be constructed according to the specifications of the manufacturer.

3.2.8 Codes and Standards

All construction would be performed in conformance with the American Concrete Institute (ACI) Code for Concrete Construction, the Building Officials Conference of America (BOCA) Code, the American National Standards Institute (ANSI) A17 Code for Escalators and Moving Walkways, and current Port Authority standards.

3.2.9 Construction Schedule

Following the completion of the Phase III equipment and user tests, Phase IV, consisting of site preparation, installation, and the demonstration of the AWS, was to begin. The estimated schedule anticipated for Phase IV activities is shown in Figure 3.3.

The sequence of events begins with (1) completion of the Stage III design work for the site preparation, i.e., final contract drawings, preparation of construction documents, and advertisement/award of the contract. This was to be followed by: (2) construction required to prepare the site for system installation, (3) installation of the AWS, (4) the year long demonstration program, (5) Stage III design for post-demonstration restoration of the site, (6) removal of the AWS, and (7) site restoration.

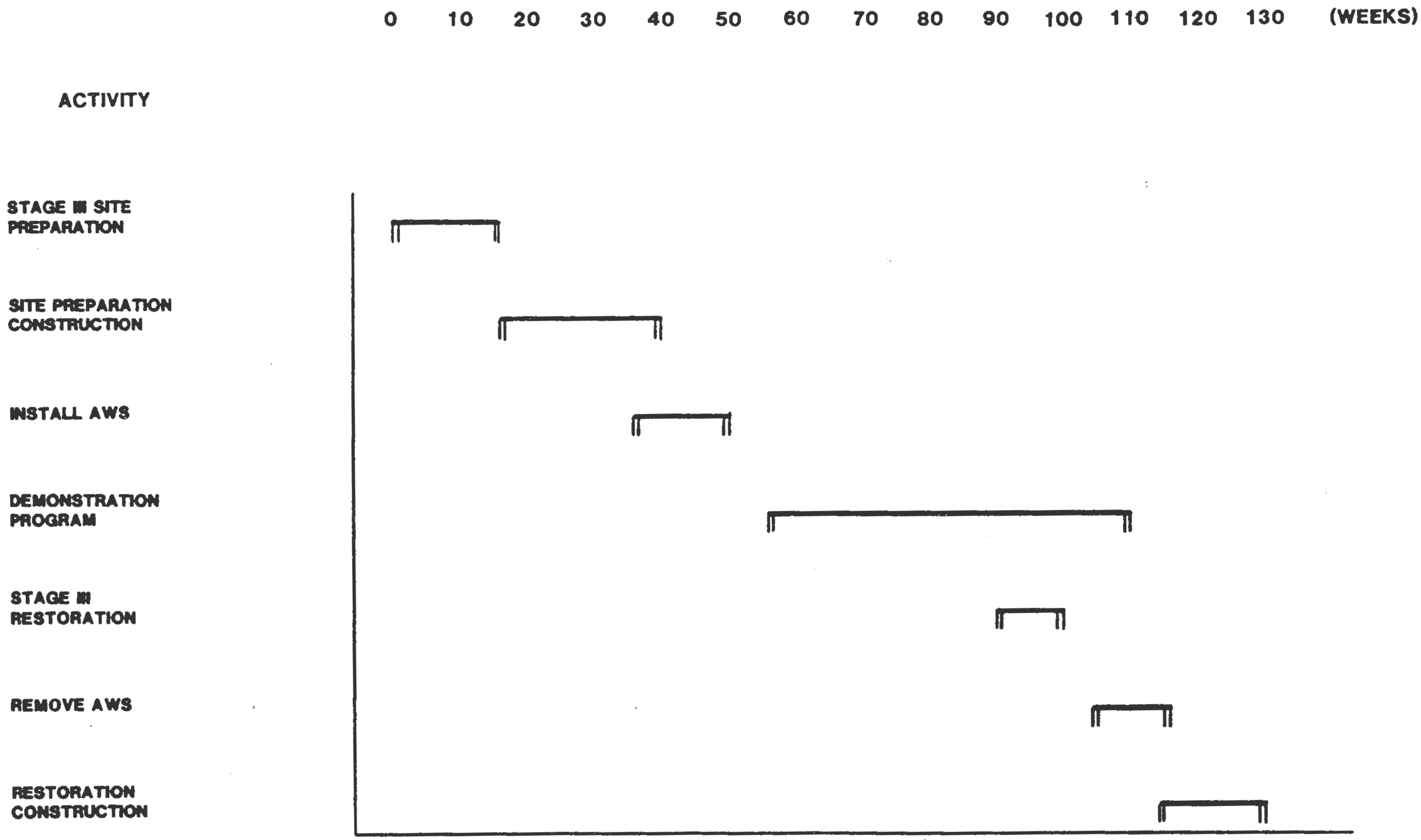


FIGURE 3.3

AWS Phase IV Construction Schedule

3.2.10 Estimated Site Preparation Cost

The estimated construction cost to prepare the site for the AWS, including slab removal, excavating, sheeting, concrete, steel and provision of electrical service is $320,000 (1983), or approximately $1100 per foot ($3350/m) of the end to end length of the loop system. This cost does not include security costs. The furnishing and installation of the AWS equipment, including all supports, balustrades, treadway and handrail elements, motors, controls and electrical wiring would be a separate contract.

Since this demonstration phase is not presently planned for implementation, the above information is given for reference only.

4.0 TRAX AWS - Equipment Evaluation

The dynamic testing of the TRAX AWS in Nantes, France showed that the basic treadway design is rugged, and this element of the system should have a high degree of reliability. Most of the problems that showed up in the dynamic tests were related to the handrail design and the "soft drive" propulsion system. The quadrilateral chain assemblies linking the treadway pallets and handrail handgrasps were found to gradually develop slack after running and "settling in". Design detail changes in the balustrade and the handrail return configuration are also indicated for U.S. applications. The initial debugging failures that occurred during the March 1983 test series showed that the TRAX AWS, although involving a large number of interconnected components, was mechanically simple and could be brought back on-line using the basic skills typical of an escalator mechanic.

Equipment factors which should be considered in the development of a second-generation system for U.S. application are discussed in more detail in the following sections.

4.1 Chain Tension

The treadway pallet and handrail/handgrasp assemblies in the TRAX AWS involve a quadrilateral chain, linked in a continuous loop to all other pallets and handgrasps. In the 410 ft. (125 m) long (overall length) Nantes test unit, there are 621 treadway units and 354 handrail units, each with its own chain assembly. The dynamic test series showed that these quadrilateral chains gradually developed a small increment of slack after running as the individual chain links "settled in". This incremental slack, compounded over the entire system, caused problems in both the treadway and handrail operation.

Since the treadway was more rugged and allowed for larger tolerances, the slack problem was effectively dealt with by removing one pallet in the loop. However the compounded slack in the handrail chains caused an excessive play and sag in the handrail which triggered a number of system failures. Among the problems encountered, the slack resulted in handgrasp bogies impacting the balustrade, causing a failure of the bogie and resulting in an automatic shut down of the system (see Figure 2.2).

The handrail chain slack problem was temporarily solved for the December 1983 test series by building a trough or runway within the balustrade to guide the bogies and prevent them from impacting balustrade supports, and additionally, by providing an adjustment link in each handrail chain assembly. However, a better long-term solution to the chain slack problem is desirable to increase system reliability and availabiity.

Escalators and moving walkways employ automatic tension take-up adjustment mechanisms to adjust for similar problems, but the mechanical configurations of these systems are not as complex as TRAX.

4.2 Soft-Drive Propulsion

The "delta-block" soft-drive propulsion utilized on the TRAX system has been devised to reduce noise and prevent potential high energy failures which, because of the forces involved, might endanger passengers (see Figure 2.4). Examples could include a sudden parting of the treadway pallets, or sudden breaking of a handrail chain under high stress. With the soft-drive, excessive resistance in the treadway or handrail loops causes the delta-block's "gears" to slip, preventing the transmitting of large forces from the propulsion system to the chain and treadway loops. However, the dynamic tests showed that slippage of the delta drive was occurring too frequently, causing unnecessary automatic shutdowns.

The concept of the delta-blocks, that of avoiding excessive forces in equipment elements exposed to passengers, is a good one. However, a system less susceptible to slippage under normal variations in operating conditions is desirable to improve system reliability and availability.

4.3 Speed Change Zones

The acceleration and deceleration speed variation zones on the test unit at Nantes are 30 ft. (9 m) long. The unit has a general slope of about 2%, and an additional slope in speed variation zones. The length and slope of these speed variation zones determines the motion effects experienced by passengers (acceleration, deceleration, and their respective rates of change).

The TRAX AWS motion effects, particularly at the entry and exit speeds of 90 to 120 fpm (.45 and .6 mps) more likely to be used in the United States, proved generally acceptable to passengers, but some riders reported minor motion problems. A greater number of passengers reported problems with the exit section on one end of the system loop where there is a "crest" or "summit" curve of 92 ft (28m) radius, and a change in grade from a positive 2% slope (upward), to negative 3% slope (downward). The compound grade change appeared to add to rider's perceived deceleration effects, and in one instance was observed to contribute to a near fall during an emergency stop.

Lengthening the deceleration zone and increasing the radius of the curve connecting the grade tangents would improve these motion characteristics.

4.4 ANSI-A.17.1 Code Compliance

A number of variations with the American National Standards Institute (ANSI), American Society of Mechanical Engineers (ASME) Section A.17.1 of the model code for escalators were observed.

4.4.1 Combing - The comb spacing of teeth 0.16 in. (4 mm) wide on a 0.79 in. (20 mm) pitch does not comply with the A.17.1 code which specifies 0.5 in. (13 mm) pitch (see Figure 1.2). However, the combing design was considered effective, and a waiver of this provision might be obtained.

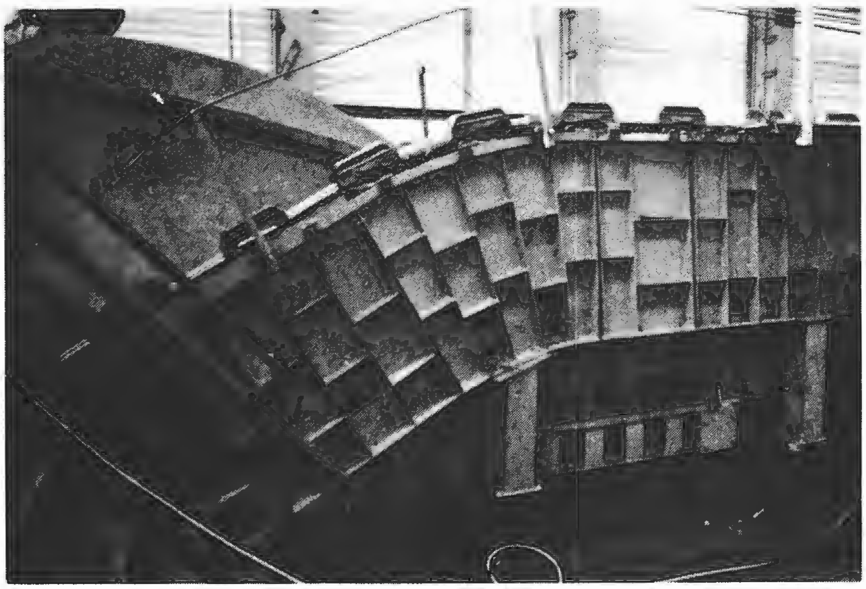
4.4.2 Treadway Width - The width of the treadway is 41 in. (1.04 m), which exceeds the A.17.1 code maximum by 1 in. This variation is insignificant and a waiver of this provision should be obtained. Conventional single speed moving walkways 54 in. wide, manufactured by Dunlop Ltd. are employed at Heathrow and Gatwick airports at London, England, without reported problems.

4.4.3 Handrail Return - The handrail entry for the return run occurs at floor level instead of 10 in. (254 mm) above the floor as required by tha ANSI code. This is due to the loop return configuration of the TRAX handrail and cannot be changed. The provision should be waived. More importantly the handrail enters the balustrade in line with the combplate, so that riders would be still holding the handgrasp preparatory to exiting. In order to comply with both the U.S.-ANSI and European codes, the handrail entry should extend at least 1 ft. (.305 m) beyond the combplate, to ensure that passengers release the handgrasp before it enters the balustrade (see Figures 4.1 and 4.2).

4.4.4 Projecting Surfaces - The top section of the balustrade was observed to be fastened to the side wall with oval head screws. Flat head screws are preferable so that the screws are flush mounted, with no projection above the parent surface. The unit should be modified accordingly. Also, studs about 3/8 in (9mm). in diameter and 1/32 in. (0.8mm) high projected out from the upper section of balustrade. The edges of these studs should be rounded.

4.4.5 Balustrade Configuration - The set-back of the handrail centerline from the treadway of 9 in. (229 mm) conforms with the ANSI code maximum of 10 in., but balustrade configurations shown in the code place the handrail closer to the balustrade edge than with TRAX. The common practice is to slope the balustrade wall in toward the handrail, or to set the wall back to provide more clearance for riders clothing and carried articles. Passengers riding TRAX were observed to be standing further away from the balustrade than with conventional

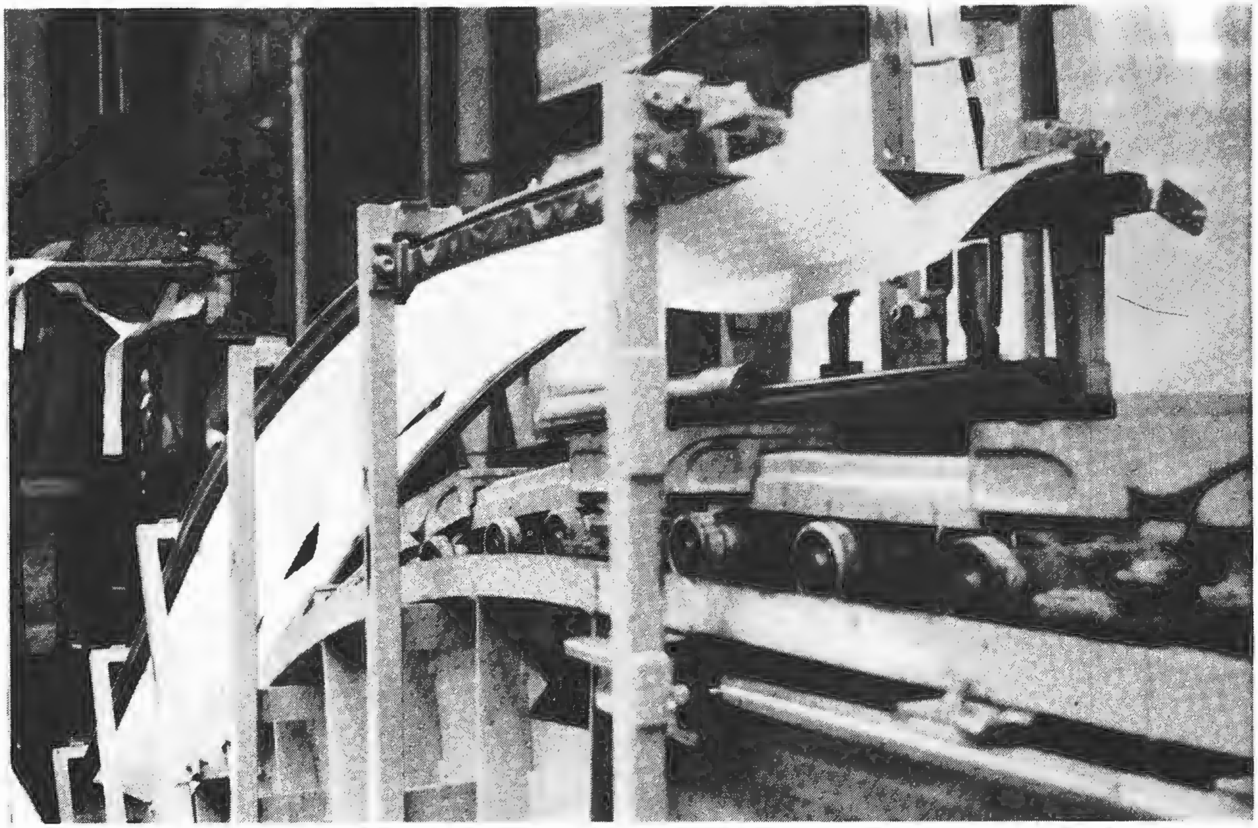
FIGURE 4.1



TRAX AWS - (Upper) Close up of handrail entry into balustrade enclosure.
(Lower) TRAX handrail slopes down at system ends and is returned on opposite side of loop.

FIGURE

4.2



TRAX AWS - Photo of handrail entry with protective cover and balustrade removed. Cylinder and plunger is automatic shutdown device in event of entrapment.

walkways to avoid brushing clothing against the balustrade (See Figure 4.3). A sloped or set-back balustrade wall is recommended for U.S. applications.

4.5 Handgrasp Clearance

It was observed that there is no way to adjust the clearance between the handgrasp bogie and the balustrade skirting. During the March 1983 test series rubbing between the handgrasp bogie and balustrade was noted all along the handrail loop. The resulting friction contributed to the handrail tension and chain slack problem discussed in Section 4.1. During the March test series the problem was mitigated by applying grease to the bogies, but this can result in the soiling of passenger clothes. In the December test series the handgrasp clearance was improved by machining the bogie to increase its running clearances. Some means of adjusting handgrasp bogie and balustrade clearances is necessary in future installations. Running clearances should be sufficent to avoid contact between moving and stationary equipment components, yet close enough to avoid entrapment hazards.

4.6 Noise

The noise levels of TRAX measured at several locations along the loop, were quite high, registering 96 decibels near the drive unit and 85 decibels at the turn-around section of the loop. The large number of bearings in the system and the lack of enclosure of the test unit contribute to the noise level. A 15 decibel noise reduction is estimated for a permanent fully-enclosed system, which is still

FIGURE 4.3

TRAX AWS PASSENGER TESTS

The TRAX handrail (right) is set back further from the balustrade edge than conventional walkways, (note below DeGaulle Airport). This causes greater arm extension than usual. The AWS handrail entry occurs on top of the balustrade near the plane of hand movement, instead of below it as in the conventional walkway shown in bottom photo. (See photos of TRAX AWS entry, other pages).

Conventional Single Speed Walkway - DeGaulle Airport, Paris relatively high in comparison with current escalator/moving walk installations.

4.7 Quality Control

The first system failure that occurred during debugging runs in the March 1983 test series was traced to the shearing off of an anti-rotation set pin. The set-pin failure was caused by excessive tightening during fabrication of the handrail assembly. The sheared set pin allowed the loosening of a bolt in a handrail bogie, triggered a bogie failure and automatic shut down. ACB has indicated that this problem can be controlled by an additional inspection step during fabrication of the handrail assembly.

5.0 Passenger Safety and Acceptability

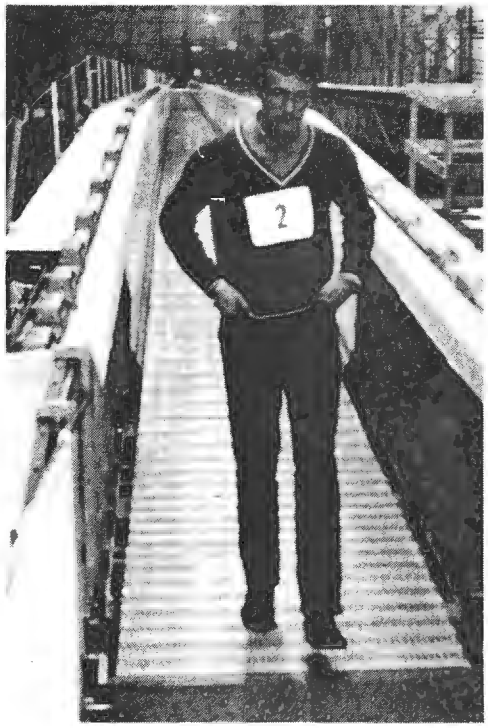
The overall impression of Technical Evaluation Team members observing the March and December 1983 passenger test series is that the ACB-TRAX accelerating walkway system has a high level of user acceptability and safety. However, there are areas where minor modifications in equipment design and operating characteristics would improve these factors. The anticipated safety experience after these improvements is considered to be at the level of an escalator.

5.1 Speed, Acceleraton, Deceleration, Emergency Stopping

During the test series the TRAX AWS was operated at entry speeds of 90, 120, and 163 fpm (0.45, 0.6, 0.8 mps), with corresponding high speeds of 360, 480, and 653 fpm (1.8, 2.4, 3.3 mps). Horizontal accelerations and decelerations at these speeds are .03 "g", .05 "g" and 0.098 "g" respectively. The December tests also included runs at 600 fpm (3 mps). As discussed in Section 4.3, at the highest speed of 653 fpm the deceleration zone appeared to be too short, particularly on one side of the loop where there is a "crest" or "summit" curve just prior to the deceleration. Deceleration rates, including emergency stop were acceptable at the lower operating speeds of 360 and 480 fpm which are more likely to be used in the U.S., except for the crest location.

For the most part passengers appeared to adapt well to the motion characteristics of the TRAX AWS at all but the highest speed. Most younger passengers rode the system without using the handrails. (See Figure 5.1.) Handrail use was observed to increase with age and

FIGURE 5.1



TRAX AWS PASSENGER TESTS NANTES, FRANCE

Younger passengers readily adapted to accelerating walkway with minimal use of handrails at all speeds.

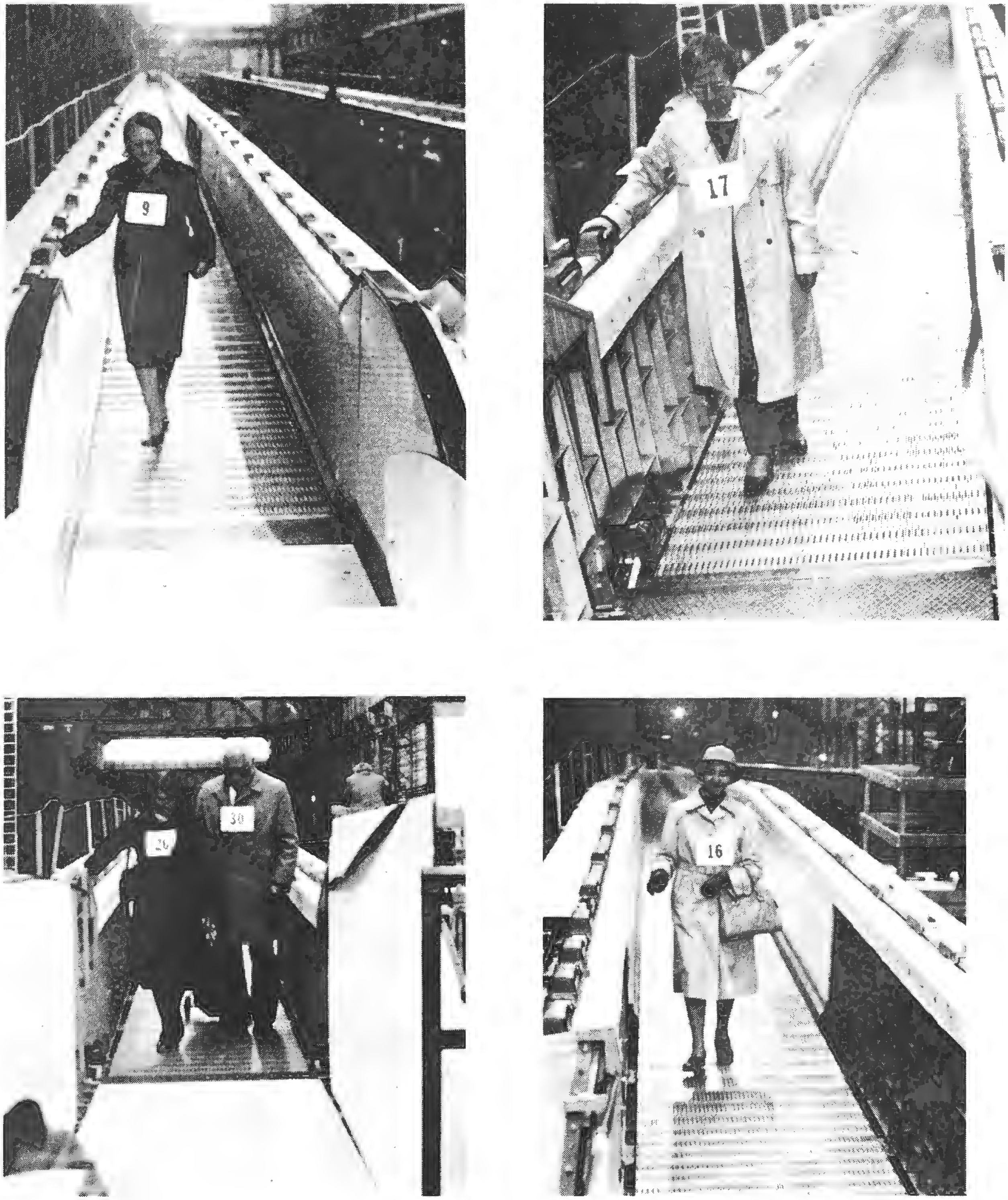
disabilities, but even some of the elderly seemed impatient with the slow acceleration and deceleration of the unit at lower speeds, and walked on and off the unit without making use of the handrail. (See Figures 5.2 and 5.3.)

No passenger falls were observed during the March 1983 tests, but two falls were observed during the December series. One of these falls involved a disabled young man, a victim of polio, with an elevated platform shoe prosthesis on his left leg. He rode through the ascending section of the loop with no problem at a speed of 480 fpm, but fell in the descending section at a point just beyond the acceleration zone. Review of the videotape recording showed that he released his grip on the handgrasp, momentarily lost his balance, and attempted to regain his support by using the stationary balustrade. The result was a fall without injury. The second incident involved a middle-aged woman in good health riding at the higher test speed of 600 fpm (3 mps), but not using the handrail. She also fell on the descending half of the loop, in the acceleration zone. She was unhurt.

5.2 Handrail Use

While the minimal use of handrails by passengers in the test series confirms that the motion characteristics of TRAX are acceptable to riders, modification of the handrail design as discussed in Sections 4.4.3 and 4.4.5, would encourage the use of the handrail and improve passenger safety. Extension of the handrail beyond the combplate would provide a lead-in for passengers, and help them to

FIGURE 5.2



<u>TRAX AWS PASSENGER TESTS NANTES, FRANCE</u>

Greater use of handrails was noted with passengers that wore glasses, particularly at system portals.

TRAX AWS PASSENGER TESTS NANTES, FRANCE

Elderly and ambulatory disabled adapted well to AWS at medium and lower speeds. (Lower right) - Sixty-two year old "commuter" rushing for train as joke.

adjust to the entry speed. A sloping or set-back balustrade would allow passengers to get closer to the handgrasp without brushing against the stationary walls of the balustrade. The shape of the handgrasp should also be slightly modified to suit the smaller hands of women and children. Maximal use of handgrasps by passengers is considered an important objective to reduce the potential bunching hazards in deceleration zones.

5.3 Bunching

Bunching tests were conducted in both the March and December test series. In the March tests passengers were specifically instructed to move forward in the deceleration zone to create crowded conditions. During these tests, passengers adjusted quite well to the bunching condition without losing balance or being upset, but there was a "jostling" effect, particularly towards the rear of the group (see Figure 5.4.)

In the December test series bunching was observed as part of a full-load test to evaluate the performance of the AWS with every handgrasp occupied. In order to conduct this test, 260 students were employed in an attempt to force-feed the TRAX AWS and occupy every exposed handgrasp in the loop. Because of difficulties in consistently maintaining full occupancy of the loop, a maximum use of only 85% of the handgrasps was attained.

Nevertheless, this was considered a good test of the bunching problem since the typical occupancy of a crowded escalator under a back-up queue is 50-60% of its theoretical capacity. Under

FIGURE 5.4

TRAX AWS

Bunching tests showed that this is a problem, but no serious difficulties noted. Signing needed to encourage use of handgrasps in deceleration zones.

the extreme conditions of the test, serious bunching conditions were in fact observed, but no falls occurred. It is unlikely that the level of pedestrian densities attained in the full-load test would occur in normal use. However, bunching remains as a recognized accident hazard with in-line accelerating walkway systems. Recommended preventative measures include flashing light signs and recorded announcements presented ahead of deceleration zones, advising passengers to hold handgrasps and avoid getting too close to other riders near the system exit.

5.4 Divergency

Minor divergency problems, requiring changes in standing position were observed during the passenger tests. This occurs when the hand-hold position slightly "leads" or "lags" the body centerline. As the system accelerates the expansion of the treadway and handrail magnifies the distance between the handhold and body. However, the adjustment of the two is accomplished with little difficulty, and would tend to improve as riders gain more experience.

Baggage carts mounted on low friction wheels were observed to cause a divergency type of problem. Because of the wheels, the AWS treadway does not accelerate or decelerate the cart, and therefore the force necessary to accelerate or decelerate the baggage cart must be provided by the person pushing it. If the passenger does not maintain control of the cart, it can potentially impact other riders, or upset the passenger using it. Further study of this problem is required.

It may become necessary to allow only carts of the type having automatically locked, manually released brakes on the AWS.

5.5 Entrapment

The large number of combing surfaces on the TRAX AWS, the movement of the covered handrail chain through the handgrasp bogie, and the handrail entry at the ends of the walkway loop, all present potential entrapment hazards. However, repeated attempts to create entrapment situations by placing small articles on the treadway showed no obvious entrapement hazard. Attempts to get a coat sleeve caught in the handgrasp were also not successful because of the small clearance. An observer team member attempted to get his fingers caught between the handrail and the grasp, and although his fingers were pinched uncomfortably, there was no entrapment. Entrapment at the handgrasp could possibly occur with the fingers of very small children, but such children could not reach the handrail, so this hazard appears to be minimal.

The handrail entry configuration is designed to minimize the entrapment hazards. The handrail enters a tunnel like section that can accommodate the entire arm without entrapment. At a certain point the arm is safely stopped, forcing the user to release the handrail before an injury can be sustained. An additonal automatic shut-off switch which would be installed at the handrail entry is under development.

5.6 Disabled Users

The adaptability of disabled users to TRAX was generally good. The exception was the one disabled person who fell, mostly due to inappropriate use of the handrail. Elderly passengers reacted remarkably well to the AWS, many riding safely without using the handrail, and gaining additional confidence during repeated uses of the system. A double-amputee with artificial legs managed using the system without incident, necessarily exercising a high degree of caution consistent with the nature of her disability.

Wheelchair users had only minor problems using the system. On the positive side, it was noted that during deceleration, any chance reversal of the wheelchair casters was corrected by the movement of the treadway, causing the casters to become properly aligned in the proper direction to exit the AWS. This is not always the case on conventional moving walks where a mis-alignment of the front casters of the wheelchair could potentially get caught at the comb plate and upset the wheelchair. One disadvantage that was noted is the valley created by the negative slope of the treadway followed by a positive slope at the combplate. One wheelchair, manually operated by a weak person, became stuck at the combplate, since the person did not have sufficient strength to move the chair out of the valley. An electrically driven wheelchair also became stuck, and the battery-powered motor did not have sufficient torque to move the chair up the grade. It is believed that wheeelchair users could overcome this problem through more experience exiting the system.

6.0 APPENDIX

Technical Report Documentation Page

1. Report No. UMTA IT-06-0126-78-1	2. Government Accession No. PB 290-682	3. Recipient's Catalog No.
4. Title and Subtitle Accelerating Moving Walkway Systems Executive Summary		5. Report Date 1978 6. Performing Organization Code
7. Author(s) Fruin, J.; Marshall, R.		8. Performing Organization Report No.
9. Performing Organization Name and Address Port Authority of New York & New Jersey One World Trade Center New York, New York 10048		10. Work Unit No. (TRAIS) 11. Contract or Grant No. No. IT-06-0126
12. Sponsoring Agency Name and Address U. S. Department of Transportation Urban Mass Transportation Administration 400 Seventh Street, S.W. Washington, D.C. 20590		13. Type of Report and Period Covered 14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

This report summarizes the results of a series of feasibility studies conducted as the first phase of a program leading to the public demonstration of an accelerating walkway system. The general conclusion of the studies are that there are currently 5 accelerating walkway systems developed sufficiently to be considered as candidates for a public demonstration of the technology. Evaluation of safety indicates that these systems should be capable of operating at levels of safety acceptable to the general population. Potential applications for the technology include a wide variety of prospective uses as a pedestrian assist system for transit, on airports, in urban activity centers, and to support and encourage certain types of urban development. Additionally, the systems offer a lower life-cycle cost and reduced energy alternative to vehicular systems under certain conditions. The systems are shown to be cost effective in high volume pedestrian corridors.

Phasing of the Demonstration Program is advisable to assure that equipment development and plans are advanced sufficiently to obtain comparable design data for candidate systems, and that adequate programs of equipment and user tests are conducted prior to the selection of the demonstration unit. Demonstration program plans include sufficient user tests to determine public acceptability of the technology, as well as to provide sufficient operating time to establish system reliability and costs.

17. Key Words Accelerating Moving Walkways, Moving Way Transit, Pedestrians, Passenger Conveyors		18. Distribution Statement Available to the public through the National Technical Information Service Springfield, Virginia 22151.	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 31	22. Price A03

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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UMTA-IT-06-0126-78-2	PB 287-082/AS	

4. Title and Subtitle	5. Report Date / 6. Performing Organization Code
Accelerating Moving Walkway Systems Technology Assessment (Report B of Series)	5. Report Date: March 1978 6. Performing Organization Code: Port Authority of NY & NJ
7. Author(s): Fruin, J., Marshall, R., Zeigen, M.	8. Performing Organization Report No.
9. Performing Organization Name and Address Port Authority of New York and New Jersey One World Trade Center New York, New York 10048	10. Work Unit No. 11. Contract or Grant No.: No. IT-06-0126
12. Sponsoring Agency Name and Address U. S. Department of Transportation Urban Mass Transportation Administration 400 Seventh Street, S. W. Washington, D. C. 20590	13. Type of Report and Period Covered 14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

Variable speed, Accelerating Moving Walkway Systems (AMWSs) represent the next evolutionary phase in a century of moving way transportation system development. AMWS(s) resemble conventional constant speed moving walks in appearance, but have the capability through changing treadway configuration to accelerate pedestrians to 4 to 5 times the conventional system speed. An assessment of the current state of AMWS technology indicates that there are five systems at various stages of hardware development and testing. Two systems are bi-directional loops using a treadway of intermeshing pallets. The remaining systems are one directional using treadways comprised of either laterally moving pallets, intermeshing leaves, or abutting rollers. Handrails are developed for only two systems, one employing multiple conventional handrails in series, and the other utilizing moving variable speed handgrips. Site adaptability of the systems varies with the system width and sub-grade depth installation envelope, as well as horizontal and vertical alignment adaptability. Furnishing and installation costs of the systems are relatively high, but their mechanical simplicity results in comparatively low operating expenses and energy use. A review of AMWS safety and human factors indicates, apriori, no significant reason why the systems cannot operate at levels of safety acceptable to the public, providing a specific safety program is followed.

17. Key Words	18. Distribution Statement
Accelerating Moving Walkways, Technology Assessment, Moving Way Transit, Pedestrians, Passenger Conveyors	Available to the Public through the National Technical Information Service Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	92	A05

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1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UMTA IT-06-0126-78-3	PB 286-831/AS	

4. Title and Subtitle	
Accelerating Moving Walkway Systems Safety and Human Factors (Report C of Project Series)	5. Report Date March 1978
	6. Performing Organization Code
7. Author(s) Fruin, J., Marshall, R., Zeigen, M.	8. Performing Organization Report No.
9. Performing Organization Name and Address Port Authority of New York and New Jersey One World Trade Center New York, New York 10048	10. Work Unit No.
	11. Contract or Grant No. IT-06-0126
12. Sponsoring Agency Name and Address U. S. Department of Transportation Urban Mass Transportation Administration 400 Seventh Street, S. W. Washington, D. C. 20590	13. Type of Report and Period Covered
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

An Accelerating Moving Walkway System (AMWS) is a pedestrian assist device having the capability through changing treadway configuration to accelerate pedestrians to 4 to 5 times normal moving way system speeds after boarding and to decelerate prior to discharge. Conventional moving way systems, escalators and moving walks, enjoy wide public acceptability and rank as one of the safest transportation modes in terms of numbers of passengers carried. Accelerating moving walkways will introduce several new operating characteristics which may influence accident experience. Depending on the system, treadway surfaces will expand and contract or change relative position, and handrails will expand and contract or be used in series at varying speeds. Based on the report studies which include an overview of transportation safety, identification and evaluation of possible AMWS hazards, an analysis of moving way accident experience on conventional escalators, the reports of Project Safety consultants and the proceedings of a Project Safety Seminar, there appears to be no apriori reason why an AMWS cannot be operated in a public demonstration mode at acceptable levels of safety. This assumes that a basic safety program is followed addressing human factors and equipment design, equipment operation and maintenance, instruction of passengers in correct use, and that the demonstration environment is appropriate and controls are maintained to assure proper system use.

17. Key Words	18. Distribution Statement
Accelerating Moving Walkways Moving Way Transit, Pedestrians, Passenger Conveyors, Human Factors, Safety	Available to the Public through the National Technical Information Service Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
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1. Report No. UMTA-IT-06-0126-78-4	2. Government Accession No. PB 287-083/AS	3. Recipient's Catalog No.
4. Title and Subtitle Accelerating Moving Walkway Systems - Market, Attributes, Applications and Benefits		5. Report Date MARCH 1978
		6. Performing Organization Code
7. Author(s) Fruin, J., Marshall, R., Perilla, O.		8. Performing Organization Report No.
9. Performing Organization Name and Address Port Authority of New York and New Jersey, One World Trade Center, New York, New York 10048		10. Work Unit No.
		11. Contract or Grant No. No. IT-06-0126
12. Sponsoring Agency Name and Address U. S. Department of Transportation, Urban Mass Transportation Administration, 400 Seventh Street, S. W., Washington, D. C. 20590		13. Type of Report and Period Covered
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

An Accelerating Moving Walkway System (AMWS) is a pedestrian assist device having the capability through changing treadway configuration to accelerate pedestrians to 4 to 5 times normal entrance speeds after boarding and to decelerate prior to discharge. Time savings resulting from these systems make deployments over longer distances more feasible than with conventional moving walkways. Potential applications include a wide spectrum of possible short range passenger movement situations including feeders to transit, as a substitute for AGT, bus, or rail transit under some circumstances, as an airport movement system, as urban land use integrator, and as a vehicle free zone support system. Benefits accruing from AMWS systems include improved transit connectivity, improved pedestrian convenience, security, and safety, upgraded urban land use, reduced pollution and energy use, and improvements in urban quality of life.

17. Key Words Accelerating Moving Walkways, Moving Way Transit, Pedestrians, Passenger Conveyors	18. Distribution Statement Available to the Public through the National Technical Information Service Springfield, Virginia 22161

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Technical Report Documentation Page

1. Report No. UMTA-IT-06-0126-78-5	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle ACCELERATING MOVING WALKWAY SYSTEMS DEVELOPMENT, TESTING, PROCUREMENT		5. Report Date NOV 1978
		6. Performing Organization Code Port Authority of NY & NJ
7. Author(s) Fruin, J.; Marshall, R.; Perilla, O.		8. Performing Organization Report No.
9. Performing Organization Name and Address		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. No. IT-06-0126
12. Sponsoring Agency Name and Address U. S. Department of Transportation Urban Mass Transportation Administration 400 Seventh Street, SW Washington, DC 20590		13. Type of Report and Period Covered
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

Variable speed accelerating walkways are moving way transportation systems resembling conventional escalators and mechanical moving walks, but having the capability by various means to accelerate pedestrians after boarding and to decelerate prior to discharge. An assessment of the current state of the art of accelerating walkway technology indicates that there are five systems at various stages of equipment development and testing. This report outlines a program for bringing qualifying accelerating walkway system developers to common stages of design development for the purpose of providing the basis for selection of one or more candidate suppliers for subsequent phases of manufacturing and testing, and for the final selection of a unit for a public use demonstration. Preliminary performance specifications for an accelerating walkway unit for the demonstration are provided in the report, as well as outlines of program tasks and schedules.

17. Key Words Accelerating Moving Walkways, Performance Specifications, Moving Way Transit, Pedestrians Passenger Conveyors	18. Distribution Statement

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages	22. Price

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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UMTA IT-06-0126-78-6		

4. Title and Subtitle Accelerating Moving Walkway Systems Demonstration Plan (Report F of Project Series)	5. Report Date March 1978 6. Performing Organization Code
7. Author(s) Perilla, O., Marshall, R., Fruin, J.	8. Performing Organization Report No.
9. Performing Organization Name and Address Port Authority of New York and New Jersey One World Trade Center New York, New York 10048	10. Work Unit No. 11. Contract or Grant No. IT-06-0126
12. Sponsoring Agency Name and Address U. S. Department of Transportation Urban Mass Transportation Administration 400 Seventh Street, S. W. Washington, D. C. 20590	13. Type of Report and Period Covered 14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract Accelerating Moving Walkway Systems are an extension of the conventional escalator and moving walkway technology which has enjoyed wide public acceptability for more than 80 years. Although AMWSs resemble conventional technology in design and operation, it will be necessary to evaluate the user acceptability, reliability, maintainability and costs of the new systems before they can be considered for general public use. Currently, five systems are at, or nearing, the hardware prototype stage of development, and have undergone some factory based component testing. Limited user tests to date have been encouraging, but full scale controlled demonstration of a completed system in a representative general use context is required to satisfactorily establish system characteristics.

The objective of the demonstration test program is to provide all the information necessary to establish the practical feasibility of AMWS use in urban settings. The program outlined in this report develops the sequence of steps to carry out a thorough evaluation of the service, human factors, safety, operation and maintenance of a demonstration system, including possible post-demo modifications. The report details the preparatory testing and evaluation work required previous to installation, as well as during the public demonstration. Because of the novelty of the AMWS, the introduction of new operating characteristics, such as acceleration-deceleration of treadway and handrails, the unfamiliarity of the public with its use, and the potential for equipment malfunctions or accidents, the program includes a relatively extensive period of mechanical and controlled use tests prior to opening to the general public.

17. Key Words	18. Distribution Statement
Accelerating Moving Walkways, Moving Way Transit, Passenger Conveyors, Public Service test plan, Public Service Demonstration plan.	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
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1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UMTA IT-06-0126-78-7	PB 287-084/AS	

4. Title and Subtitle	5. Report Date
Accelerating Moving Walkway Systems Safety Seminar Proceedings (Report G of Series)	March 1978
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
9. Performing Organization Name and Address	10. Work Unit No.
Port Authority of New York & New Jersey One World Trade Center New York, New York 10048	11. Contract or Grant No. No. IT-06-0126
12. Sponsoring Agency Name and Address U. S. Department of Transportation Urban Mass Transportation Administration 400 Seventh Street, S. W. Washington, D. C. 20590	13. Type of Report and Period Covered
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

On April 18, 1977 a seminar devoted to the discussion of the safety and human factors associated with the development and public use of accelerating walkway systems was held. Accelerating walkways resemble conventional constant speed moving walkways in appearance, but have the capability through changing treadway position or configuration to accelerate pedestrians to 4 to 5 times the speed of the conventional systems and then to decelerate for exiting. AMWS(s) will introduce several new operating characteristics which may affect the use and acceptance of these systems by the general public, including the elderly and handicapped. The objective of the seminar was to provide a forum for discussion of the potential problems that might be associated with the use of this technology based on its current state-of-the-art. The seminar was attended by more than 50 persons including representatives of the escalator and moving walk industry, AMWS developers, human factors and safety professionals, physically handicapped persons and representatives of government agencies participating in the Accelerating Moving Walkway System study program.

The proceedings of the seminar included presentations illustrating the design details of several AMWS(s) under development, presentations by four consultants dealing with various aspects of AMWS safety, and workshops in which all seminar attendees participated.

17. Key Words	18. Distribution Statement
Accelerating Moving Walkways Moving Way Transit, Pedestrians, Passenger Conveyors, Safety, Human Factors	Available to the Public through the National Technical Information Service Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	81	A05

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Technical Report Documentation Page

1. Report No. UMTA IT-06-0126-82-1	2. Government Accession No. PB 82-218942	3. Recipient's Catalog No.
4. Title and Subtitle Accelerating Walkway Systems Phase II Summary Report		5. Report Date January 1982
		6. Performing Organization Code
7. Author(s) Fruin, J., Marshall, R.		8. Performing Organization Report No.
9. Performing Organization Name and Address Port Authority of New York and New Jersey One World Trade Center New York, New York 10048		10. Work Unit No.
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address U. S. Department of Transportation Urban Mass Transportation Administration 400 Seventh Street, S. W. Washington, D. C. 20590		13. Type of Report and Period Covered
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

The report summarizes the final reports of design development programs by four accelerating walkway developers conducted as part of Phase II of the UMTA Accelerating Walkway System (AWS) Demonstration Program. The four Phase II Contractors are: (1) Ateliers et Chantiers de Bretagne, licensed manufacturer of the TRAX AWS; (2) Dunlop Ltd., manufacturer of the Speedaway AWS; (3) The Boeing Company; and (4) The Dean Research Corporation. Contractor tasks summarized in the report for each of the AWS systems include: Task 1 - Description and Design Details, Task 2 - Safety and Performance, Task 3 - Maintainability and Reliability, Task 4 - Life Cycle Cost Analysis, and Task 5 - Phase III Preliminary Program Implementation Plan.

17. Key Words Accelerating Walkways, Moving Way Transit, Passenger Conveyors, Public Demonstration		18. Distribution Statement Available to the Public through the National Technical Information Service Springfield, Virginia 22161	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 90	22. Price A05

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Technical Report Documentation Page

1. Report No. UMTA IT-06-0126-82-2	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Accelerating Walkway Systems Demonstration Site/Geotechnical Report		5. Report Date April 1982 6. Performing Organization Code
7. Author(s) H. Sitomer, T. Munfakh		8. Performing Organization Report No.
9. Performing Organization Name and Address Port Authority of New York and New Jersey One World Trade Center New York, New York 10048		10. Work Unit No. (TRAIS) 11. Contract or Grant No. IT-06-0126
12. Sponsoring Agency Name and Address U.S. Department of Transportation Urban Mass Transportation Administration 400 7th Street, S.W. Washington, D.C. 20590		13. Type of Report and Period Covered 14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

A demonstration of an Accelerated Walkway System (AWS) at the Hoboken Terminal in New Jersey is part of a phased project to evaluate public acceptance of the system and its potential applications in urban areas. Completed phases of the program include a feasibility study of walkway design and development, its benefits and safety, and an evaluation of equipment operating and cost data.

Preliminary site investigation and engineering studies form the basis of this report. Geotechnical conditions of the region and terminal area were established from known data and subsurface boring data collected at the site in order to recommend a suitable foundation to support the AWS. Soils and rock strata were described in sequence of their occurrence and their geotechnical properties analyzed. Soil samples were obtained and classified; water content was determined for all samples, and consolidation tests were made from undisturbed samples. Estimates were made of the amount of total future settlement of the stratum under the new load. Existing piles and pile supported platforms were examined for potential use as a foundation for the proposed AWS. Three foundation alternatives were evaluated based on test data: independent, continuous spread footings; slab footings supported by existing piles, and existing pavement support. Continuous spread footings were recommended.

17. Key Words Accelerating Moving Walkways, Site Engineering Studies, Geotechnical Report.	18. Distribution Statement		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages	22. Price

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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UMTA-IT-06-0126-83-1		

4. Title and Subtitle Accelerating Walkway Systems Pre-Demonstration User Profile	5. Report Date September 1983 6. Performing Organization Code
7. Author(s) Cohen, S.; Botzow, H.	8. Performing Organization Report No.
9. Performing Organization Name and Address Port Authority of New York and New Jersey One World Trade Center New York, New York 10048	10. Work Unit No. (TRAIS) 11. Contract or Grant No. No. IT-06-0126
12. Sponsoring Agency Name and Address U.S. Department of Transportation Urban Mass Transportation Administration 400 Seventh Street, S.W. Washington, D. C. 20590	13. Type of Report and Period Covered 14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

The Accelerating Walkway Systems (AWS) demonstration program was designed to test the feasibility of operating AWS systems in urban transportation. Based on the feasibility studies performed in Phase I of the program, the connection between the NJ Transit commuter railroad station and the westend mezzanine level of the Port Authority Trans-Hudson (PATH) station in Hoboken, New Jersey was selected for a demonstration of AWS technology. An AWS at this location would be used by passengers to speed transfer between the two services. Potential usage of an AWS in this location was analyzed, utilizing data from PATH turnstile counts and a PATH origin and destination survey. Ridership levels for an AWS at the Hoboken test site were predicted, and travel time savings due to the AWS installation were determined.

17. Key Words	18. Distribution Statement
Accelerating Walkways, Hoboken Terminal, Moving Way Transit, Pedestrians, Passenger Conveyors, User Profile	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
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1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UMTA IT-06-0126-83-2	PB 84-198415	

4. Title and Subtitle	5. Report Date
Accelerating Walkway System Hoboken Rail Terminal Demonstration Site Engineering Report	December 1983
	6. Performing Organization Code
	8. Performing Organization Report No.
7. Author(s) A Morrison, G. Hobbins, J. Paratore	
9. Performing Organization Name and Address Port Authority of New York and New Jersey One World Trade Center New York, NY 10048	10. Work Unit No. (TRAIS)
	11. Contract or Grant No. IT-06-0126
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address U.S. Department of Transportation Urban Mass Transportation Administration 400 Seventh Street, S.W. Washington, D.C. 20590	14. Sponsoring Agency Code URT-42

15. Supplementary Notes

Drawings executed by G. Astudillo and J. Barbariantz

16. Abstract

The Accelerating Walkway System (AWS) Demonstration Program was designed to test the feasibility of operating such a system in an urban setting. The New Jersey Transit commuter railroad station at Hoboken, New Jersey was selected as the demonstration site. Completed phases of the program include feasibility studies; AWS design and development, including preliminary site investigation and site engineering studies; and the award of a contract for the manufacture of the system. A series of equipment and user tests initiated in March 1983 is also nearing completion.

This report describes the program of site engineering work planned by the Port Authority's Engineering Department in preparation for the installation and operation of the AWS system, including the excavation, equipment, foundation design, installation, and site restoration plans, as well as related cost, scheduling, and specifications data.

During the preparation of this report, the proposed Hoboken demonstration was cancelled. However, this report is written assuming that the demonstration site was still being planned.

17. Key Words	18. Distribution Statement
Accelerating walkways; site engineering; site engineering report; urban transportation; pedestrian movers; people movers	Available to the public through the National Technical Information Service, Springfield, Va. 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	109	A07

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Descriptions of Accelerating Walkways Systems Evaluated in Program

A. Applied Physics Laboratory (APL)

This variable speed walkway design is a linear, one-directional system with a treadway composed of intermeshing leaves that comb each other, and pass through a conventional combplate at entry and exit. The leaves are supported by a track and linked together to form an endless chain. Acceleration and deceleration is controlled by a variable pitch screw beneath the treadway. The screw pitch changes the leaf angle to expand the treadway surface for acceleration, and contract it for deceleration. The handrail concept is a covered coil spring synchronized with the movement of the treadway. A 31 ft. long (9.4 m.) 18 in. wide (457 mm.) laboratory prototype of the system treadway is shown on Appendix Figure A-1.

B. Boeing Company

The Boeing design is a two-directional loop system with a continuous treadway composed of overlapping, intermeshing, sliding pallets combing each other and combed at entry and exit. The matching speed handrail design employs overlapping sections to form a telescoping variable speed handrail. Photographs of the prototype treadway and handrail are shown on Appendix Figure A-2.

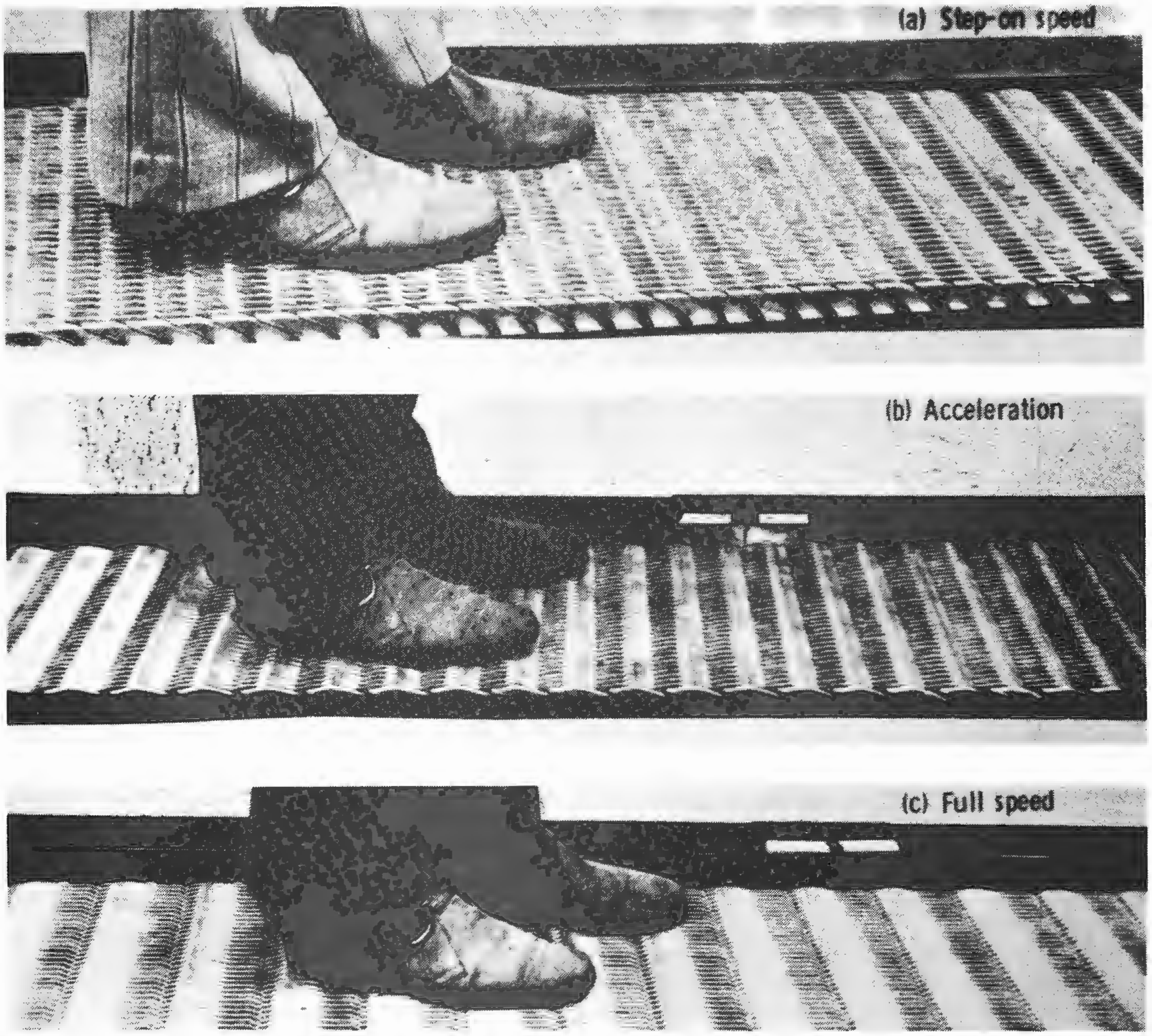
C. Dean Research

The Dean design is a linear, one-directional system utilizing a treadway surface composed of a series of abutting steel rollers. The speed of the steel rollers is programmed to gradually accelerate passengers as they enter the system and decelerate them at the exit. No operational handrail design was developed. A photo of 60 ft. (18 m.) prototype is shown on Figure A-3.

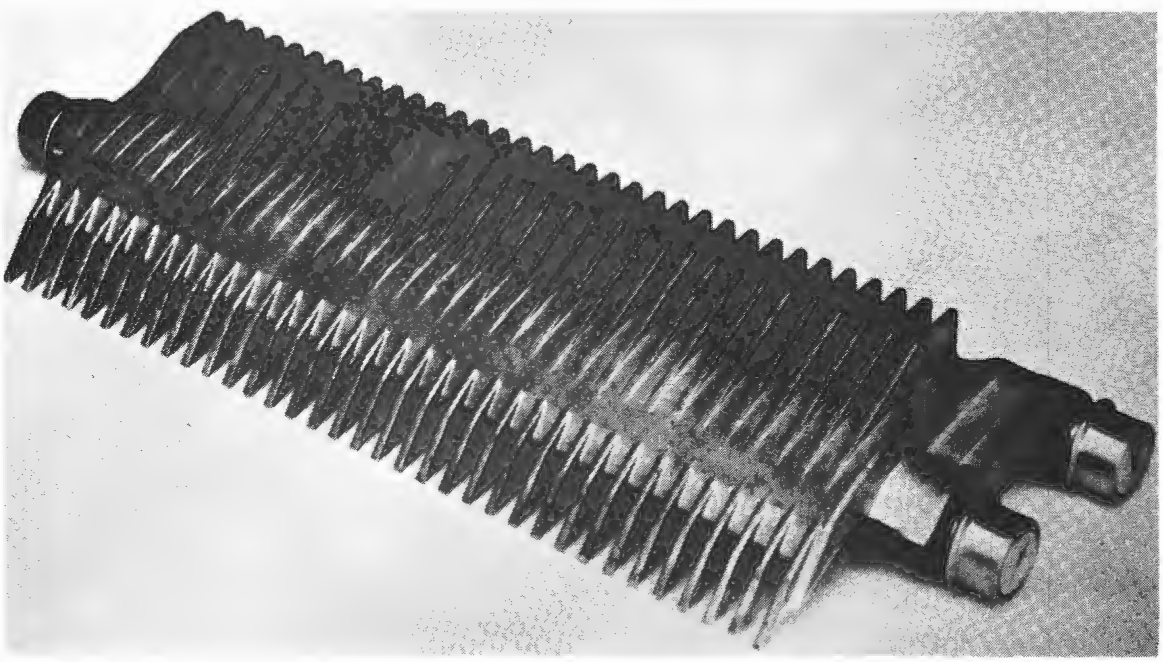
D. Dunlop Speedaway

The Dunlop Speedaway is a one-directional design resembling a horizontal escalator but with a much wider entrance and exit. This system prototype was more advanced in development than others discussed in this section, having undergone passenger acceptance and running tests. The Dunlop treadway consists of rectangular pallets operating at normal escalator speeds of 90-120 fpm (0.45-0.6 mps) at entry, and then accelerated laterally up to five times the boarding speed. This combination of transverse and longitudinal speeds produces a curved, S-shaped path for the pallets which are supported by rollers running in guide tracks. The speed ratio and acceleration and deceleration rates determine the geometric shape of the platforms, the width of guideway tracks, and dimensions of the entry and exit sections of the system. The Speedaway handrail design consists of seven constant speed sections operating at speeds averaged to that of each adjacent walk section. The Dunlop system is the only AWS utilizing a nonchanging tread like an escalator. Photos of Speedaway production unit are shown on Figure A-4.

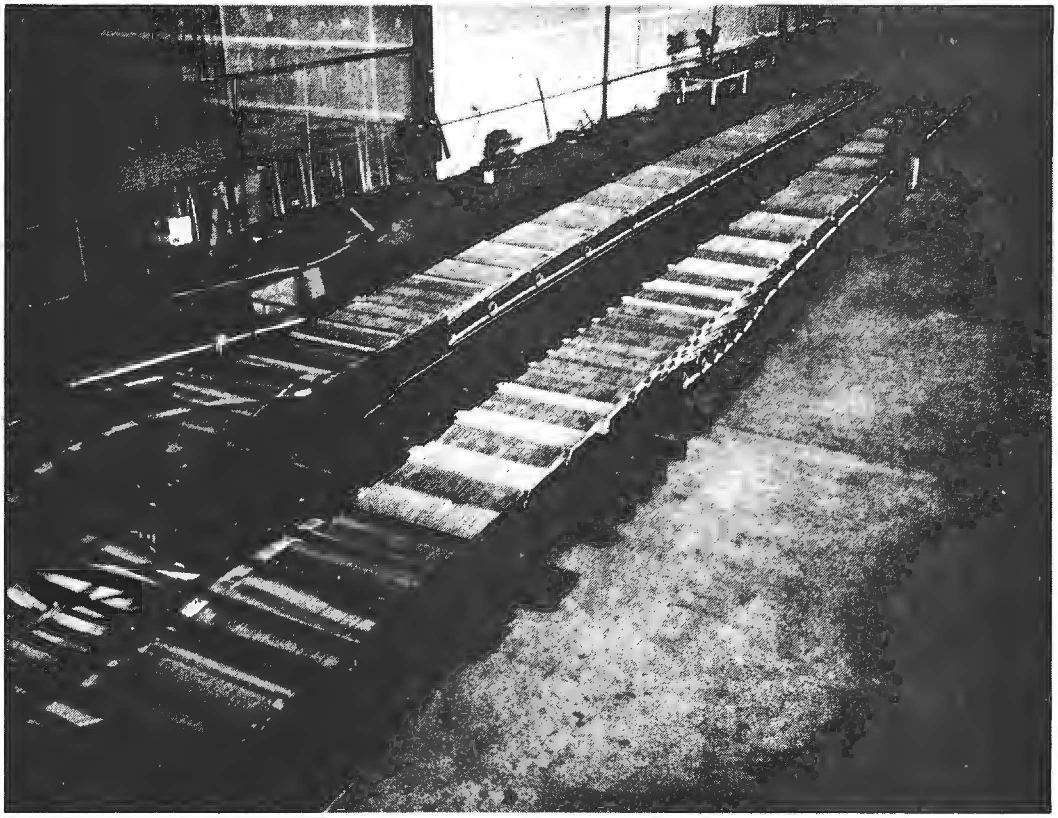
FIGURE A-1

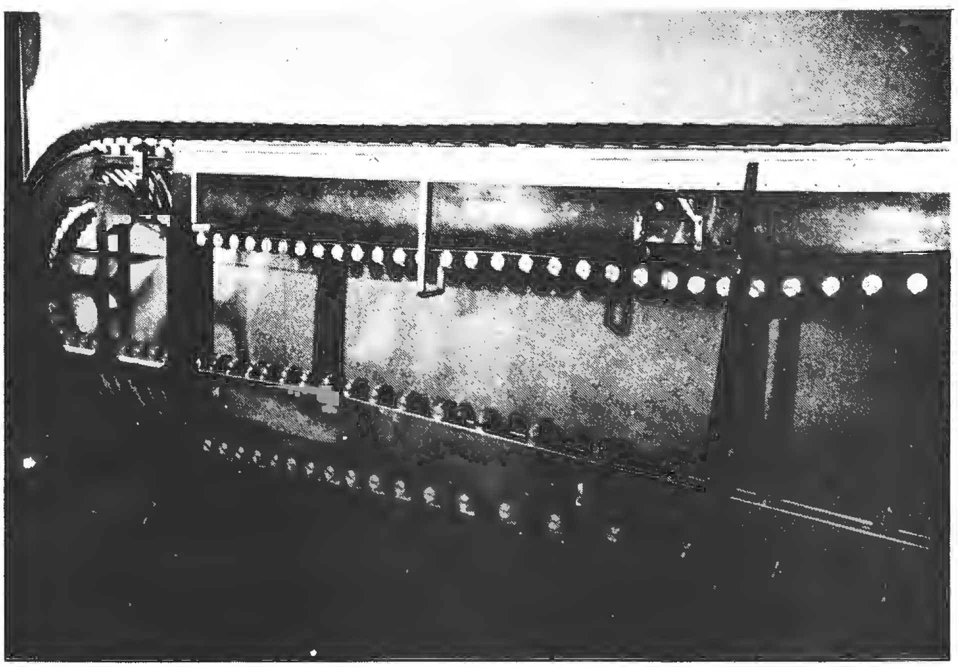


TREADWAY SURFACE. (a) STEP ON SPEED (b) ACCELERATION SECTION (c) CONSTANT HIGH SPEED SECTION.



BASIC LEAF AND LEAF DETAIL.

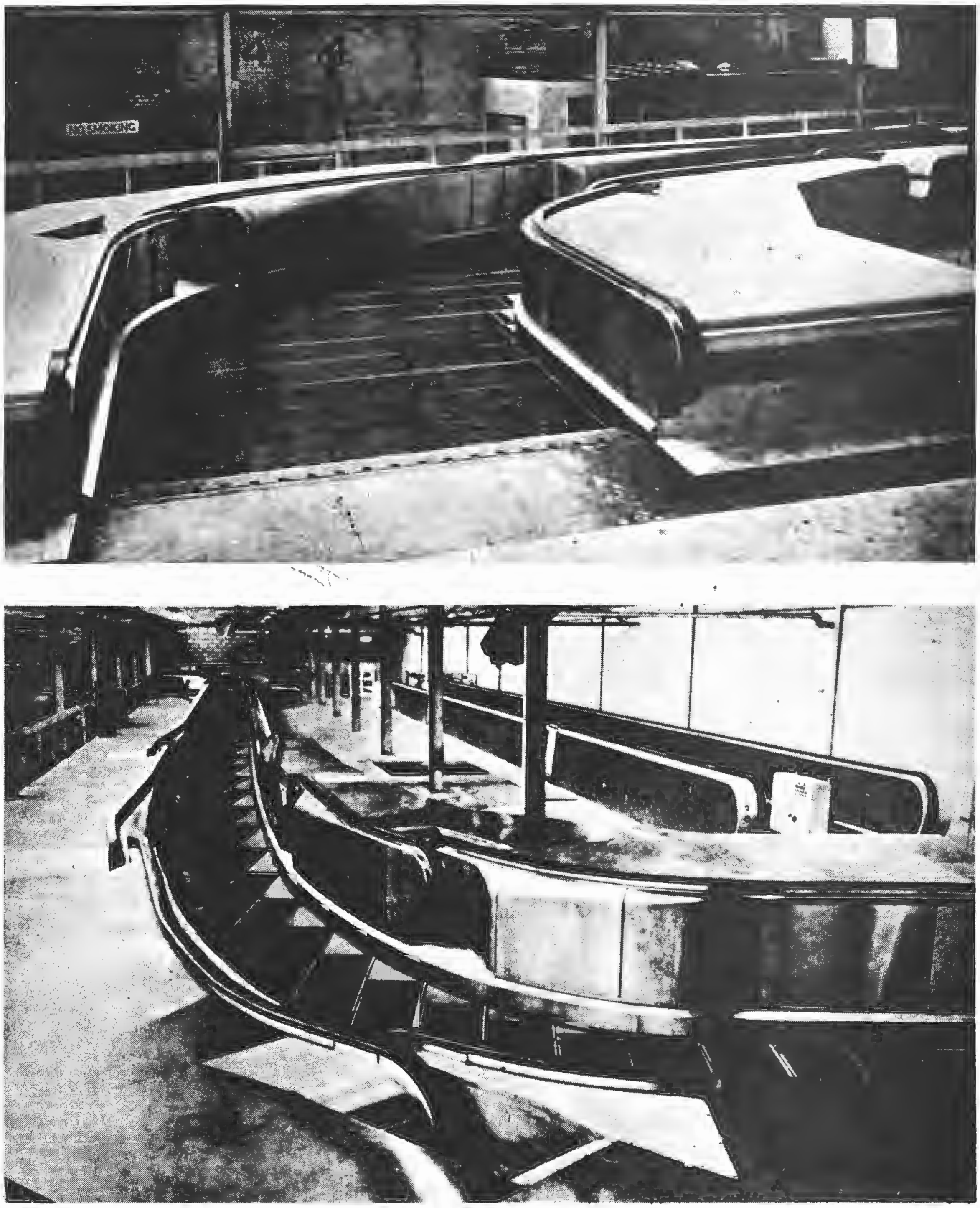




THE BOEING COMPANY AWS
(Upper-treadway, lower-handrail)

FIGURE A-3

DEAN RESEARCH AWS
60' PROTOTYPE



DUNLOP SPEEDAWAY AWS