LAX

CITY OF LOS ANGELES

DEPARTMENT OF AIRPORTS

LOS ANGELES INTERNATIONAL AIRPORT EXPANSION PROGRAM

INTRA-AIRPORT TRANSIT SYSTEM STUDY
PHASE II - PART A

DECEMBER 1968

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LOS ANGELES

INTRA-AIRPORT TRANSIT SYSTEM

STUDY

PHASE II – PART A

ENGINEERING REPORT

FOR

LOS ANGELES DEPARTMENT OF AIRPORTS

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PREFACE

While the Los Angeles International Airport is recognized as one of the world's most modern and progressive airports, its facilities are already overtaxed. Passenger and baggage facilities, cargo handling and ground transportation— all parts of the airport complex—require development of new concepts to accommodate the unprecedented growth of commercial aviation.

The Los Angeles Department of Airports and the Airport Commission have initiated a Master Plan to guide creation of the required super airport. A planned capital expenditure of $410 million will allow for increasing runway capacity, expanding satellite terminals, enlarging cargo facilities, constructing underground terminals, and increasing the airport's capacity for handling automobiles.

Studies already conducted under the Master Plan show that it is the ground access to the airport that will determine its ultimate capacity. Additional studies have concluded that increasing the present parking area in the central terminal complex would only add to existing traffic congestion. It is therefore planned that new parking lots, located on the periphery of the airport, provide the necessary expansion.

Because these new parking areas will be widely separated from each other and from the central terminal area, a grade-separated, automatic intra-airport transit system is needed to transport passengers, visitors, baggage, airport employees, mail and airfreight. Such a system does not exist today at any airport.

A four-phase design and construction program has therefore been created under the Master Plan to establish the required intra-airport transit system. The first phase, Program Definition, defined the system objectives, policies, transit requirements, and prepared preliminary criteria for presentation to the manufacturers. Phases III and IV will include system procurement, and construction and operation.

This report presents the results of the first part of Phase II: an analysis of the types of transit systems available, an evaluation of the manufacturers who can build them, and a selection of the recommended system including route alignment, anticipated levels of service, and order-of-magnitude cost estimates. Based on these data, the preparation of detail requirements and performance specifications will conclude Phase II.

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SUMMARY AND CONCLUSIONS

ESTIMATED COST OF THREE PHASE SYSTEM IS $125,200,000

Analysis of types of transit systems shows a feasible system that meets established criteria. The estimated order-of-magnitude cost for implementation of the selected system is $125,200,000 for the first three phases.

In April 1968, 23 firms attended an industry briefing and accepted criteria which would enable them to propose systems and concepts to fulfill the Los Angeles intra-airport transit system requirements. These proposals were requested for the purpose of analyzing transit equipment, and evaluating the experience, capabilities and excellence of concept of the organizations. Eighteen manufacturers and developers of transit equipment responded by indicating interest in the project and presented engineering concepts and data on their systems.

ANALYSIS

The engineering and operational data presented by the 18 respondent firms are classified according to 12 characteristics. The concepts of two systems are insufficiently developed for inclusion in the analysis. Sixteen systems as represented by these organizations, are divided into two categories, "A" and "B," because of basic similarities. ("A" systems are adaptations of existing urban rapid transit systems – "B" systems would utilize smaller vehicles to offer more personal accommodations with direct travel from origin to destination, and therefore would make use of new and emerging technologies.

An evaluation of the organizations in terms of experience, capabilities and excellence of concept shows that five firms are capable of providing an adequate "A" system, while a "B" system of adequate capacity will not be available for about a decade. Further, the "A" system meets all the other requirements of capacity, safety, comfort and convenience. It is therefore recommended that the "A" transit system be implemented.

IMPLEMENTATION PHASES

Approximately 10.6 miles of route alignment, to be implemented in three phases, are planned to connect 12 passenger stations in the central terminal with 18 stations in five peripheral parking lots. Phase I provides one loop connecting the central terminals, another loop within Parking Lot No. 2, and a connecting route along Century and Aviation Boulevards. The route alignment profile from the central loop to the parking lot and around the parking lot loop is part aerial, part at grade and part below grade. During implementation, Phase I, six intra-airport transit stations will be constructed around the central loop. The Phase I route alignment profile around the central loop is level except for a gentle rise to clear the Century Boulevard overcrossing at Sepulveda Boulevard.

Implementation Phases II-A, II-B, III-A, III-B, and IV will complete the system. Implementation Phase II-A adds two new stations in new Terminal 1, an aerial route along Sepulveda Bouldvard and four at-grade stations in Parking Lot No. 3; Implementation Phase II-B connects four stations in the new underground west terminal to Parking Lot No. 4 and to the central terminal loop; and Implementation Phase III-A and III-B connects two parking lots near the ocean to the new west terminal. Due to the very preliminary planning being conducted on Phase IV at this time route definition and cost estimates for Phase IV have not been developed in this report.

PERFORMANCE AND SERVICE

The selected system is capable of providing a very high level of service. Passing routes enable vehicles to proceed directly from origin to destination. Schedules will optimize system performance based on expected patronage; then a centralized control system will make schedule changes to compensate for differences between expected and actual patronage.

Travel times for all routes between parking lot stations and terminal stations range from just over 1 minute to about 10 minutes; the expected waiting time at any station ranges from 2-1/2 to 4-1/2 minutes. Between those stations implemented in Phase I and any station in the central terminal loop, the travel time variation is 4.3 to 10.4 minutes. The capacity requirements between Parking Lots No. 2, 3, and 4 combined, and the central terminal loop, are for 26,400 people. Ninety-two passenger vehicles and 33 baggage vehicles are required to serve this design capacity.

ESTIMATE OF COSTS

The total capital costs required to implement each phase have been estimated and are shown in the following summary tabulation. All estimated costs are classified as order-of-magnitude because of the limited nature of the study. They are based on construction costs for a Type "A" system having potential application to the intra-airport transit system and are included in the report for feasibility evaluation of the system concept.

Phase I	$ [redacted]
Phase II-A	[redacted]
Phase II-B	[redacted]
Phase III-A	[redacted]
Phase III-B	[redacted]
Total	[redacted]

CONCLUSIONS

Based on the analysis and route studies conducted the following conclusions are presented:

1. The Type "A" systems can be furnished and installed within the criteria and the operational date of 1972. Based on the reivew of Type "A" systems five organizations appear to be qualified and could install such a system.

2. The small personalized vehicle systems designated as Type "B" must undergo considerable research and development before they are capable of safe reliable operation. It is estimated that these systems will not be fully developed until 1978 to 1980.

3. The alignment selected for the system is predominantly above ground. In the parking lots the system is at grade. Generally from the lots into the airline terminal area the system will be on aerial structures. Some below ground construction will be required at runway, and road crossings and the West Terminal. Overhead alignment was selected because it provides the necessary grade separation at the lowest first cost.

4. In order to provide the most efficient transit service during the peak periods it is essential that management of vehicles and people be accomplished at the parking lots. This is best done by assigning station platforms and parking areas to an airline or combination of airlines. This will result in the simplest and most direct routing of trains.

5. The intra-airport system concept makes use of clear zones for parking areas and stations. Discussions have been held with the Federal Aviation Administration regarding the use of these areas. In order to arrive at a clear-cut policy decision it is concluded that planned use of the clear zones should continue with technical effort directed toward definition and isolation of electromagnetic interference and continued discussions with the FAA.

SECTION 2
ANALYSIS

PRELIMINARY TECHNICAL CRITERIA WERE PRESENTED TO INDUSTRY

Twenty-three firms attended an industry briefing and accepted criteria which would enable them to propose systems and concepts to fulfill the intra-airport transit requirements.

On April 26, 1968, the Los Angeles Department of Airports held an industry briefing to describe intra-airport transit requirements and plans to manufacturers and developers of transit equipment. Preliminary technical criteria were presented to representatives of approximately 23 organizations. The organizations were asked to evaluate the requirements and develop generalized, preliminary engineering concepts which would satisfy the transit requirements. The concepts were requested for the purpose of analyzing available and emerging transit equipment and the organizations which offer them. The analyses were planned to accomplish two objectives:

1. Select a system that is capable of providing safe, reliable, fully operational adequate capacity service by late 1971 or early 1972.

2. Select the system concept that offers the highest level of personalized transit service, without the time schedule constraint.

Some of the criteria were offered as general guidelines to assist organizations in developing proposed systems; however, those criteria listed in italics were specified as definite and inflexible. Parts of the criteria were reconsidered and some were modified as the study progressed (for example, capacity requirements were approximately doubled). Nevertheless all information received from industry were based on these criteria, summarized on the facing page.

TABLE 1. SUMMARY OF PRELIMINARY TECHNICAL CRITERIA

Functional Criteria

System must handle passenger, baggage, and cargo in varying quantities and relationships

Hold passenger walking distances to a minimum

Keep interfaces and transfers to a minimum

Be compatible with interfacing transportation modes

Keep system simple and flexible

Operational Criteria

Operate on a 24-hour basis

Have high operational flexibility

Be capable of accomodating wide range of schedule frequencies

Be relatively maintenance free

Be capable of future expansion

Provide facilities for checking baggage at the remote parking lots

Provide capability for future installation of fare equipment

System Design Capacity

Rated Capacity: 5,000 seated passengers per hour one way

Overload capacity: double-rated capacity

Environmental Criteria

Be capable of operating under all weather conditions

Be quiet in operation

Do not exceed established levels of air pollution

Be aesthetically acceptable

Do not cause electrical interference with airport or aircraft operations

Maintain comfortable car temperature

Vehicle Requirements

Seating capacity: range of two to 30 passengers per car

Baggage and cargo capability: may be carried in separate vehicles

Accommodate small size carry-on baggage

Dimensional Criteria

Modular car size: 8 ft by 8 ft (exclusive of running gear), by 10-ft, 20-ft, 30-ft and 40-ft lengths

Turning radius: 150-ft minimum

Performance Criteria

Speed range: 45 mph maximum

Acceleration (or deceleration): 3 mph per second maximum

Jerk: 1½ mph per second/second

Grade: 4% desired, 6% maximum

Car load capacity (rated maximum): passenger – 6,000 lb. cargo – 6,000 lb.

Control and Communications

Automatic operation

Safe operation

Fail-safe system design

Two-way voice communication

Centralized system management

TRANSIT TECHNOLOGIES AND SYSTEM TYPES ARE ANALYZED

Engineering and operational data presented by 18 manufacturers and developers of transit equipment are classified in 12 categories for analysis. Sixteen systems are classified into two types, designated as "A" and "B"; versions of the two types are designated by numbers. The concepts of two systems are insufficiently developed for inclusion in the analysis.

TRANSIT SYSTEM CHARACTERISTICS

Type "A"

Is an adaptation of urban rapid transit systems

Employs proved, safe, reliable devices and methods

Embodies technological improvements that have been added through an evolutionary process rather than by revolutionary developments

Assembles passengers into variable length trains of vehicles having capacities of at least 30 passengers per vehicle

Provides seats for normal passenger capacities, plus additional standing space.

Type "B"

Offers a high level of personal services in terms of private accommodation and direct travel from origin to destination

Carries passengers in small vehicles not connected into trains

Provides for all passengers to be seated

Offers higher acceleration and deceleration rates than would be comfortable for standees

Provides for vehicles to operate with closer time-distance separation than those commonly employed in the "A" system

Makes use of new and emerging technologies

TABLE 2. TRANSIT SYSTEM CHARACTERISTICS

SYSTEM CLASSIFICATION	OPERATION	VEHICLE SEATS	STANDEES	MAX SPEED (MPH)	NO. PER TRAIN	SUSPENDED OR SUPPORTED	RUNNING WHEELS	GUIDEWAY	SWITCHING	PROPULSION	SYSTEM CONTROL	BRIEFING EMPHASIS
A-1	MULTIPLE STOP STATIC LOADING TRANSFERS	30	20	20	1-6	SUSPENDED SUPPORTED	NOT SPECIFIED	MONORAIL/ DUAL RAIL	MAINTENANCE ONLY	ROTARY MOTOR WITH POWER PICKUP	NOT SPECIFIED	MULTIPLE SYSTEM [illegible] Transfer
A-2	MULTIPLE STOP STATIC LOADING TRANSFERS	30	NOT SPECIFIED	25	1-5	SUPPORTED	FLANGED STEEL WHEELS	DUAL RAILS	CONVENTIONAL SPLIT SWITCH	ROTARY MOTOR WITH POWER PICKUP Considering Linear Motor & Flywheel	CENTRAL COMPUTER SUPERVISION	PROVEN TECHNIQUES UNDERGROUND SYSTEM
A-3	MULTIPLE STOP STATIC LOADING TRANSFERS	30	NOT SPECIFIED	40	2-3	SUPPORTED	RUBBER TIRES	HORIZONTAL GUIDE WHEELS	MAINTENANCE ONLY	ROTARY MOTOR WITH POWER PICKUP	NOT SPECIFIED	RELIABILITY SIMPLICITY
A-4	MULTIPLE STOP STATIC LOADING TRANSFERS	40	NOT SPECIFIED	60	NOT SPECIFIED	SUSPENDED	RUBBER TIRES	HORIZONTAL GUIDE WHEELS	IN BEAMWAY	ROTARY MOTOR WITH POWER PICKUP	CENTRAL COMPUTER SUPERVISION	Requested Study Program
A-5	MULTIPLE STOP STATIC LOADING TRANSFERS	28	NOT SPECIFIED	25	NOT SPECIFIED	SUSPENDED	RUBBER TIRES	HORIZONTAL GUIDE WHEELS	FLEXIBLE BEAM	ROTARY MOTOR WITH POWER PICKUP	CLOSED CIRCUIT TV MONITORING	LIGHTWEIGHT VEHICLES
A-6	MULTIPLE STOP STATIC LOADING TRANSFERS	30	30	45	ONE	SUPPORTED	STEEL WHEELS (4)	DUAL RAILS	CONVENTIONAL SPLIT SWITCH	ROTARY MOTOR WITH POWER PICKUP	CENTRAL COMPUTER SUPERVISION	AVAILABILITY RELIABILITY
A-7	SELECTIVE OD STATIC LOADING	6-8	8-22	20	ONE	SUSPENDED/ SUPPORTED	RUBBER TIRES	RUNNING WHEELS BOTH SIDE OF "I" BEAMFLANGE	IN BEAM	ROTARY MOTOR WITH POWER PICKUP	PREPROGRAMED ELECTRICAL CONTROL SYSTEM	DESIGN AND OPERATIONAL FLEXIBILITY
A-8	MULTIPLE STOP STATIC LOADING TRANSFERS	37-50	NOT SPECIFIED	45	1-4	SUPPORTED	RUBBER TIRES	HORIZONTAL GUIDE WHEELS	IN VEHICLE	ROTARY MOTOR WITH POWER PICKUP	CENTRAL COMPUTER SUPERVISION	CONVENTIONAL APPROACH RELIABILITY
A-9	MULTIPLE STOP STATIC LOADING TRANSFERS	16	18	50	2-8	SUPPORTED	RUBBER TIRES	HORIZONTAL GUIDE WHEELS	IN ROADWAY	ROTARY MOTOR WITH POWER PICKUP	CENTRAL COMPUTER SUPERVISION	DEVELOPED CONCEPT Requested Study Program
B-1	SELECTIVE OD STATIC LOADING	2-6	0	20	ONE	SUSPENDED	CONVEYOR	BELT OR CHAIN	AIR-SUPPORT LIFT AND CONVEYOR TRANSFER	MOTOR DRIVEN CONVEYOR	NOT SPECIFIED	AIR SWITCHING CONCEPT
B-2	SELECTIVE OD DYNAMIC/STATIC LOADING DUAL MODE	2-12	0	40	ONE	SUPPORTED	RUBBER TIRES	GUIDEWAY/MANUAL STEERING	IN VEHICLE Synthetic-Fibre Push In Either of Two Channels	ROTRAY MOTOR WITH POWER PICKUP	COMPLEX CENTRAL COMPUTER SYSTEM	DUAL MODE OD CONCEPT COMPUTER CONTROL
B-3	MULTIPLE STOP STATIC LOADING TRANSFERS	12	0	30	6-20	SUPPORTED	STEEL WHEELS ABOVE & BELOW STEEL RAILS	HORIZONTAL GUIDE WHEELS	VERTICAL OR HORIZONTAL IN ROADWAY	ROTARY MOTOR WITH POWER PICKUP	PREPROGRAMED ELECTRO MECHANICAL AND MONITORING	MECHANICAL CONCEPT MATERIAL HANDLING CAPABILITY
B-4	SELECTIVE OD STATIC LOADING	4	0	60	ONE	SUPPORTED	NOT SPECIFIED	NOT SPECIFIED	IN VEHICLE	LINEAR MOTOR	COMPLEX CENTRAL COMPUTER SYSTEM	OD CONCEPT LINEAR MOTOR COMPUTER CONTROL
B-5	SELECTIVE OD STATIC LOADING	6	6	20	ONE	SUPPORTED	RUBBER TIRES	HORIZONTAL GUIDE WHEELS	NOT SPECIFIED	LINEAR SYNCHRONOUS MOTOR BEING DEVELOPED	COMPLEX CENTRAL COMPUTER SYSTEM	OD CONCEPT COMPUTER CONTROL
B-6	SELECTIVE OD STATIC LOADING	4	0	45	ONE	SUPPORTED	AIR CUSHION	AIR CUSHION IN GUIDEWAY	LINEAR MOTOR Lateral Movement at Station	LINEAR MOTOR IN ROADWAY OR IN VEHICLES	COMPLEX CENTRAL COMPUTER SYSTEM	AIR-BEARING SUSPENSION LINEAR MOTOR OD CONCEPT
B-7	CONTINUOUS MOVING DYNAMIC LOADING	4	0	12	4	SUPPORTED	PLASTIC WHEELS	IN SUPPORT RAILS	MAINTENANCE ONLY	ROTARY MOTORS IN ROADWAY Testing Linear Motor	OPERATOR MONITORED AT STATIONS	LICENSING ARRANGEMENT PEOPLE-MOVING EXPERIENCE

ORGANIZATIONS ARE EVALUATED IN TERMS OF EXPERIENCE, CAPABILITIES AND EXCELLENCE OF CONCEPT

Analysis shows that at least five organizations are capable of providing an adequate "A" system. A "B" system of adequate capacity will not be available for about a decade.

All 16 organizations were evaluated in terms of the experience and capability categories which are described below and also with respect to the excellence of their system concept. These evaluations, included on the facing page, show which organizations are rated "high", "medium" or "low" in each category.

Four organizations rate "high" in all eight of the categories, and one other organization rates "high" in five categories. The analysis therefore indicates that at least four organizations are highly qualified and another is adequately qualified to furnish an "A" system that will satisfy capacity and schedule requirements.

Four other organizations, each of which is rated "high" in four experience and capability categories, are reasonably well qualified to satisfy the requirements and criteria. Although two of these companies specialize in the "B" system, all four can become fully responsive bidders for an "A" system by supplementing their qualifications or joining forces with other organizations.

Analysis of the transit system concepts shows that the group of organizations which is developing the concepts, in terms of potential to provide the highest level of passenger service, is mutually exclusive from the group qualified to meet the specified requirements by 1972.

The analysis indicates that because of required development time, a "B" system of adequate capacity could not be fully demonstrated and operational for approximately 10 years. Appendix 1 quotes portions of a U.S. Housing and Urban Department development report that coincides with this conclusion.

The overall analysis indicates existance of at least a sufficient quantity of responsive bidders to make competitive procurement of an "A" system feasible. The analysis does not predict a maximum number of qualified organizations, or identify potentially responsive bidders.

EXPERIENCE AND CAPABILITY CATEGORIES

Manufacturing Experience—Relative duration and extent of experience in manufacturing transit equipment

Engineering Experience—Relative experience in engineering design of transit equipment

Operational Experience—Experience in operational aspects of transit equipment

Systems Experience—Extent of experience in assembling transit devices into operational subsystems and systems

R & D Experience—Relative depth and duration of research and development experience in transit devices and methods

Schedule Compliance—Appraisal, based on experience, of ability to fulfill a restrictive transit system construction and startup schedule

Technical Status—Status of development in transit technology, ranging through experimental, developmental and qualified stages

Overall Capability—Overall appraisal of ability to fulfill intra-airport transit system requirements

System Concept—Excellence of transit system method and equipment with respect to offering a high level of passenger service

TABLE 3. ANALYSIS OF ORGANIZATION

ORGANIZATION CLASSIFICATION	MANUFACTURING EXPERIENCE	ENGINEERING EXPERIENCE	OPERATIONAL EXPERIENCE	SYSTEMS EXPERIENCE	R & D EXPERIENCE	SCHEDULE COMPLIANCE	TECHNICAL STATUS	OVERALL CAPABILITY	SYSTEM CONCEPT
A-1	HIGH	HIGH	HIGH	HIGH	MEDIUM	MEDIUM	MEDIUM	MEDIUM	LOW
A-2	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	MEDIUM
A-3	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	MEDIUM
A-4	HIGH	HIGH	MEDIUM	MEDIUM	HIGH	MEDIUM	MEDIUM	HIGH	MEDIUM
A-5	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM	LOW	LOW
A-6	HIGH	HIGH	MEDIUM	LOW	HIGH	HIGH	HIGH	HIGH	MEDIUM
A-7	MEDIUM	MEDIUM	LOW	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM
A-8	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	MEDIUM
A-9	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	MEDIUM
B-1	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	MEDIUM
B-2	MEDIUM	MEDIUM	MEDIUM	MEDIUM	HIGH	LOW	MEDIUM	MEDIUM	HIGH
B-3	HIGH	HIGH	MEDIUM	MEDIUM	HIGH	MEDIUM	MEDIUM	HIGH	MEDIUM
B-4	MEDIUM	MEDIUM	LOW	LOW	MEDIUM	LOW	LOW	MEDIUM	HIGH
B-5	MEDIUM	LOW	LOW	LOW	MEDIUM	LOW	LOW	HIGH	HIGH
B-6	LOW	LOW	LOW	LOW	HIGH	LOW	LOW	MEDIUM	HIGH
B-7	HIGH	HIGH	HIGH	HIGH	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM

THE "A" TRANSIT SYSTEM IS SELECTED

The "A" transit system, selected by the analysis process, meets all requirements of availability, capacity, safety, comfort and convenience.

AVAILABILITY

The "A" system is capable of being furnished by any one of several qualified manufacturing companies or combinations of companies. The system can be made fully operational in accordance with construction master plans.

CAPACITY

The system has adequate capacity to carry maximum passenger volumes predicted for the future. It provides for baggage to be transported in separate, special vehicles, or to be carried in passenger vehicles, depending on passenger preference and circumstances. It also carries containerized airfreight and mail in specially designed vehicles.

SAFETY

A very high level of passenger safety is provided by the use of methods and devices, i.e., switches, propulsion and controls, that have been demonstrated and proved. Highest levels of reliability available in today's most advanced technologies, combined with fail-safe design methods guard continuously against injury or damage.

COMFORT AND CONVENIENCE

The selected system transports passengers with a level of comfort very much like that of the airlines. Although the selected system uses technologies developed for urban transit systems, improvements in design provide much better levels of riding smoothness and quietness. Automatic train control makes speed changes smooth and gentle.

Vehicles offer comfortable seating for rated volumes of passengers and additional room for other passengers to stand during periods of high-volume usage. Large door areas allow easy passage to and from the vehicles. Visual and audio aids clearly inform passengers about schedules and destinations. Passengers will find the automatic equipment as easy to operate as automatic elevators.

Centralized computer control, combined with high-speed data communications, continually optimize movement and scheduling of vehicles to minimize travel times and waiting periods.

Route alignments, way structures and station arrangements for the "A" system will be suitable for adaptation of new technologies being developed for future transit systems.

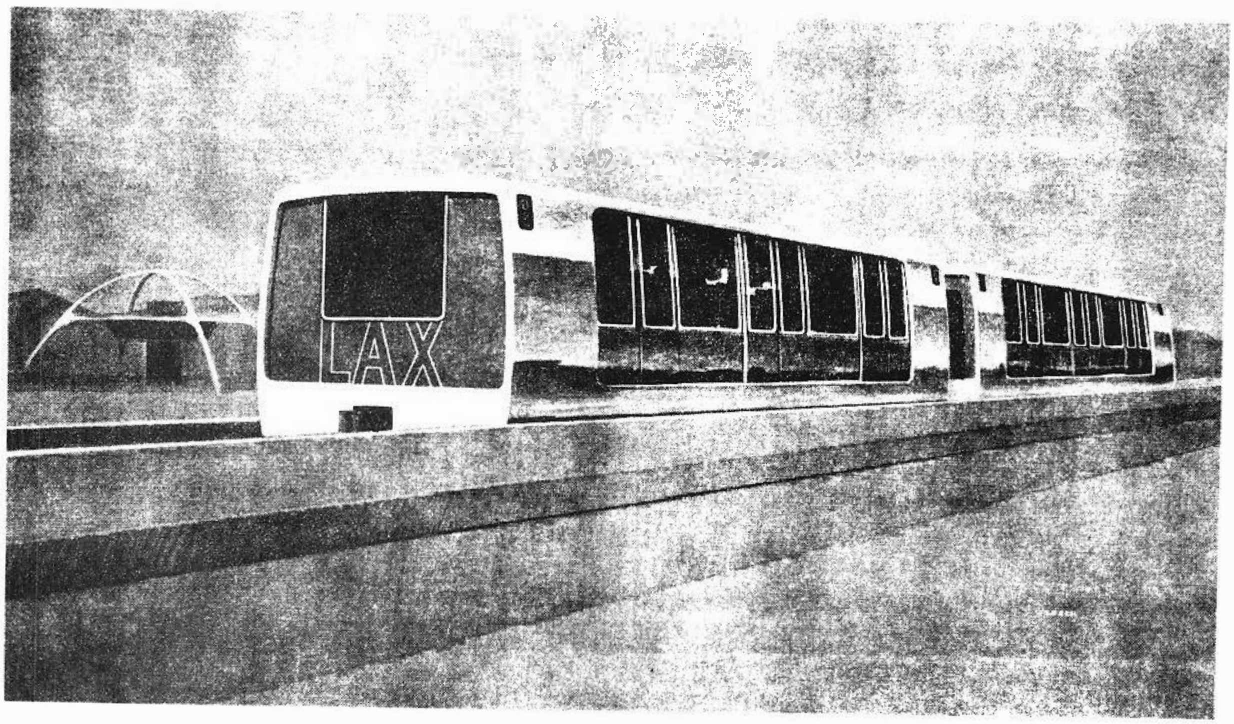


FIGURE 1. CONCEPTUAL ILLUSTRATION OF SELECTED SYSTEM

SECTION 3

IMPLEMENTATION PHASES

ROUTES ARE PLANNED TO CONNECT CENTRAL TERMINAL COMPLEX WITH FIVE PERIPHERAL PARKING LOTS

Approximately 10.6 miles of route alignment, to be implemented in three phases, will connect 12 central terminal passenger stations with 18 stations in five peripheral parking lots.

The route alignment drawing on the facing page shows the overall configuration of the planned intra-airport transit system. Routes from Parking Lots No. 2 and 3 connect to the east end of the central terminal complex and routes from Parking Lots No. 4, 5 and 6 connect to the west end of the central terminal complex.

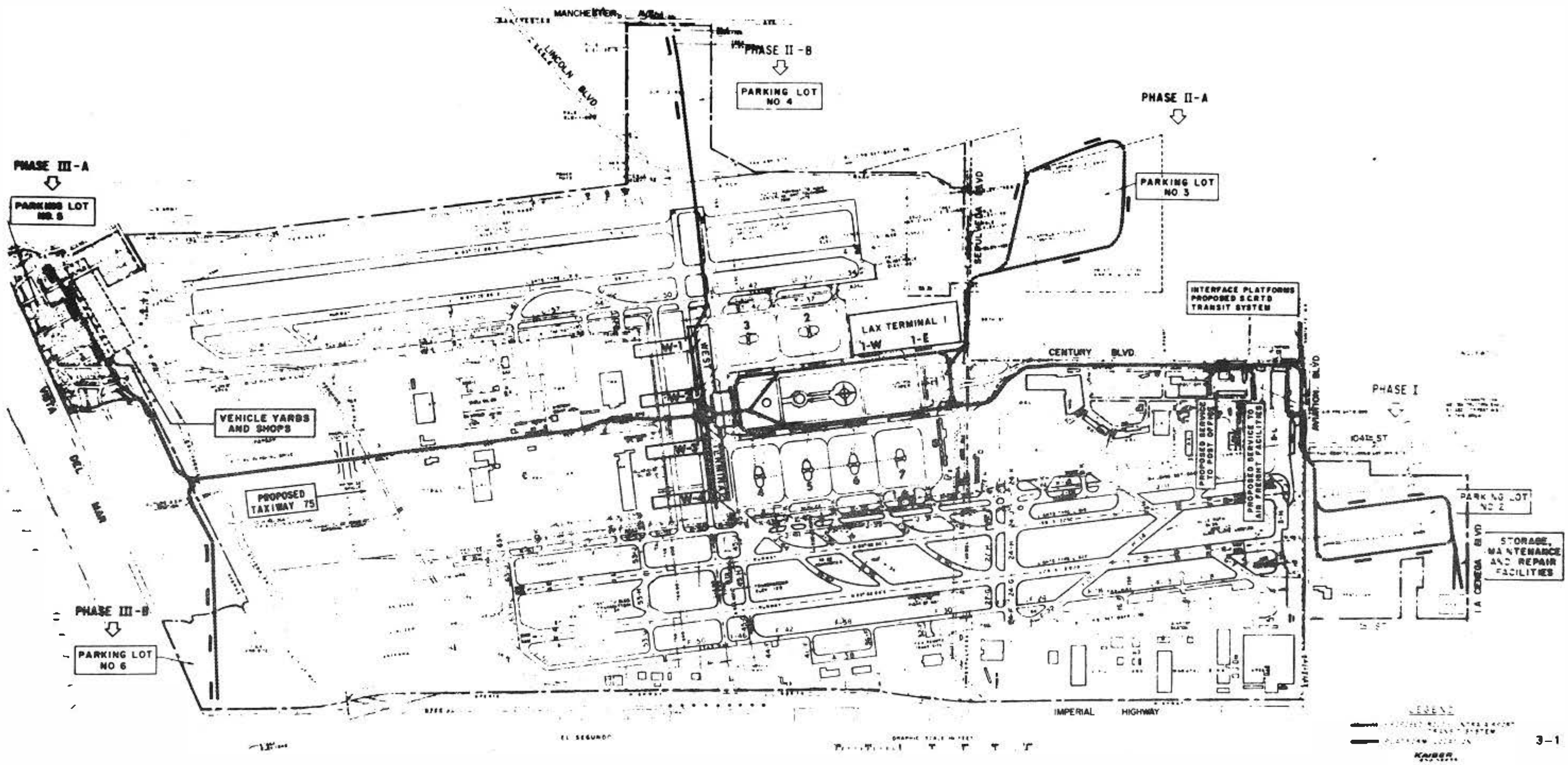
Of the 12 passenger stations in the central terminal complex, six are located in the vicinity of existing ticketing buildings and the other six are planned for inclusion within or adjacent to passenger terminals envisioned in the Airport Master Plan.

Phasing of the implementation is shown below in tabular form giving the incremental increase in route lengths and number of stations for each phase, and also the cumulative total of route lengths and number of stations at the completion of each phase.

TABLE 4. IMPLEMENTATION PHASES

PHASE	Incremental Increase Each Phase: Route Distance (Miles)	Incremental Increase Each Phase: No. Of Central Loop Passenger Stations	Incremental Increase Each Phase: No. Of Parking Lot Stations	Cumulative Total At Completion of Each Phase: Route Distance (Miles)	Cumulative Total At Completion of Each Phase: No. Of Central Loop Passenger Stations	Cumulative Total At Completion of Each Phase: No. Of Parking Lot Stations	Reference Drawing: ROUTE ALIGNMENT DWG NO.
I	4.1	6	4	4.1	6	4	2, 3, 4, 5
IIA	1.7	2	4	5.8	8	8	6
IIB	1.9	4	2	7.7	12	10	7
IIIA	2.3	0	4	10.0	12	14	8
IIIB	0.6	0	4	10.6	12	18	8
IV	I M P E R I A L T E R M I N A L						

PROPOSED LOS ANGELES INTRA-AIRPORT TRANSIT SYSTEM
OVERALL PLAN



PHASE I – OVERALL PLAN

Phase I will provide a route alignment around existing central terminal loop, a connecting route along Century Boulevard and Aviation Boulevard to Parking Lot No. 2, and a loop route alignment within Parking Lot No. 2.

Route Alignment Drawing No. 2 illustrates the alignment and associated facilities included in Implementation Phase I. Details of the alignment in central terminal loop are shown in Route Alignment Drawing No. 3.

In Parking Lot No. 2, passing routes and crossovers will allow trains to bypass a train that is stopped at a station. Sections of the parallel way will also be used to store vehicles and to facilitate moves in and out of the maintenance facility in the southeast part of the parking area.

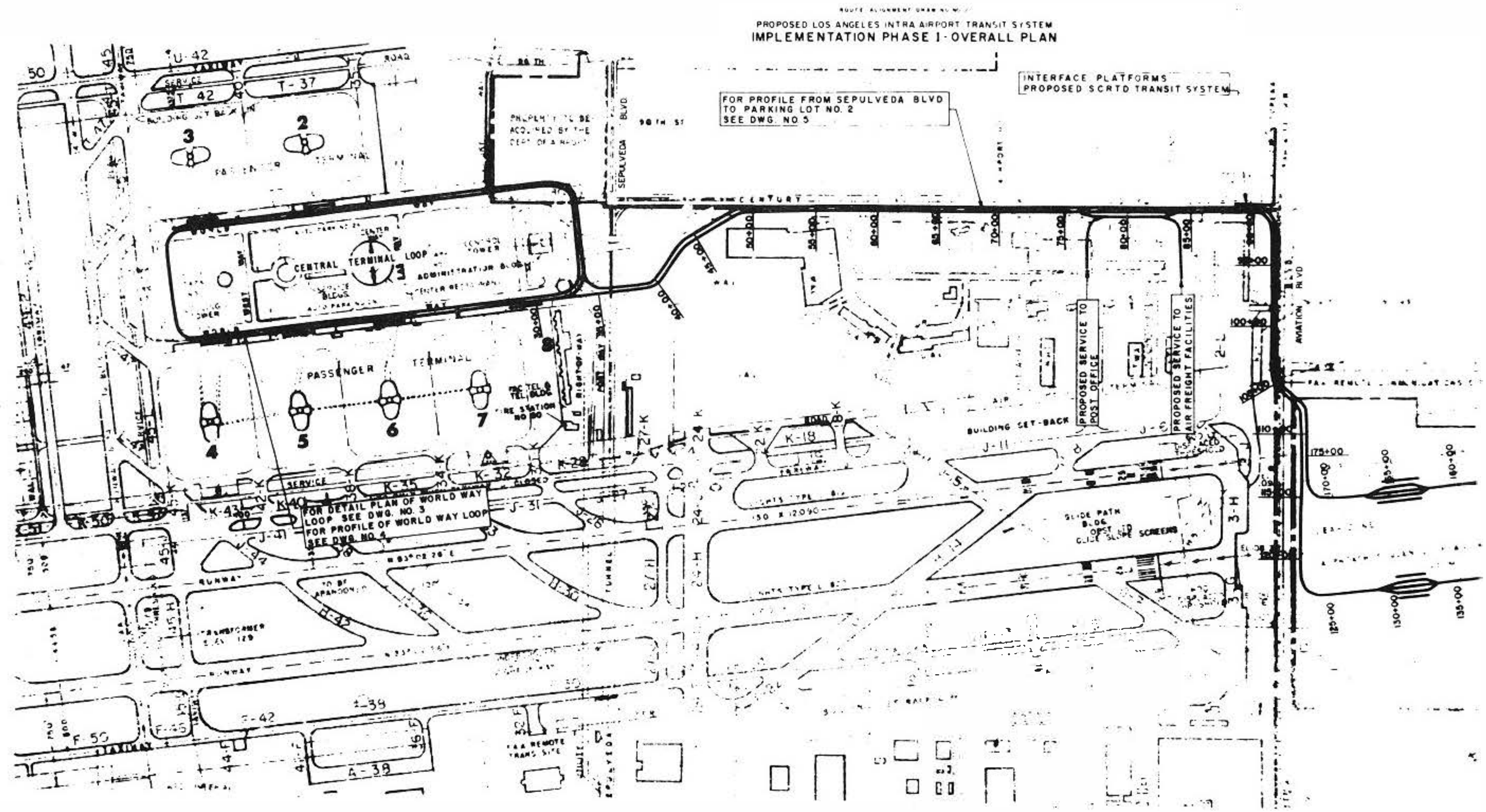
Along the connecting route, provision is made for future addition of an interchange passenger station to connect with a proposed aerial Southern California Rapid Transit District (SCRTD) station at Century Boulevard. Phase I also provides for future addition of spurs into the post office and airfreight facilities along Century Boulevard.

The approximate length in feet of structure types required to implement Phase I are tabulated as follows:

Alignment Configuration	1 Track	2 Track	3 Track	Total
Aerial	835	13,450		14,285
At Grade		1,900	2,000	3,900
Retained Cut	1,800	1,550		3,350
Tunnel or Cut & Cover		400		400

TABLE 5. IMPLEMENTATION – PHASE I

	Incremental Increase Each Phase			Cumulative Total At Completion of Each Phase			Reference Drawing
PHASE	Route Distance (Miles)	No. Of Central Loop Passenger Stations	No. Of Parking Lot Stations	Route Distance (Miles)	No. Of Central Loop Passenger Stations	No. Of Parking Lot Stations	ROUTE ALIGNMENT DWG NO.
I	4.1	6	4	4.1	6	4	2, 3, 4, 5
IIA	1.7	2	4	5.8	8	8	6
IIB	1.9	4	2	7.7	12	10	7
IIIA	2.3	0	4	10.0	12	14	8
IIIB	0.6	0	4	10.6	12	18	8
IV	I M P E R I A L T E R M I N A L						


PROPOSED LOS ANGELES INTRA AIRPORT TRANSIT SYSTEM
IMPLEMENTATION PHASE I - OVERALL PLAN
INTERFACE PLATFORMS
PROPOSED SCRTD TRANSIT SYSTEM
FOR PROFILE FROM SEPULVEDA BLVD TO PARKING LOT NO. 2 SEE DWG. NO 5
FOR DETAIL PLAN OF WORLD WAY LOOP SEE DWG. NO. 3
FOR PROFILE OF WORLD WAY LOOP SEE DWG. NO. 4
PROPOSED SERVICE TO POST OFFICE
PROPOSED SERVICE TO AIR FREIGHT FACILITIES
CENTRAL TERMINAL LOOP
ADMINISTRATION BLDG
PASSENGER TERMINAL
SEPULVEDA BLVD
AVIATION BLVD
CENTURY
BUILDING SET-BACK
RUNWAY
50+00
60+00
70+00
80+00
85+00
100+00
125+00
130+00
135+00
175+00

PHASE I – CENTRAL TERMINAL LOOP PLAN

During Implementation Phase I six intra-airport transit stations will be constructed around the central loop.

As shown on Route Alignment Drawing No. 3, six passenger stations and approximately 1.5 miles of transit route are located in existing central terminal loop to serve the seven existing passenger terminals.

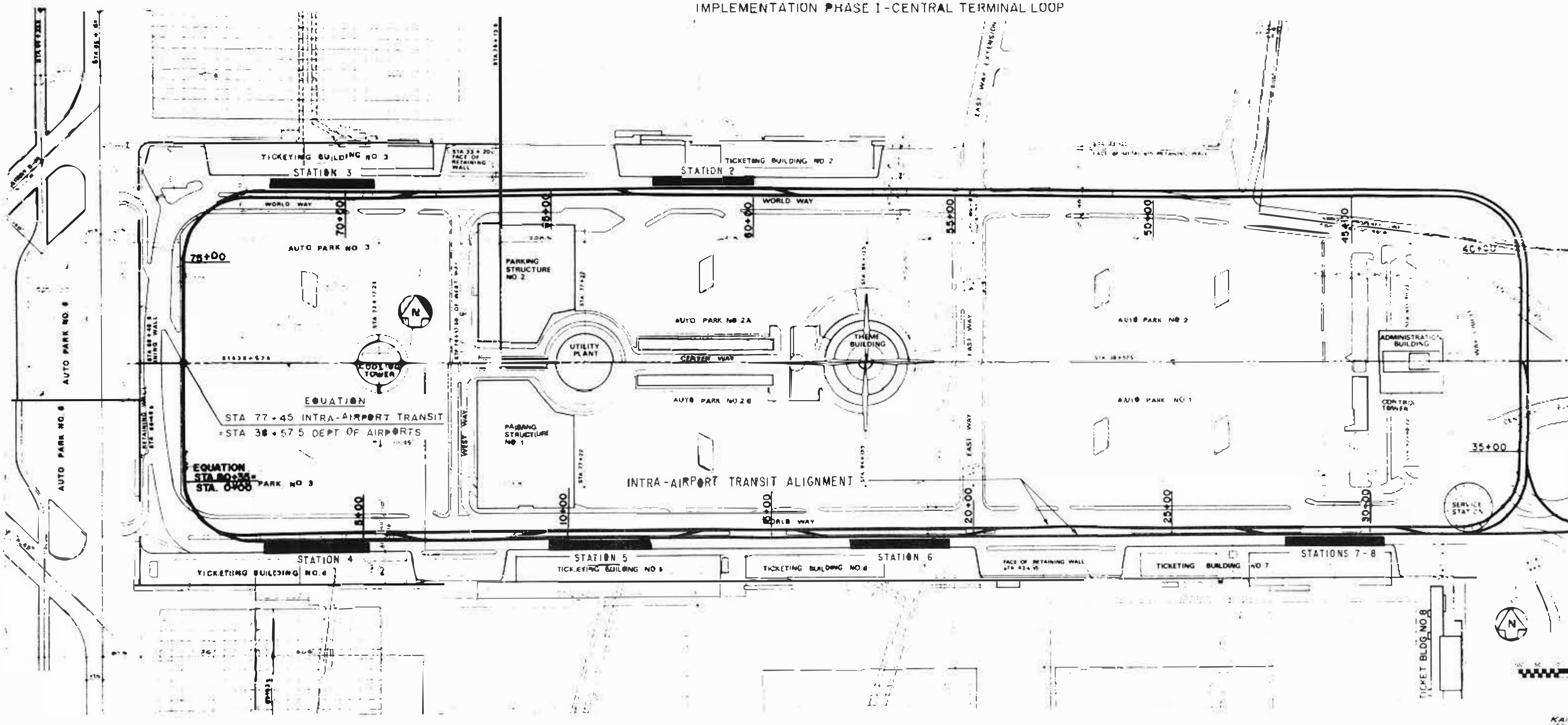
Parallel routes will provide operational flexibility, allowing a transit vehicle or train to either berth at the station platform or bypass the station on the parallel route.

Sections of the parallel route between stations will be used for temporary storage of vehicles to provide immediate availability for peak loads of deplaning passengers.

Phase I plans provide for connection of additional route alignment in subsequent phases. The connecting points are west of Stations 2 and 5 as shown on Route Alignment Drawing No. 7.

PROPOSED LOS ANGELES INTRA-AIRPORT TRANSIT SYSTEM

IMPLEMENTATION PHASE I-CENTRAL TERMINAL LOOP



PHASE I – CENTRAL TERMINAL LOOP PROFILE

Phase 1 route alignment profile around the central terminal loop is level except for a gentle rise to clear the Century Boulevard overcrossing at Sepulveda Boulevard.

Route Alignment Drawing No. 4 illustrates that Implementation Phase 1 provides a route that is nearly level all around the central terminal loop. A short, gentle rise is necessary at the east end of the loop to provide adequate clearance at the east end of the loop.

This relatively level profile is achieved by placing the transit track elevation at approximately the elevation of the second floor roof of the existing ticketing buildings. The level profile offers both operational advantages and aesthetic appeal.

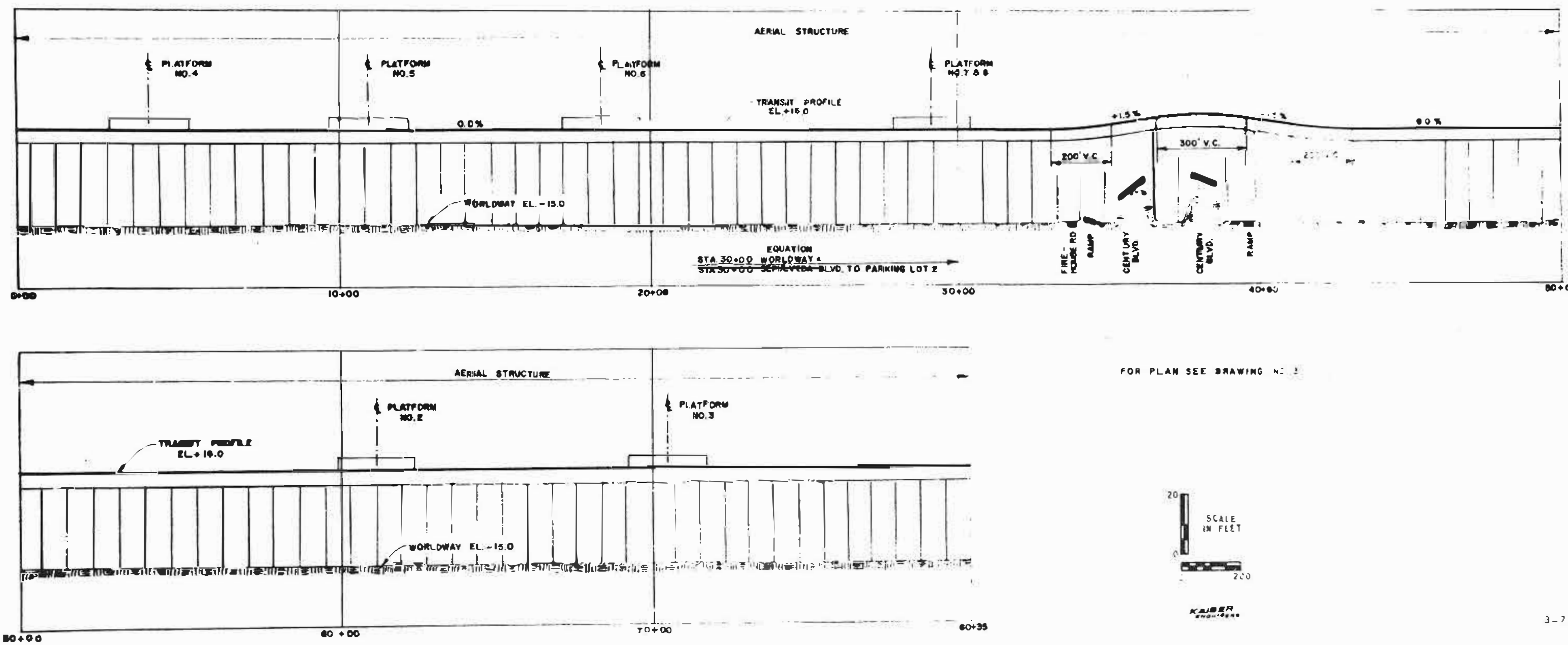
In a subsequent phase there will be connecting routes immediately west of Stations 2 and 5 descending into a proposed underground west terminal as shown on Route Alignment Drawing No. 1. These routes can be achieved with gradients of approximately 4.5%.

Also in a subsequent phase there will be connecting routes at the northeast corner of the central terminal loop as shown on Route Alignment Drawing No. 6. The profile of this connection can be accomplished with minimum gradients.

ROUTE ALIGNMENT DRAWING NO 4

PROPOSED LOS ANGELES INTRA-AIRPORT TRANSIT SYSTEM

IMPLEMENTATION PHASE I - CENTRAL LOOP PROFILE



FOR PLAN SEE DRAWING NO. 3

SCALE IN FEET

KAISER ENGINEERS

PHASE I – INTERCONNECTING ROUTE AND PARKING LOT NO. 2 PROFILE

The route alignment profile from the central loop to the parking lot and around the parking lot loop is partly aerial, partly at grade and partly below grade.

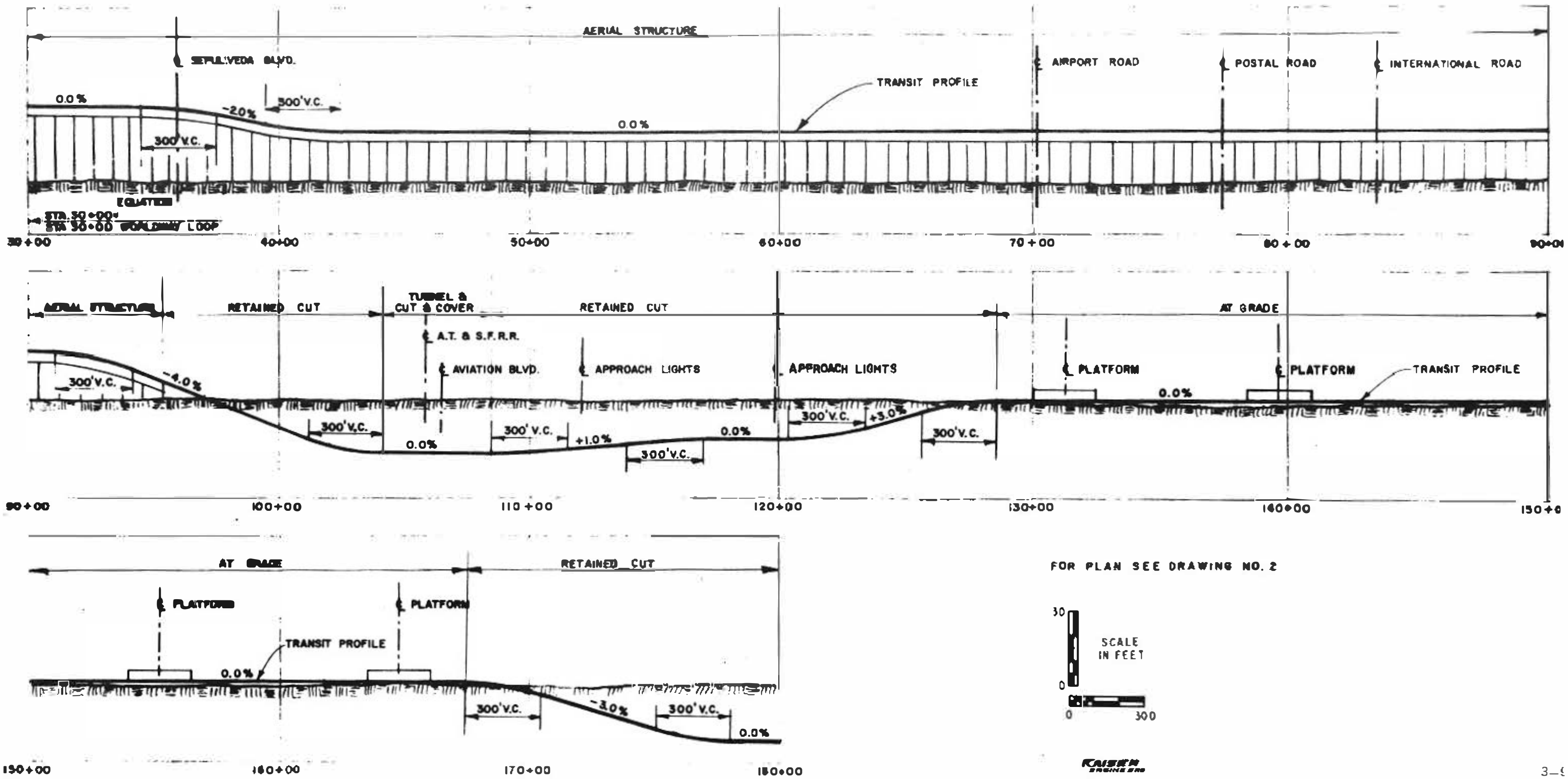
Route alignment Drawing No. 5 shows the profile of both the interconnecting transit route and the route through Parking Lot No. 2.

The profile begins at a point immediately east of existing Ticketing Building 7 and continues on aerial structure along Century Boulevard to Aviation Boulevard. At this point the profile begins a descent to a tunnel and cut-and-cover section under the Atchison, Topeka and Santa Fe Railroad and under Aviation Boulevard. The transit route is underground in this area to conform to the vertical restrictions imposed by the glide path approach to the runway. The profile continues in a retained cut section along the east side of Aviation Boulevard under runway approach lights and under proposed access bridges to the parking lot. At the southwest corner of Parking Lot No. 2, the profile emerges to an at-grade section and continues at grade around the parking lot loop. The route again descends into retained cut as it approaches the west end of the parking lot.

ROUTE ALIGNMENT DRAWING NO 5

PROPOSED LOS ANGELES INTRA-AIRPORT TRANSIT SYSTEM

IMPLEMENTATION PHASE I - INTERCONNECTING ROUTE AND PARKING LOT LOOP PROFILE



FOR PLAN SEE DRAWING NO. 2

SCALE IN FEET

30

0

0 300

KAISER ENGINEERS

PHASE II-A – ROUTE ALIGNMENT FOR PARKING LOT NO. 3 AND CONNECTION TO CENTRAL TERMINAL LOOP

Phase II-A implements an additional 1.7 route miles, two passenger stations and four stations in Parking Lot No. 3.

The route alignment is on aerial structure adjacent to Sepulveda Boulevard on airport property from the northeast corner of the central terminal loop to 96th Street. At this point the route alignment turns east into Parking Lot No. 3 and descends to an at-grade section and continues at grade around the entire Parking Lot No. 3 loop.

The two new aerial passenger stations are located in the proposed Terminal 1 at the northeast corner of the central terminal loop. Route alignment Drawing No. 4 shows the transit profile adjacent to proposed Terminal 1 which establishes the elevation of the new aerial stations.

The four stations in Parking Lot No. 3 are all at grade.

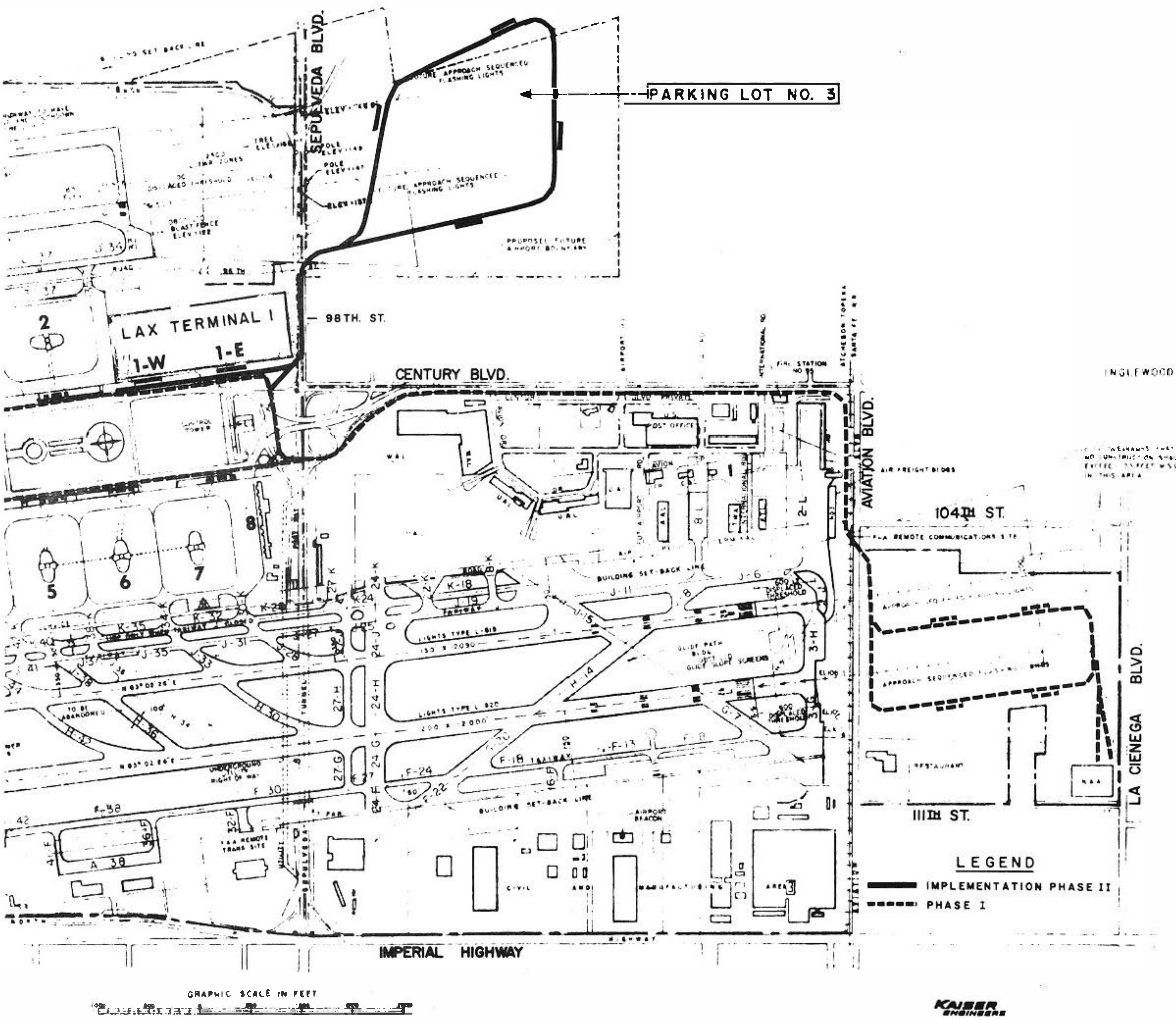
TABLE 6. IMPLEMENTATION – PHASE IIA

PHASE	Incremental Increase Each Phase			Cumulative Total At Completion of Each Phase			Reference Drawing
	Route Distance (Miles)	No. Of Central Loop Passenger Stations	No. Of Parking Lot Stations	Route Distance (Miles)	No. Of Central Loop Passenger Stations	No. Of Parking Lot Stations	ROUTE ALIGNMENT DWG NO.
I	4.1	6	4	4.1	6	4	2, 3, 4, 5
IIA	1.7	2	4	5.8	8	8	6
IIB	1.9	4	2	7.7	12	10	7
IIIA	2.3	0	4	10.0	12	14	8
IIIB	0.6	0	4	10.6	12	18	8
IV	I M P E R I A L T E R M I N A L						

ROUTE ALIGNMENT DRAWING NO. 6

PROPOSED LOS ANGELES INTRA-AIRPORT TRANSIT SYSTEM

IMPLEMENTATION PHASE II-A- ROUTE ALIGNMENT PLAN



KAISER ENGINEERS

PHASE II-B – ROUTE ALIGNMENT FOR PARKING LOT NO. 4 TO PROPOSED WEST TERMINAL AND CONNECTIONS TO CENTRAL TERMINAL LOOP

Phase II-B integrates Parking Lot No. 4 and the proposed west terminal into the central terminal loop transit system. This phase is planned and scheduled to coordinate with airport master plans.

The route configuration within the proposed west terminal is a stub-end design with a switchback at the south end of the terminal. Crossovers and turnouts at the center of the terminal provide a connection to the central terminal loop. The reverse movements and crossovers in this route configuration will create an inefficiency of operation during peak periods; therefore a systems analysis of the illustrated route and alternative routes is planned to assure that the final Phase II-B route alignment will be optimized with respect to all architectural, engineering and operational aspects. Earlier phases are planned to be compatible with the full scope of alternatives that will be considered.

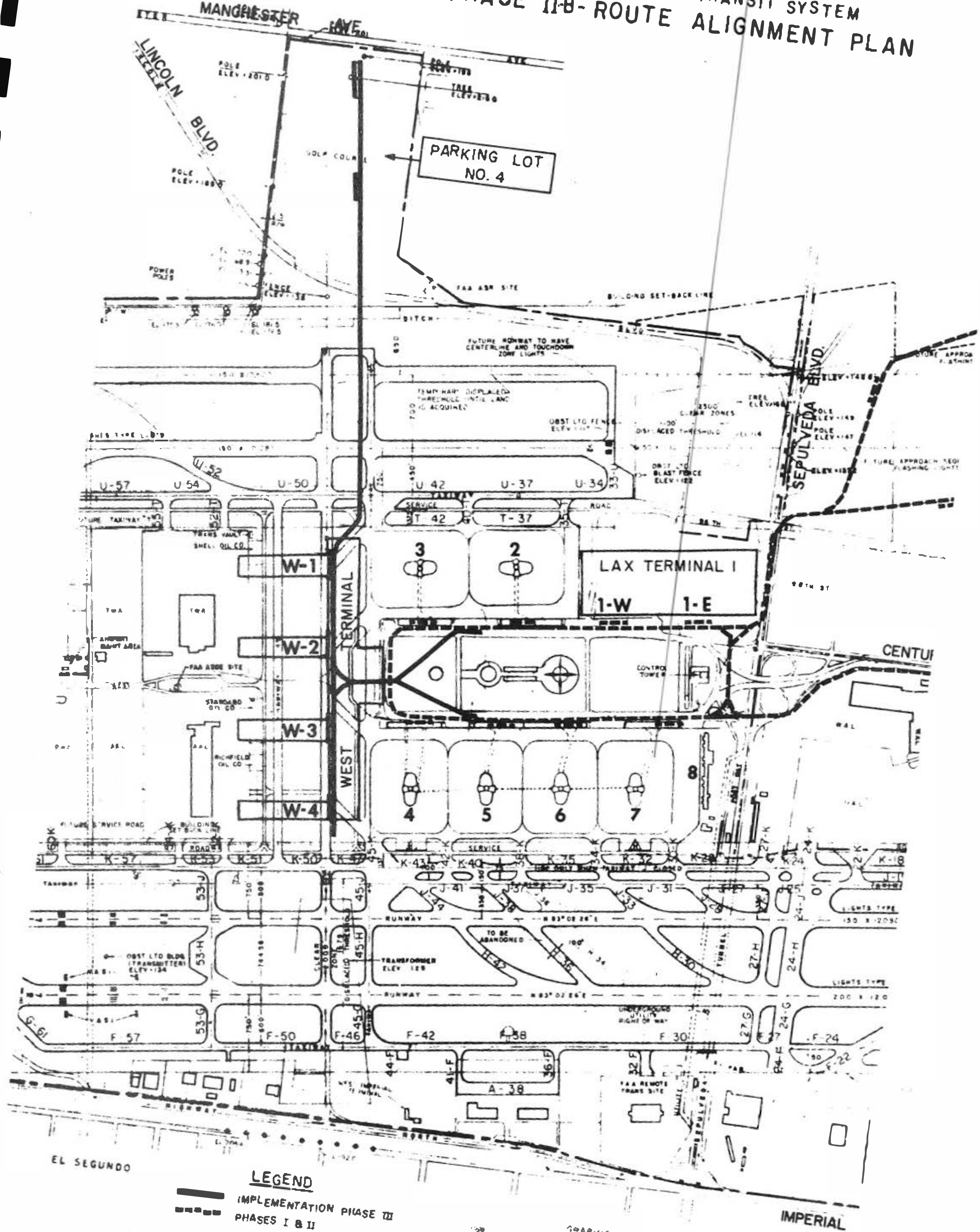
Phase II-B adds two stations in Parking Lot No. 4 and four passenger stations in the proposed west terminal. The route is at-grade in Parking Lot No. 4, crosses over Lincoln Boulevard on an aerial structure and then crosses the existing runways and taxiways in a tunnel. The connection tracks from the underground west terminal to the central terminal loop have grades of approximately 4.5%.

TABLE 7. IMPLEMENTATION – PHASE IIB

	Incremental Increase Each Phase			Cumulative Total At Completion of Each Phase			Reference Drawing
PHASE	Route Distance (Miles)	No. Of Central Loop Passenger Stations	No. Of Parking Lot Stations	Route Distance (Miles)	No. Of Central Loop Passenger Stations	No. Of Parking Lot Stations	ROUTE ALIGNMENT DWG NO.
I	4.1	6	4	4.1	6	4	2, 3, 4, 5
IIA	1.7	2	4	5.8	8	8	6
IIB	1.9	4	2	7.7	12	10	7
IIIA	2.3	0	4	10.0	12	14	8
IIIB	0.6	0	4	10.6	12	18	8
IV	IMPERIAL TERMINAL						

ROUTE ALIGNMENT DRAWING NO. 7

PROPOSED LOS ANGELES INTRA-AIRPORT TRANSIT SYSTEM
IMPLEMENTATION PHASE II-B - ROUTE ALIGNMENT PLAN



LEGEND

IMPLEMENTATION PHASE III

PHASES I & II

PHASES III-A AND III-B – ROUTE ALIGNMENT FROM PROPOSED WEST TERMINAL TO PARKING LOTS NO. 5 AND 6

Implementation Phase III connects two parking lots near the ocean to the new west terminal.

Route Alignment Drawing No. 8 shows the alignment to be implemented in Phases III-A and III-B. The alignment is in a tunnel in the west terminal area and aerial structure along World Way west to the proposed Pershing Drive with a tunnel crossing under proposed Taxiway 75. After crossing Pershing Drive on aerial structure the route alignment is at grade to Parking Lot No. 5. Four at-grade parking lot stations are added to the system. Phase III-A also includes the development of vehicle yards and shop facilities in the area immediately west of Parking Lot No. 5.

The drawing also shows the limits of the route alignment and location of the four parking lot stations to be implemented in Phase III-B. All of the route alignment and the four parking lot stations will be at grade.

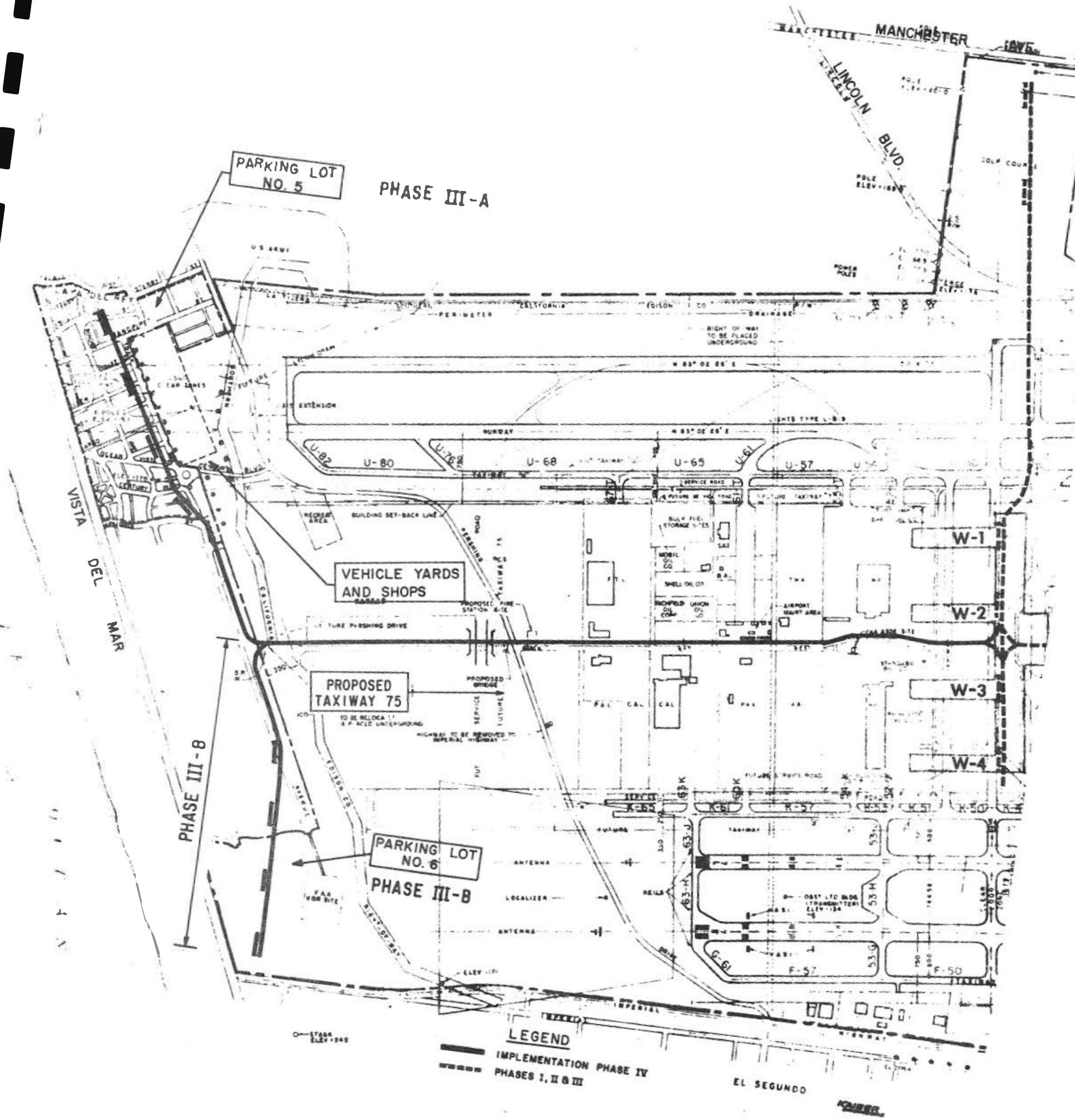
TABLE 8. IMPLEMENTATION – PHASES IIIA AND IIIB

	Incremental Increase Each Phase			Cumulative Total At Completion of Each Phase			Reference Drawing
PHASE	Route Distance (Miles)	No. Of Central Loop Passenger Stations	No. Of Parking Lot Stations	Route Distance (Miles)	No. Of Central Loop Passenger Stations	No. Of Parking Lot Stations	ROUTE ALIGNMENT DWG NO.
I	4.1	6	4	4.1	6	4	2, 3, 4, 5
IIA	1.7	2	4	5.8	8	8	6
IIB	1.9	4	2	7.7	12	10	7
IIIA	2.3	0	4	10.0	12	14	8
IIIB	0.6	0	4	10.6	12	18	8
IV							

ROUTE ALIGNMENT DRAWING NO. 5

PROPOSED LOS ANGELES INTRA-AIRPORT TRANSIT SYSTEM

IMPLEMENTATION PHASES III-A AND III-B — ROUTE ALIGNMENT PLAN



SECTION 4

PERFORMANCE AND SERVICE

TRAVEL TIMES AND WAITING TIMES — ALL ROUTES

Travel times between parking lot stations and terminal stations range from just over 1 minute to about 10 minutes; the expected waiting time at any station ranges from 2-1/2 minutes to 4-1/2 minutes.

The selected system is capable of providing a very high level of service. Passing routes, in parallel with all station siding routes enable vehicles to proceed directly from origin to destination, neither stopping at intermediate stations nor waiting for vehicles serving other stations to move out of the way. In this scheme, all parking lot trains merge into World Way loop in the same direction so that minimum headway in this loop governs maximum rate of passenger travel in the system.

All vehicle movements will be scheduled by the use of computer programs that will predict patronage patterns throughout each day. By simulating actual operating conditions and restraints, the computer will test and optimize the schedules. If, as the schedules are put into operation, actual patronage varies significantly from predicted patterns, a centralized computer control system will continually adjust vehicle movements to better satisfy actual conditions. The centralized control will always optimize the extent to which the system can give fastest, most direct service for the largest possible number of passengers. During low demand periods virtually all passengers will enjoy direct origin-to-destination service.

Operational policies and methods that tend to assemble passengers into common destination groups influence the level of service which the transit system can provide. For example, assigning parking areas and stations to specified airlines reduces overall travel time and waiting time for a considerable number of passengers.

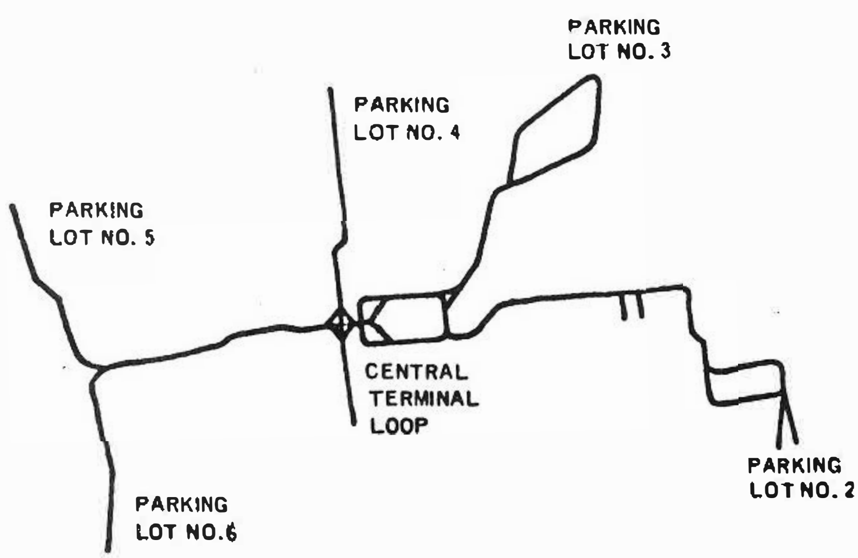
increased system = >> wait. At

The length of time passengers can expect to wait for a train to take them to their desired destination will be about 2.6 minutes until Phase II-B is implemented; then expected waiting time will increase to about 4.1 minutes. Maximum waiting time will be about 5.6 minutes before Phase II-B is implemented and 8.6 minutes afterwards. Table 9 tabulates travel and waiting times in minutes.

Expected and maximum waiting times in Parking Lots No. 5 and 6 will depend on plans yet to be finalized. They can be the same order of magnitude as those shown for other lots.

TABLE 9. TRAVEL AND WAITING TIMES (MINUTES)

PHASE	PARKING LOT NO.	2	3	4	5	6
I through III-8	MINIMUM TRAVEL TIME	4.3	1.1	1.3	3.7	3.7
	MAXIMUM TRAVEL TIME	10.4	9.7	10.1	8.5	8.5
I	EXPECTED WAITING TIME	2.6				
II-A		2.6	2.6			
II-B		4.1	4.1	4.1		
I	MAXIMUM WAITING TIME	5.6				
II-A		5.6	5.6			
II-B		8.6	8.6	8.6		



TRAVEL TIME FOR PHASE I, BY STATIONS

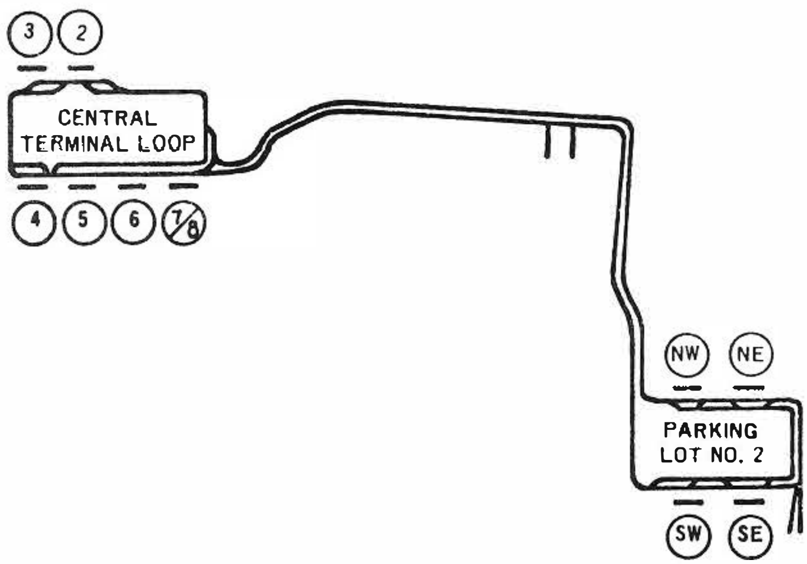
Between any station in Parking Lot No. 2 and any station in the central terminal loop, travel time varies between 4.3 minutes and 10.4 minutes.

Tabulated in Table 10 are travel times between each station in Parking Lot No. 2 and any station in the terminal loop, after implementation of Phase I. The shortest journey, between the station in the northwest portion of the lot and the first station in the terminal loop is about 4.3 minutes. The longest journey, 10.4 minutes, refers to the station in the southwest part of the parking lot and the last station in the central loop.

Travel times include an allowance for expected intermediate stops during normal peak demand periods. Allowances, assumptions and basic derived data used to compute the performance and service data are presented in Appendix 2.

TABLE 10. TRAVEL TIMES – PHASE I (MINUTES)

TERMINAL STATION NO.	2	3	4	5	6	7/8
PARKING AREA NO. 2, N.W. STATION	4.3	5.1	6.0	6.6	7.2	8.0
PARKING AREA NO. 2, N.E. STATION	5.0	5.7	6.6	7.2	7.9	8.6
PARKING AREA NO. 2, S. E. STATION	6.1	6.8	7.7	8.3	8.9	9.7
PARKING AREA NO. 2, S.W. STATION	6.7	7.5	8.4	8.9	9.6	10.4



CAPACITY AND VEHICLE REQUIREMENTS

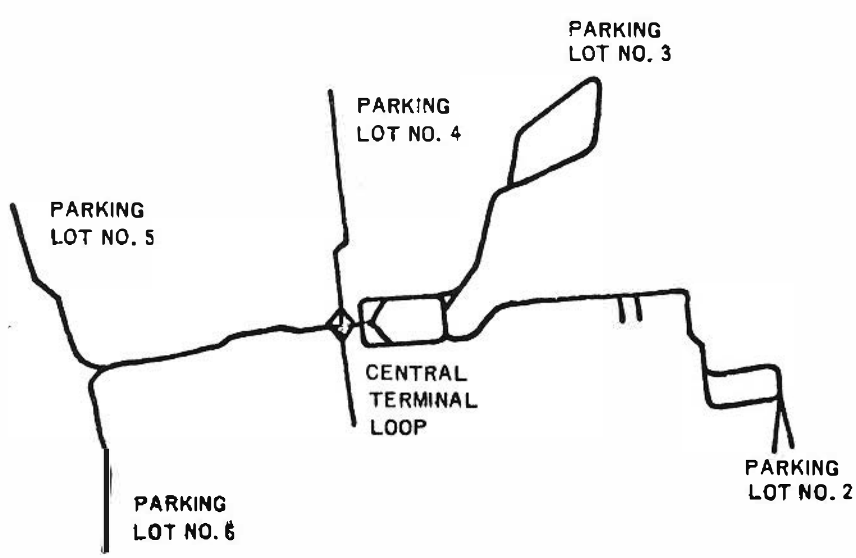
Between Parking Lots No. 2, 3 and 4 combined, and the central terminal loop, design capacity is for 26,400 passengers. Ninety-two passenger vehicles and 33 baggage vehicles are required to serve design capacity.

Table 11 shows design capacities and ultimate capacities of portions of the system serving Parking Lots No. 2, 3 and 4 and numbers of vehicles required to provide the design capacities. Design capacities are approximately equal to requirements expected within a few years after completion of the system. Capacities can be increased to the ultimate by increasing vehicle quantities.

Capacities and vehicle quantities required to serve Parking Lots No. 5 and 6 are not shown because they depend on plans yet to be finalized.

TABLE 11. PASSENGER CAPACITY AND VEHICLE REQUIREMENTS

PHASE	PARKING AREA	PASSENGERS/HOUR Design Capacity	PASSENGERS/HOUR Ultimate Capacity	VEHICLES IN SERVICE (DESIGN CAPACITY) Passenger	VEHICLES IN SERVICE (DESIGN CAPACITY) Baggage	VEHICLES IN SERVICE (DESIGN CAPACITY) Total
I	LOT NO. 2	4,400	26,400	20	10	30
II-A	LOT NO. 2	4,400	13,200			
	3	11,000	13,200			
	TOTALS	15,400	26,400	62	27	89
II-B	LOT NO. 2	4,400	6,600			
	3	8,800	13,200			
	4	4,400	6,600			
	TOTALS	17,600	26,400	92	33	125



SECTION 5

ESTIMATES OF COSTS

CAPITAL COSTS ARE ESTIMATED FOR ALL PHASES

The costs shown are for concepts only and the limited nature of this study requires that their classification be as order of magnitude only. The costs are based on the costs of a system having the potential for application to the intra-airport system. The cost classifications are defined.

COST ACCOUNT CLASSIFICATIONS

Structures and Roadbeds—Includes track, roadbed, way structures, aerial underground and grade structures.

Stations—Includes the total cost of stations in the terminals and parking lots. Also includes the escalators, architectural finish, lighting and station structures.

Electrification—Includes substations, supply and collector rails, feeders, supervisory control and all necessary equipment to provide electric power for propulsion.

Control and Communication—Includes all costs for all on-board and wayside train control apparatus and wayside and central communications and control center.

Utility Relocation—Includes costs for removing, relocating or supporting and replacing utilities necessary for construction.

Yards and Shops—Includes all buildings and track and shop equipment required for transit vehicle inspection, maintenance and repairs.

Vehicles—Includes the cost of transit vehicles based upon assumed speeds, headways and current prices. Includes an allowance of 10% for spaces.

Parking Lots—Includes all site work, paving, lighting, automatic traffic gates and access roads required for parking lots.

Engineering and Project Administration—An allowance of 10% covers project administration, planning, soil investigation, field engineering and construction surveillance.

Contingency—An allowance of 10% of all construction costs covers unknown and unanticipated conditions which could develop during design and construction.

Escalation—An allowance of 7% per year on labor and materials covers the cost of escalation for the construction period.

Exclusions—Excluded are land acquisition costs for right-of-way and easement as well as demolition of existing structures; and costs for possible shielding against transit system electromagnetic interference that might interfere with operation of ILS or other similar systems. Operating and maintenance costs have not been developed due to the range of equipment offered for Type "A" systems. Based on steel wheel systems, it is estimated that the Phase I operation would be in the range of $ [illegible] annually.

APPENDIX

COMPONENTS TECHNOLOGY

During the past few years several intensive studies have been directed toward new and emerging technologies that are potentially applicable to transit systems for urban areas such as airports. The most comprehensive of those was an 18-month study authorized by Section 6(b) of the Urban Mass Transportation Act of 1964, as amended in 1966. Results of the report were published by the U.S. Department of Housing and Urban Development during the last few weeks of phase II, part A of the intra-airport transit system study.

> The Housing and Urban Development (HUD) report provides a wide scope of information about new transit systems under development— designated "B" systems in the intra-airport transit study. Entitled "Tomorrow's Transportation—New Systems of the Urban Future" the report summarizes the findings of "a systematic investigation of the possibilities for technological 'breakthrough' in urban transportation research comparable to those accomplished in the fields of medicine, atomic energy, and aerospace technology.
>
> "The study brought some of the finest research skills available— in government, industry, universities, research centers, and the foundations—together with experts possessing years of experience in dealing with urban transportation problems. Thus, traditional approaches were combined with new methods of research and systems analysis used successfully in the aerospace and defense industries. Working together, this unique team was able to explore urban transportation possibilities as never before, and to winnow fact from popular fiction. The improvements and new systems presented in this report also show the great potential benefits possible through combining technical advances with social service."
>
> "The technology which underlies the development of the new transportation systems covers a wide range of subsystems and components. These include:
>
> o command and control devices for safe and reliable guidance;
>
> o propulsion subsystems to power the vehicles with little or no air pollution or noise;
>
> o suspension subsystems to improve comfort and safety; and many other mechanical and electrical components which in combination become the total operating system.
>
> "Establishing the technical feasibility, advantages, and limitations of innovative concepts and their subsystems and components is critical to advancing new systems of urban transportation. The following is a review of some of the promising technologies of components which should be explored through a program of research and development to determine their advantages for longer range systems which constitute the whole.

COMMAND AND CONTROL

"Control is one area in which the technological problems of urban transportation are considerably more complex even than those of space travel; thousands of vehicles with hundreds of options for switching and stopping are involved. Without automation, few of the new systems would be economically feasible."

"While much research and development associated with 'command and control' technology must be done in connection with a specific concept, there likely will be byproducts of this work that will be useful in advancing other ideas.

AUTOMATED VEHICLE MONITORING

"In order to control the movement of vehicles, one must know where they are—no problem if the number of vehicles to be controlled is small. Two-way voice radio is entirely ade uate for dispatching small fleets of taxis, trucks, or police cars. But when the fleets become large, the amount of information becomes unmanageable without automation."

PROPULSION, ENERGY, AND POWER TRANSMISSION SUBSYSTEMS

"Two types of propulsion systems drive most of our present transit vehicles: Internal-combustion engines, whether gasoline or diesel; and electric, whether supplied from internal sources or by external transmission systems. With the exception of the gas turbine engine which has been developed primarily for aircraft but which has seen some recent application for ground transportation, these propulsion systems are all products of 19th century technology' with some 20th century refinements."

"*Electrically powered* vehicles offer advantages for urban transportation in eliminating noise and pollution emissions as well as their proven adaptability to automatically controlled systems. Self-contained electric propulsion systems are relatively undeveloped for urban transportation. Lead acid batteries are now the only practical means available for storing energy to operate vehicles off of guideways. They are heavy, expensive, and cannot store and deliver energy well enough to permit battery-powered vehicles to travel very far or fast or to perform adequately in competition with internal combustion engines. For vehicles on guideways, third rail and pantograph-overhead wire systems are the only means for transmitting power.

"Electric motors for both kinds of systems are far from being as sophisticated as the automated systems of the future will require. Electric motors have now been developed that are much lighter than the conventional ones used to propel trolleys and rapid transit. A 130-pound, 100-horsepower motor, for example, was recently demonstrated successfully in a small electric car. Solution of the weight problem opens the way for use of electric motors in small vehicles. The focus of development in the conventional electric motor field no doubt now will be on the engineering necessary to achieve the most efficient application of lightweight reliable motors.

"*Linear electric motors* have been experimented with for at least 20 years. Reduced to its simplest terms, a linear motor is a rotary motor cut parallel to its axis and laid out flat. Instead of a rotor spinning inside a stator, a flat shuttle passes along a controlled guideway. In transportation applications, the guideway is the stator and the rotor is on the vehicle—or in some cases, the rotor is the vehicle. Power windings can be either in the guideway or on the vehicle. Usually they are on the guideway but applying this convention to transportation guideways could be enormously expensive, since it would require tons of copper or some other conductor to 'wind' a guideway. Most concepts, therefore, put the windings in the vehicle though this requires a method of supplying it with power.

"The new systems study indicates that development of the linear motor offers some advantages for the development of several new urban transportation systems. Since thrust is direct, relying on electromagnetic reaction between vehicle and guideway, no power is lost nor is weight added through gearing, and the system need not rely on tractive friction. Vehicle weight can be reduced, since in effect half the motor is in the guideway. Since the linear motor depends on a narrow gap or clearance between stator and rotor (guideway and vehicle), it may be suited to propel air suspension vehicles. Vehicle speeds can be controlled for an entire automatic system, but this introduces serious problems. The practicability and economy of 'winding' a roadbed must be resolved. If power is applied to the vehicle, connections are necessary between it and some adjacent power source. To keep thrust constant, theory suggests that the air gap between vehicle and guideway must also be kept constant, though research has yet to determine the range of acceptable variations. In sum, linear electric motors, especially if used in conjunction with air bearing suspension, appear to have good potential for use in urban transportation systems. Further research is required, however, to determine whether they possess significant or unique advantages in this application.

"*Energy Storage:* Lack of routing flexibility is one of the penalties incurred with systems which run on a guideway; this is one of the reasons most often cited for the decline of the trackless trolley bus. Attention has focused recently on energy-storage devices which would allow a vehicle to operate without being in contact with a power source, yet without producing air pollution. Such systems would be driven by electrical power produced on-board, either by batteries or by fuel cells; or else they would carry mechanical or thermal energy-storage devices.

"There are several differences between batteries and fuel cells. Generally, a battery must be recharged, while a fuel cell needs to be refueled (energy is the regenerating means in the one case, matter in the other). Further, batteries possess a relatively higher power density (measured in watts or kilowatts per pound), and fuel cells possess a relatively higher energy density (measured in kilowatt-hours per pound). Thus, fuel cells might permit reasonable driving range and rapid refueling, while batteries can more readily supply peak load requirements for better acceleration but require relatively long reenergizing times.

"*Conventional lead-acid batteries* represent a well-developed technology, and are fairly inexpensive, but their range capability is low. Newer experimental high-energy-density batteries are less well developed, currently more expensive, and may be more complex to operate. Typical of these newer batteries are the sodium-sulfur, sodium-air, zinc-air, lithium-chlorine, and lithium-organic electrolyte. None of these concepts is yet developed to a point where it would be inexpensive enough for practical urban transportation use. Nevertheless, further work will likely bring some of these concepts to a point at which they can be put to practical use."

"Among the various fuel cell types which have been developed (largely in response to space requirements) are hydrogen-air, direct hydrocarbon-air, and some types which consume hydrazinc, ammonia, methanol, or other fuels. The largest types now known have a capacity of 50 kilowatts. One truck has been designed which uses stored hydrogen and oxygen in its fuel cell; the cell develops 32 kilowatts continuously, or up to 100 kilowatts for short transient loads.

"The major disadvantage of fuel cells at the moment is that they use expensive and relatively scarce fuels, and that they themselves are expensive to produce. The fuel-cell technology is one in which more research effort is needed."

"*Mechanical flywheels* have been used to store energy for buses in Europe and Japan. The flywheels are accelerated at stops from overhead electric power posts, which takes only a few moments, and operate without pollution and with very little noise. Advances in materials are possible which could permit smaller wheels and greater energy storage. If developed, flywheels could be a feasible means for propelling buses under American urban conditions. Hybrid combinations of a flywheel with an electric motor-generator and another form of engine can provide vehicle propulsion or means of accelerating the flywheel at peak engine efficiency with little or no air pollution.

"*Electric Power Transmission:* For vehicles which stay in contact with the guideway, including those vehicles driven by linear motors with the power applied to the rotor, novel power-distribution and power– collection schemes are being explored. The standard shoe-on-power-rail or pantograph-on-catenary will probably continue in use; servo systems have been suggested so that the shoe or pantograph can follow the rail or catenary more closely without being spring-loaded. Direct-contact techniques will serve for vehicles up to the 200-m.p.h. range, even if the vehicle itself is riding on air. Power transmission techniques which involve an air gap merit further investigation for longer term application to high-speed future systems of transportation.

SUSPENSION AND GUIDEWAY COMPONENTS

"Guideway and suspension methods remain a major challenge for research and development, partly because the advances needed for futuristic systems, being largely inapplicable to automobiles, have received relatively less attention than propulsion devices. They are, however, of great importance. Improvements in conventional mechanical suspension and rail guideways are required for even modest increments in speed and comfort, while for major advances new technology clearly will be needed.

"*Active Suspension Devices:* Performance characteristics of springs and dampers, modulated to anticipate roadbed irregularities, may be worked out through the adaptation of aircraft, military tank, and intercity rail technologies. Though there are many engineers who believe such complex mechanisms may cause more trouble than they are worth, the possibilities should be researched in terms of the potential improvements for passenger comfort, especially at urban speeds.

"*Air Suspension or Air Cushions:* These offer some of the most promising developments in means for supporting new transportation systems. They will require, however, a great deal of further test and evaluation before problems of noise, excessive need for power, vehicle switching and steering, and operation on grades are solved. The potential advantages, however, are substantial: Wide distribution of weight on guideway and vehicle, reducing structural complexities; negligible roadway wear, elimination of wheel problems such as bearing failure, imbalance, and bounce; and simplification or elimination of secondary suspension devices such as springs and shock absorbers. Several vehicles have been designed using air suspension with high clearances, but low clearances are better from the standpoints of noise and power consumption.

"The frictionless character of the air-cushion system requires that some thrust-producing device be provided to drive the vehicle, and that some method of producing either reverse thrust or frictional drag, or both, be provided for braking. Since the air gap is an integral characteristic of the system, the linear electric motor seems a logical choice as the propulsion means, and this tends to limit the use of air-cushion vehicles to routes with some types of guideway. Combustions of linear-motor propulsion and air-cushion suspension appear to offer considerable promise in the development of quiet, simple, pollution-free urban transportation systems."

RECOMMENDED FUTURE SYSTEMS

The HUD report recommends development of seven future transit systems employing new technologies. It estimates required development costs ranging $15 million to $400 million (Table 13) and developmental times ranging from 5 to 10 years. Approximate time and cost to develop and demonstrate the "B" system, analyzed in the intra-airport study, are inferred by the excerpts from the HUD report.

> "The following seven major types of new systems of all the many candidates investigated were found to possess not only a high expectation of technical and economic feasibility but also to contribute significantly to the solution of major urban problems."
>
> 1. DIAL-A-BUS (DEMAND-ACTIVATED BUS SYSTEM)
>
> "The Dial-a-Bus, which is a hybrid between an ordinary bus and a taxi, could be the basis for such flexibility. It would pick up passengers at their doors or at a nearby bus stop shortly after they have telephoned for service. The computer would know the location of its vehicles, how many passengers were on them, and where they were heading. It would select the right vehicle and dispatch it to the caller according to some optimal routing program which had been devised for the system. Thus, the system could readily link many origins to many destinations."
>
> "Technically, there is little question that the system will work. Any number of existing vehicles can comfortably carry 12 to 24 passengers. Some of the best are now offering service to airports. Present computers, radio communications, and telephone links are fully adequate to the major needs of Dial-a-Bus. Mathematical routing and the associated computer programming present no real obstacles. What must be done is to put these isolated elements together into a unified system. Dial-a-Bus service could be made somewhat more efficient if the buses were equipped with automatic monitors to report each vehicle's location to the dispatchers at frequent intervals. Although these monitors do not now exist, there is no technological barrier to developing them, as discussed above under the automatic vehicle monitoring subsystem."
>
> "A limited demonstration of the Dial-a-Bus concept, using existing equipment, could almost certainly be achieved within 3 years at a cost of less than $1 million. A definitive full-scale demonstration of Dial-a-Bus service, using vehicles and control equipment specifically designed for this purpose to test the full range of possible benefits, probably could be completed within 7 years at a cost of less than $20 million."
>
> "One such concept is 'personal rapid transit,' sometimes called areawide individual transit or network transit. It would consist of small vehicles, each carrying about the same number of persons as an automobile. These vehicles would travel over an exclusive right-of-way or guideway network, either over standard routes, or else automatically routed individually from origin to destination at network stations.

"Personal rapid transit would provide travelers the important advantages of minimum waiting time at the origin station, and private, secure accommodations."

"Empty passenger vehicles or 'capsules' would be available at each station on the network. The riders would enter one, select and register their destination, and then be transported there automatically, with no stopping. The average speed would be essentially equal to the vehicle speed. The station spacing on a guideway network for the system would have no influence on speed of travel. Passenger demand and station costs would dictate proper station spacing.

"Empty vehicles would be recirculated automatically to maintain an inventory at each station, and passengers could be routed past stations without stopping until they reached their destinations. Ideally, such a system would give travelers the same privacy as a private automobile, although during peak periods in cities with particularly heavy corridor movements a traveler might have to share a vehicle with two or three other passengers."

"The new systems study found over 20 existing proposals for various kinds of personalized transit, most of them little advanced beyond the original concept. The greatest amount of development work is needed for automatic electronic controls. Maintaining safe headways to permit stopping in case of an emergency on the line ahead is a very substantial problem in a system using small vehicles and yet still aiming at high traffic volumes. Such operation requires vehicles to be run far closer together than they can now, but the problems involved in realizing this potential require further research."

"A prototype of such a system could be developed, working perhaps from an existing system such as the Transit Expressway demonstrated in a HUD project in Pittsburgh. Such a prototype system might minimize control difficulties, for instance, by requiring passengers to transfer—a requirement that might not be too onerous in some metropolitan areas because networks requiring few transfers could be designed.

"The ultimate goal should be a system that does not require this kind of temporizing. Yet control problems become even more complex in the areas of merging one vehicle stream into another and of routing numerous small vehicles automatically over a network of guideways, with provisions for switching off the line at stations, of maintaining adequate supplies of empty cars at stations, and of distributing vehicles so that congestion does not result on any line. The new systems study found that these problems are surmountable, and that a prototype system could be developed, tested, and evaluated in less than 10 years at a cost of about $250 million."

3. DUAL MODE VEHICLE SYSTEMS

"In a dual mode system, the vehicle can convert easily from travel on a street to travel on an automated network. It thus could serve as a logical extension or elaboration of personal rapid transit."

"A dual mode system presents more technical development problems than the personal transit system. However, it should be possible to work on such problems simultaneously with the development of personal transit, and to so design personal transit systems for ultimate dual mode use. The earliest developmental problems will be in the adaptation of propulsion, suspension, and guidance systems for use on both automatic guideways and regular streets. None of them seems insurmountable in the light of present knowledge.

"Propulsion on the guideway, as in the case of the personal transit system, would almost certainly be electric, probably using third rail power distribution in prototypes. In the final development of the system, however, propulsion might be a version of the linear motor discussed previously. Vehicles would thus need an electric motor; off the guideway they would run on batteries or use a separate engine to generate power for the electric motor.

"Since these are the directions in which propulsion technology for ordinary automobiles may evolve to achieve reductions in air pollution, the propulsion problems of a dual mode personal vehicle are likely to be solved well before its other problems.

"The most difficult technical problems are those associated with the development of a control system. Two different courses are possible. One is to concentrate the burden of control in the automated guideway (using equipment like linear synchronous motors and wayside computers); the other is to concentrate it in the capsules. The cost and complexity of the guideways would be reduced if the controls were in the capsule, but the controls could be damaged when the capsules were off the guideway and being driven by individuals, and there could be additional safety hazards."

"If research and development of personal rapid transit and the dual mode system were undertaken in concert, the principal costs for guideways, controls, and propulsion systems could be shared. The development, test, and evaluation of street vehicles which could also operate automatically on the guideways could add $150 million to the previous $250 million estimate. While one first-generation form of the dual mode system could be demonstrated in less than 10 years at a cost of less than $35 million, the full-scale development, test, and evaluation of a compatible personal rapid transit and small dual mode vehicle system would be a more uncertain venture and could require a total of about 10 years and $400 million."

"The automated dual mode bus would operate on the public streets as a conventional bus to pick up and discharge passengers. On longer high speed runs it would operate as a fully automatic vehicle on a private right-of-way. Thus, it offers the possibility for a system of public transit which combines the high speed capacity of a rail system operating on its private right-of-way with the flexibility and adaptability of a city bus. This flexibility would make it possible for the transit system to serve areas where the cost of extensive fixed rights-of-way could not be justified, and to minimize the number of transfers which the passenger would have to make.

"In the automatic mode, the vehicle would be powered electrically from an external source. While in the manual or street mode, propulsion might be initially from a turbo-electric power-plant. Eventually, an all-electric propulsion system could achieve minimum levels of noise and air pollution.

"Because of the relatively long headways between vehicles, the controls for intervehicle spacing, speed, switching, and stops are not as complex as those required by the personal rapid transit or small dual mode vehicle systems. Nevertheless, the controls will constitute a major portion of the research and development effort leading to a demonstration of the automated dual mode bus system. Significant efforts will also be required for the design and development of the guideway propulsion system and mainline stops for passenger entry and exit while the vehicles are operated automatically. The redistribution and effective use of vehicles and drivers during off-peak and manual operating periods will require careful analysis. Consideration has been given to the possible use of some of these vehicles as a Dial-a-Bus during off-peak hours.

"The automated dual mode bus could be developed and its feasibility demonstrated very likely within 5 years at a possible cost of less than $15 million."

5. PALLET OR FERRY SYSTEMS

"A corollary to the dual mode personal vehicle systems which would provide this type of service would use pallets to carry (or ferry) automobiles, minibuses or freight automatically on high-speed guideways."

"The system would provide high-flow capacities per lane, as well as automatic operations over long route segments. Loading and unloading might be automated, although the operations would have to be restricted to terminals with transfer equipment."

"While only a limited comparison of a pallet and dual mode system was made, the new system study concluded that each had certain advantages in particular applications. A federal program of research should examine both on the basis that a rail pallet system could initiate dual mode operation when a substantial portion of metropolitan guideways were converted. The feasibility of one form of rail pallet system could be demonstrated within 5 years at a cost of less than $25 million."

"The new systems study investigated all the conceivably feasible new types of fast intraurban transit links. At their best, they can be quieter, smaller, and less demanding in guideway requirements than current high speed intercity systems. Moreover, they can take less land, and can minimize adverse impact on areas adjacent to rights-of-way."

"If future intraurban link systems are to succeed where commuter lines have failed, they must be automatically controlled, with vehicles capable of operating either independently or coupled into trains. Automated systems of single-car trains would not require a large labor force to operate them, and could be easily adjusted to fluctuations in demand. Linear motors for propulsion, air-cushion support and suspension for the higher speed ranges, and automatic vehicle monitoring, ticketing, and ridership counting equipment, would all contribute to safe, reliable, flexible service."

"The development, test, and evaluation of the 20-passenger-per-car fast intraurban transit link system probably could be accomplished in less than 10 years at a cost of less than $50 million."

7. SYSTEMS FOR MAJOR ACTIVITY CENTERS

"The new systems study has identified several circulation systems which offer the potential for moving large numbers of people over short trips in a relatively small area and are capable of doing so safely, comfortably, economically, and with a minimum of waiting. Because modal separation is imperative under the congested conditions of travel in activity centers, such systems must operate on some kind of exclusive guideway."

"The most complicated part of these systems is the merging and spacing control. In the simplest type of system, operation would be in a single loop and the merging would occur only when cars left stations. Each vehicle being merged would proceed only if a slot were available; slots would not be deliberately created upstream of a merge point. Spacing would be uncontrolled except for the minimum amount necessary for emergency stops. Speed control would not be precise, but would be limited to the nominal system speed. More sophisticated versions are possible, verging on the personal rapid transit system described previously.

"If developed concurrently, the feasibility of one example of these types of systems could be demonstrated during a 5-year period at a cost of about $6 million per system for a total program estimate of $18 million. In order to fully develop, test, and evaluate a series of desirable systems which could be certified safe for public demonstration, a program extending over 10 years is estimated to cost approximately $118 million."

TABLE 13. PREDICTED TIME AND COST TO DEVELOP RECOMMENDED FUTURE TRANSIT SYSTEMS

Type of New Transit System	Predicted Years to Fully Develop	Predicted Cost to Develop and Demonstrate (Millions of Dollars)
Dial-a-Bus System	7	20
Personal Rapid Transit	10	250
Dual Mode Vehicle System	10	400
Automated Dual Mode Bus	5	15
Pallet or Ferry System	5	25
Fast Intraurban Transit Links	10	50
Systems for Major Activity Centers	10	118

ASSUMED DATA

The performance and service calculations in the intra-airport transit systems report are based on assumed data that are universally accepted among those manufacturers prepared to furnish the "A" transit system. The data reflect proven transit methods and equipment that assure a high level of safety and riding comfort.

Maximum acceleration and deceleration rates = 3.0 mph/sec

Maximum jerk rate = 1.5 mph/sec/sec

Average acceleration and deceleration rates = 2.5 mph/sec/sec

Maximum speed between parking lots and terminal loop = 45 mph

Maximum speed in parking lot loops and in terminal loop = 30 mph

Average speed between lot and terminal loop = 30 mph

Average speed in loops = 20 mph

Minimum headway = 45 sec

Minimum instantaneous time separation = 30 sec

Vehicle length = 30.5 ft

Rated vehicle capacity = 28 passengers

Maximum vehicle capacity = 55 passengers

Passenger vehicles per one baggage vehicle = 1 to 4

Passenger vehicles per two baggage vehicles = 5 or 6

Maximum train length = 8 vehicles = 244 ft

Maximum train capacity = 660 passengers

System design capacity

Parking Lot No. 2 = 4,400 pass./hr
Parking Lot No. 3 = 10,800 pass./hr
Parking Lot No. 4 = 4,800 pass./hr
Parking Lots No. 2, 3, & 4, combined = 20,000 pass./hr

Average dwell time = 12 seconds per station in its route (trains are assumed to bypass 50 to 80% of all stations).

DERIVED DATA

Performance and service data are derived using straightforward arithmetic relationships. Averaging techniques make allowance for operational methods that tend to group passengers into efficient groups.

Cycle time = elapsed time between successive movements past any point in a route = total run time, plus total dwell time, plus hold time

Total dwell time = the sum of all time periods berthed at station platforms

Hold time = an increase over run time plus dwell time to make cycle time equal to a multiple of headway

Number of trains required = cycle time divided by headway

During peak demand periods trains are assumed to berth at every other station (on the average)

At turnback stations (e.g., in Parking Lot No. 4) time allowed for unloading, turnback and loading = 44 seconds

Table 14 presents derived cycle times for all planned routes.

Table 15 tabulates passenger capacities and numbers of cars in service for Phases I, II and III.

TABLE 15 – CAPACITIES AND REQUIRED VEHICLES												
PHASE	SECTION	TRAINS PER HOUR	PSGRS PER TRAIN	PASSENGERS PER HOUR	VEHICLES PER TRAIN			TRAINS IN SERVICE	VEHICLES IN SERVICE		
					Passengers	Baggage	Total		Passengers	Baggage	Total
I	Parking Lot No. 2	40	110	4,400	2	1	3	10	20	10	30
(Design)	Terminal Loop				SAME						
I (Max)	Parking Lot No. 2, Max	80	330	26,400	6	2	8	20	120	40	160
	Terminal Loop				SAME						
II-A	Parking Lot No. 2	40	110	4,400	2	1	3	11	22	11	33
(Design)	Parking Lot No. 3	40	275	11,000	5	2	7	8	40	16	56
	Terminal Loop	80		15,400				19	62	27	89
II-A	Parking Lot No. 2, Max	40	330	13,200	6	2	6	11	66	22	88
(Max)	Parking Lot No. 3, Max	40	330	13,200	6	2	8	8	48	16	64
	Terminal Loop, Max	80		26,400				19	114	38	152
II-B	Parking Lot No. 2	20	220	4,400	4	1	5	6	24	6	30
(Design)	Parking Lot No. 3	40	275	11,000	5	2	7	8	40	16	56
	Parking Lot No. 4	20	275	5,500	5	2	7	6	30	12	42
	Terminal Stations	80		20,900				20	94	34	128
II-B	Parking Lot No. 2, Max	20	330	6,600	6	2	8	6	36	12	48
(Max)	Parking Lot No. 3, Max	40	330	13,200	6	2	8	8	48	16	64
	Parking Lot No. 4, Max	20	330	6,600	6	2	8	6	36	12	48
	Terminal Stations	80		26,400				20	120	40	160

TABLE 14 – ROUTE DISTANCES AND SCHEDULE TIMES											
PHASE	PARKING LOT	TWO-WAY DISTANCE (FEET)			RUNNING TIMES (SECONDS)			DWELL TIMES (SECONDS)			CYCLE TIME (SECONDS)
		20 MPH	30 MPH	Total	20 MPH	30 MPH	Total	Station	Hold	Total	
I	2	8,035	21,215	29,250	272	481	753	120	27	147	900
II-A	2	9,935	19,315	29,250	335	440	775	144	71	215	990
	3	11,415	6,920	18,335	388	157	545	144	31	175	720
II-B	2	9,935	19,315	29,250	335	440	775	144	161	305	1,080
	3	11,415	6,920	18,335	388	157	545	144	31	175	720
	4	15,615	6,900	22,515	532	158	690	244	146	390	1,080
III-A	2, 3 and 4	NO CHANGE FROM PHASE II-B									
and	5	8,325	19,600	27,925	283	444	727	240	113	353	1,080
III-B	6	8,325	19,250	27,575	283	437	720	240	120	360	1,080

POWER FACTOR

Because power factor penalties are incorporated in power bills, the anticipated low power factor will need correction. For the purposes of this study, the corrected average power factor is assumed to be 71% for sizing equipment, cables and substations; at the utility interface the power factor is assumed to average 85% for billing purposes.

A preliminary design of the traction power distribution system envisages a single power supply point with metering and protective relaying interfacing with the utility at 34.5 kv.

Here the power is transformed to 4.8-kv 3 phase alternating current for distribution to local substations situated along the transit system guideway. At the local substations, transformers with ratio 4.8:2.4 transform the power for use at the contact rails. The contact rails are connected throughout the loop system to provide load sharing between substations.

Circuit breakers at each substation permit sectionalizing of the loop should fault trouble develop in the power system. Removal of faulted sections will permit continued service in other areas via the by-pass or parallel guideways.

It is assumed that phase-controlled semiconductor devices will control direct current voltage to the vehicle traction motors. Without power factor correction, the alternating current load will suffer a power factor ranging from very low values up to about 80% and averaging about 50%. This is quite low and serious from the monthly power bill viewpoint where power factor penalties are incorporated in the rate structures. Further, low power factor directly degrades voltage regulation and may affect the location and number of substations.

It is expected that fixed capacitors will be installed on each vehicle to reduce radio interference, system harmonic content, and to increase power factor. Full power factor compensation without capacitor switching at the vehicle is not justified due to the increased dead load providing a weight penalty reducing payload and because the no load increase in voltage may cause further troubles in the distribution.

Probably the best compromise will show the need for the installation of some capacitors on the vehicle, some further installations of fixed capacitors at the local substations, and a bank of switched capacitors at the utility interface.

For the purposes of this study, the average power factor is assumed to be 71% for sizing equipment, cables and substations. At the utility interface, for billing purposes, the power factor is assumed to average 85%. Further study on this aspect may show that modification of these values is in order.

SUBSTATION CAPACITY AND LOCATION

Preliminary study has indicated that in Phase I, two local substations will be required in the World Way Loop and one at Parking Lot No. 2. In Phase II-A a substation will be required at Parking Lot No. 3 and an additional one in the World Way due to the added 1-W and 1-E passenger stations. In Phase II-B a substation will be required at Parking Lot No. 4 and an additional one due to the added stations at W-1, W-2, W-3 and W-4 if Stations 3 and 4 remain in operation. Although calculations have not been made on Parking Lots No. 5 and 6 for Phases III-A and III-B it is expected that a substation will be necessary at each lot and also at the Imperial Terminal when it is activated.

As already noted, substation capacity requirement changes with headway magnitudes. In Phase I substations (SS) could be located as follows:

SS-1 at Parking Lot No. 2 in the incoming and outgoing lines forming a "Y" to catch both ends of the loop.
SS-2 in the World Way Loop midway between Stations 2 and 3.
SS-3 in the World Way Loop midway between Stations 6 and 7/8.

For best customer service using a lot transit system integral with the World Way system the following ultimate capacities prevail for Parking Lot No. 2 operation:

Phase	Headway Min	Train Consist – Cars Passenger	Baggage	Passengers/Hour	Peak Capacity MVA at 71% pf
I	0.76	1	1	4330	2.34
II-A	2.9	4	1	4550	1.88
II-B	3.63	6	2	5450	2.54

It is to be noted that despite an increase in headway in Phase II-A, substation capacity requirement decreases due to the new Phase II-A World Way Loop substation SS-4 between station 1-W and 1-E. Since a maintenance yard is required in Parking Lot No. 2 during Phase I, it appears that 2.5-mva capacity would take care of the requirements in this area.

The following is an estimate of the propulsion power substation capacities required in the various phases:

	Phase I	Phase II-A	Phases II-B, III-A, III-B
SS- 1	2.3	1.9	2.5
SS- 2	1.4	2.6	3.3
SS- 3	1.8	3.3	4.1
SS- 4		1.7	2.2
SS- 5 Package Lot No. 3 Loop Y		3.9	5.0
SS- 6 Between W3, W 4			4
SS- 7 Package Lot No. 4 – end			2
SS- 8 Package Lot No. 5			2
SS- 9 Package Lot No. 6			2
SS-10 Imperial Terminal			2
Total	5.3	12.2	25 mva
At PF 0.85, 34.5 kv =	4.5	10.0	20 mva

The total ultimate capacity requirement appears to be about 25 mva which would amount to about 20 mva when power factor corrected for utility billing purposes on the primary side of the incoming 34.5-kv 3 phase transformer. These are ultimate capacities based upon projected 20,000 persons per hour peak.

Alternative A—Phase I

Utility power may be received from the 34.5-kv overhead line at a 3 phase, 60 Hertz, 55 C self-cooled transformer rated 3,750 kva having provision for boosting to 4,687 kva by fan cooling. Power is transformed to 4.8 kv and distributed to substations SS-1, SS-2 and SS-3. This is the superior installation as the irregular power demands are isolated from the general power consumption of the Airport.

Alternative B—Phase I

Since the earlier power demands are likely to be light, there is a possibility that reserve power in the existing substations may be sufficient to carry the load in a satisfactory manner. This means, however, multiple metering, possibly some voltage difficulties on the contact rails due to different sources, and only postpones the installation of Alternative A.

Beyond Alternative A, all substations should be fed from a single source switching station.

SUMMARY REPORT

PHASE II-A - CONCEPT EVALUATION
INTRA-AIRPORT TRANSPORTATION SYSTEM

LOS ANGELES INTERNATIONAL AIRPORT

Prepared For

LOS ANGELES DEPARTMENT OF AIRPORTS

Under

Contract No. DA-733

November 1968

By

TRANSPORTATION SYSTEMS CORPORATION

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I

INTRODUCTION

The initial Program Definition Phase of the Intra-Airport Transportation System developmental program defined the objectives, policies, and general system criteria — or, in other words, established "what is needed."

During the Phase I program preliminary system criteria were presented to twenty-three industry organizations who were invited to submit their design concepts and company qualifications. The Phase II-A program is an evaluation of the responsive industry concepts and company capabilities to determine, within the 1972 time-frame constraint, what types of systems best satisfy the established criteria — and which organizations exhibited a demonstrated total design, construction, operational, and management capability. The broad intent of the Phase II-A program was to determine "how the job can best be accomplished — and approximately how much should it cost."

Specific objectives of the Phase II-A Program are defined in Figure 1.

OBJECTIVES - PHASE II-A

EVALUATE INDUSTRY CONCEPTS and --

- **CLASSIFY POTENTIAL SYSTEM CONTRACTORS**
- **RECOMMEND SYSTEM TYPE**
- **RECOMMEND STATION CONFIGURATION**
- **RECOMMEND FUNCTIONAL OPERATION**
- **RECOMMEND IMPLEMENTATION STAGES**
- **ESTIMATE ORDER-OF-MAGNITUDE COSTS**
- **DEFINE NEXT PROGRAM PHASE**

Figure 1.

The Phase II-A program was accomplished as a team effort by Transportation Systems Corporation, Kaiser Engineers, and William L. Pereira and Associates, in collaboration with the Department of Airports Staff. This report summarizes the efforts of all three consultant contractors. Specific contractor contributions are identified in the various report sections.

Kaiser Engineers' primary tasks were the technical definition of system type and performance, and estimation of order-of-magnitude costs for the system proper. William L. Pereira and Associates defined the parking area distribution, station architectural arrangements, and preliminary station cost estimates. The respective efforts of the two consultant organizations are described in separate reports which supplement this summary report. Transportation Systems Corporation provided overall systems management, and conducted the functional analysis of passenger, baggage, and cargo handling capabilities of the system summarized in Appendix I of this report.

During the course of the Phase II-A program, the importance and urgency of developing airport ground transportation systems to relieve airport and airport access congestion was emphasized in the report of the National Academy of Engineering on Civil Aviation Research (Reference 1). The system concept under development for LAX is consistent with the National Academy recommendations.

II

SUMMARY AND CONCLUSIONS

The Phase II-A Concept Evaluation summarized herein is an interim step in the second phase of a four part program to develop an Intra-Airport Transportation System for Los Angeles International Airport. A plan for the total program and establishment of preliminary design criteria were accomplished in the earlier Program Definition Phase reported in Reference 2. The preliminary criteria were presented to twenty-three industry organizations who were invited to present their concepts and capabilities. Significant contributions were made by the responding industry organizations. The Department of Airports subsequently requested an evaluation of the industry concepts and capabilities prior to preparation of definitive bid specifications for system design, construction, and operation. The evaluation was conducted as a team effort by the three consultant contractors; Transportation Systems Corporation, Kaiser Engineers, and William L. Pereira and Associates.

The Phase II-A program was authorized by the Board of Airport Commissioners August 14, 1968 and was scheduled for completion on 1 October. Due to the complexity of defining the system configuration to the extent necessary to establish meaningful cost estimates, a 30 day extension was granted. In addition to the study and engineering effort, a total of eight coordination meetings, attended by each consultant firm and the Department of Airports, were held during the ten week period. A ninth meeting was held with the FAA local and regional personnel to discuss the intended land use of the runway clear zone areas. A tenth meeting, a briefing to the Department of Airports staff on the Phase II-A study results, was held 15 October 1968. Minutes of all meetings were documented and are on record.

It became obvious during the early coordination meetings that the system design capacity of 5,000 seated, and 10,000 total peak-hour passengers, originally established in Phase I, was too low. More accurate data on passenger/visitor ratios, and reassessment of central versus remote parking distribution consistent with terminal design criteria resulted in increasing the transit design capacity to 10,000 seated, and 20,000 total, one-way peak hour passengers. While this did not affect the industry concept and capability evaluation per se, it did influence the final recommendation as to general system type. It is considered essential that the system finally selected not only be a high capacity system with extreme operational flexibility, but must have an inherent capability to expand as dictated by future air traffic growth. The expansion capability should be accomplished by the addition of vehicles to the network and modification of scheduling and operational procedures without major capital expenditure.

During the course of the evaluation several additional firms presented their concepts. These did not alter the results of evaluation since the concepts were quite similar to those already investigated.

The FAA discussion of the intended use of runway clear zone areas disclosed several problems which will require investigation or tests. These include determination of acceptable levels of system electromagnetic interference with ground and aircraft navigational equipment, and the effect of ground illumination, or halo, under nighttime conditions of fog and limited visibility. Neither of these are insurmoutable problems and should not delay the program.

The Phase II-A briefing to the Department of Airports staff resulted in general agreement with the evaluation results. Primary conclusions and recommendations resulting from the Phase II-A efforts of the three organization consultant team are as follows:

Conclusions

1. Conventional, bottom supported, transit type vehicle systems (Type A) are the most fully developed -- and offer the greatest possibility of providing a fully operational reliable system by 1972. Such systems should embody the latest proven technical innovations resulting from evolutionary rather than revolutionary development.

2. A conventional transit vehicle system is capable of meeting all presently established technical, functional, and operational criteria.

3. A conventional large vehicle system is capable of handling peak loads well in excess of 20,000 passengers per hour, with a maximum transit time from any remote lot to any station (or return) of approximately 3 to 4 minutes under peak load conditions.

4. Small personalized vehicle, origin-destination systems (Type B) are not yet fully developed and would involve high developmental costs and technical risk. Many systems, however, have excellent concepts and considerable future potential.

5. Full operational capability of a small vehicle personal service system does not appear likely until the 1975-80 time period. Development of the complex computer management devices

associated with these systems is considered to be the major problem area.

6. Only five of the eighteen organizations evaluated appear to have demonstrated experience in all essential categories. The number of qualified potential suppliers makes competitive procurement feasible.

7. Each of the five organizations is considered managerially and financially capable of ensuring an operational system by 1972.

8. Only three of the eighteen organizations considered the baggage and cargo handling problems in depth.

9. The capability of carrying passengers, baggage, and cargo on a single network is a major factor in the economic viability of the intra-airport transit system.

10. The total transit system cost, including remote parking development, will be less than the cost of providing equivalent parking in the central terminal complex.

11. The Phase II-A Concept Evaluation further substantiates the earlier Phase I study findings:

    - The system should provide a high level of passenger convenience -- and passenger time saving.

    - The remote parking and intra-airport transportation concept will reduce traffic congestion in the central terminal area and on the aircraft loading aprons.

    - The system should be capable of future expansion to match the ultimate capacity of the airport.

    - The transportation system could provide an important source revenue for the airport -- and an equally important source of operating cost reduction for the airlines.

<u>Recommendations</u>

1. The Phase II-B Technical Performance Specifications be written around a conventional state-of-the-art system incorporating proven technical developments.

2. The Management Specifications should establish bidder qualifications requiring substantiation of prior engineering, manufacturing

and system operational experience.

3. The specifications should require baggage, cargo, and passenger carrying capability on a single, or combined network.

4. Construction of the system should be implemented in Phases. The first phase to include the Central World Way loop and a spur to remote parking lot #2.

5. A development test program should be established in Phase II-B to work out all developmental problems on the initial system prior to construction of subsequent phases.

6. The program should proceed with high priority.

III

INDUSTRY CONCEPT EVALUATION

Technical concepts of the systems presented by the eighteen responding industry organizations and associated subcontractors, were evaluated during the Phase II-A program. All members of the Project Team participated in the evaluation. Supporting information was re-examined and each technical concept was categorized according to system type and operation, vehicle type and suspension, guideway and switching, and propulsion and control method. The data were summarized in matrix form to facilitate correlation. Significant results of the technical comparison of the eighteen systems are summarized in Figure 2.

The proposed concepts fall within two general system categories: (A) Conventional Urban Rapid Transit, and (B) New Technology Small Vehicle Transit. Presentations ranged from sophisticated multi-personnel industry team efforts to one-man briefings of concept only.

TECHNICAL CONCEPTS

OF THE 18 RESPONDING ORGANIZATIONS --

- NINE PROPOSED MULTIPLE STOP SYSTEMS
- SIX PROPOSED SELECTIVE ORIGIN-DESTINATION SYSTEMS
- ONE PROPOSED A CONTINUOUS MOVING SYSTEM
- TWELVE WERE SUPPORTED -- SIX WERE SUSPENDED
- ALL HAD SWITCHING CAPABILITY -- ALTHOUGH SOME HAD SEVERE SWITCHING LIMITATIONS
- ALL WERE ELECTRICALLY POWERED

Figure 2.

Average car capacity was 19 seated passengers -- 8 standees. It should be noted that the car capacities were based on the originally specified system design capacity of 5,000 seated (10,000 total) passengers per hour.

Subsequent analysis and evaluation concentrated on examination of the proposed concepts with respect to criteria compliance, including status of technological development. The primary purpose of the evaluation being to determine a system type, which can be fully operational by 1972, based on the correlation of significant system characteristics. A secondary objective was to determine which system types showed the most promise for development within a somewhat later time frame, i.e. 1973 to 1975.

A tabular summary of the industry concept comparison is presented in Figure 3.

TECHNICAL SUMMARY - INDUSTRY CONCEPTS

TECHNICAL CATEGORY	TABULATED RESULTS
METHOD OF OPERATION	9 multiple stop, 6 selective O. D., 2 concepts only, 1 continuous moving
VEHICLE AND SUSPENSION	
Seated pass/vehicle	19 average
Standees/vehicle	8 average
Maximum speed (m. p. h.)	35 m. p. h. average
Cars per train	3 average
Supported/suspended	12 supported, 4 suspended, 2 suspended/supported
Running wheels or supporting device	5 steel wheels, 8 rubber tires, 1 plastic wheel, 1 air cushion, 1 conveyor, 2 undefined
GUIDEWAY TYPE	7 horizontal guide wheels 3 dual rails 1 air cushion 1 follower in guideway 1 belt or chain 4 beam or channel structure 1 undefined
SWITCHING METHOD	2 conventional split switch 3 in vehicle 2 in roadway 4 moveable or flexible beam 1 linear motor 1 air lift 3 maintenance switching only 2 undefined
PROPULSION METHOD	12 rotary motor 3 linear motor 1 motor driven conveyor 2 undefined
CONTROL METHOD	9 central computer 1 preprogrammed electro-mechanical 1 preprogrammed electrical 1 closed circuit television 1 operator monitored 5 undefined

Figure 3.

IV

INDUSTRY CAPABILITY EVALUATION

Industry capability was evaluated by the Project Team using a methodology similar to that utilized in the foregoing technical comparison. In fact, the technical and capability comparisons were conducted simultaneously since they are mutually dependent. Both were based on the material presented and distributed by the industry organizations.

Primary criteria applied to the evaluation were technical capability, production capability, and operational capability. Both demonstrated experience and potential capabilities were considered. The significant results of the comparison are presented in Figure 4.

CAPABILITY COMPARISON

OF THE 18 ORGANIZATIONS EVALUATED --

- NINE HAVE DEMONSTRATED ENGINEERING EXPERIENCE
- NINE HAVE DEMONSTRATED MANUFACTURING EXPERIENCE
- SIX HAVE DEMONSTRATED OPERATIONAL EXPERIENCE
- ONLY FOUR RATED HIGH IN ALL EIGHT CATEGORIES - A FIFTH RATED HIGH IN SIX OF THE EIGHT
- NONE OF THE OTHERS RATED HIGH IN MORE THAN FOUR CATEGORIES

Figure 4.

Thus the correlation narrowed the field to five organizations having the demonstrated capability of providing an operational system by late 1971 or early 1972, in compliance with the defined criteria.

Each of the five organizations is considered financially and managerially capable of constructing and guaranteeing the successful operation of a project of this complexity and size. Although the other organizations undoubtedly are capable, their lack of demonstrated experience in certain fields, or the developmental status of their concept, indicates a higher degree of risk.

The analysis confirmed the existence of a sufficient number of potential bidders to make competitive procurement feasible and was not intended to limit the maximum number of bidders.

A tabular summary of the capability comparison is presented in Figure 5. The first two columns define the contractor-subcontractor relationship. The subsequent categories relating to experience and criteria compliance are listed in order of relative priority.

CAPABILITY SUMMARY - INDUSTRY ORGANIZATIONS

CAPABILITY CATEGORY	TABULATED RESULTS
PRIME CONTRACTOR	12 prime, 3 joint venture, 3 unspecified
ASSOCIATE CONTRACTORS	9 with associates, 9 unspecified
ENGINEERING EXPERIENCE	9 demonstrated, 5 limited, 4 undemonstrated
MANUFACTURING EXPERIENCE	9 demonstrated 4 limited, 5 undemonstrated
OPERATIONAL EXPERIENCE	6 demonstrated, 5 limited, 7 undemonstrated
SYSTEMS EXPERIENCE	6 demonstrated, 5 limited, 7 undemonstrated
RESEARCH & DEVELOPMENT EXPERIENCE	9 demonstrated, 6 limited, 3 undemonstrated
SCHEDULE COMPLIANCE	5 definite, 4 possible, 9 questionable
TECHNICAL STATUS	5 qualified, 7 developmental, 4 experimental, 2 concept only
OVERALL CAPABILITY	8 high, 7 medium, 3 low
SYSTEM TECHNICAL CONCEPT	4 excellent, 10 good, 2 fair, 2 poor
CRITERIA COMPLIANCE	11 high, 7 low

Figure 5.

V

SYSTEM CONFIGURATION

The preliminary system criteria, established in the earlier Phase I program, emphasized the desirability of origin-to-destination service, i.e. service from any parking area to any terminal without transfer, and preferably without intermediate station stop. While some concepts proposed by industry met this requirement better than others, all of the proposed systems are capable of origin-destination service if the following conditions are met:

1. Switching capability is provided.

2. Turnouts, or bypasses, are provided at each station stop.

3. Specific terminal stations have a correspondingly identified station loading area in each remote parking lot.

Simplicity, flexibility, safety, and reliability also were specified as fundamental criteria.

General System Type

Examination of the system technical characteristics and company capability narrowed the field to five potential system suppliers as previously noted. The transit systems proposed by the five organizations are very similar and all fall within the Type "A" category -- conventional urban transit. All include the use of vehicles with capacities of at least 30 passengers, with the vehicles connected into variable-length trains. Single car operation also is possible, during off-peak hours. Operation of each of the systems includes multiple stops at all or part of the stations and they all load and unload while statically berthed at station platforms. Each of the five noted systems is capable of switching into and out of a central loop and onto sidings or turnouts. Each is capable of handling a relatively high volume of passengers within relatively short time periods, and with high levels of comfort and safety. Transit times are less than comparable automobile travel time.

Examination of the Type "B", or new technology personal transit systems, disclosed that whereas many of these emerging system types had excellent concepts and future potential as intra-airport transportation devices, their technical state of development was not sufficiently advanced to warrant consideration for a high capacity system at this time. This determination is substantiated by the recent studies conducted for the Department of Housing and Urban Development (H. U. D.), which indicated that comparable advanced technology systems probably would not be fully demonstrated within the next decade and ultimately would require developmental expenditures approaching $250-400 million. (Reference 3)

The parking distribution and system capacity study conducted by Wm. L. Pereira and Associates during the Phase II-A program determined that approximately 15,000 one way passengers and visitors would use the system during a peak hour enplaning hour in the 1972-75 time period. Since this forecast is subject to many variables which can alter the value significantly in either direction, it was established that a 20,000 passenger per hour capacity would be specified as a maximum design value.

Based upon these findings, Kaiser Engineers conducted an extensive route alignment and system performance study using a representative Type "A" system. Results of their analysis are contained in Kaiser Engineers' Phase II-A Engineering Report, (Reference 4) which is a supplement to this summary document. The primary objectives of the study were to:

- Determine route feasibility.
- Formulate a general description of a recommended system, including operating performance and maximum peak/hour capacities.
- Develop order-of-magnitude costs on an incremental and total basis.
- Provide recommendations as to the type of advanced design systems which could be developed within the 1973 to 1975 time period if increased resources were available.

Results of the engineering study are summarized in the following paragraphs.

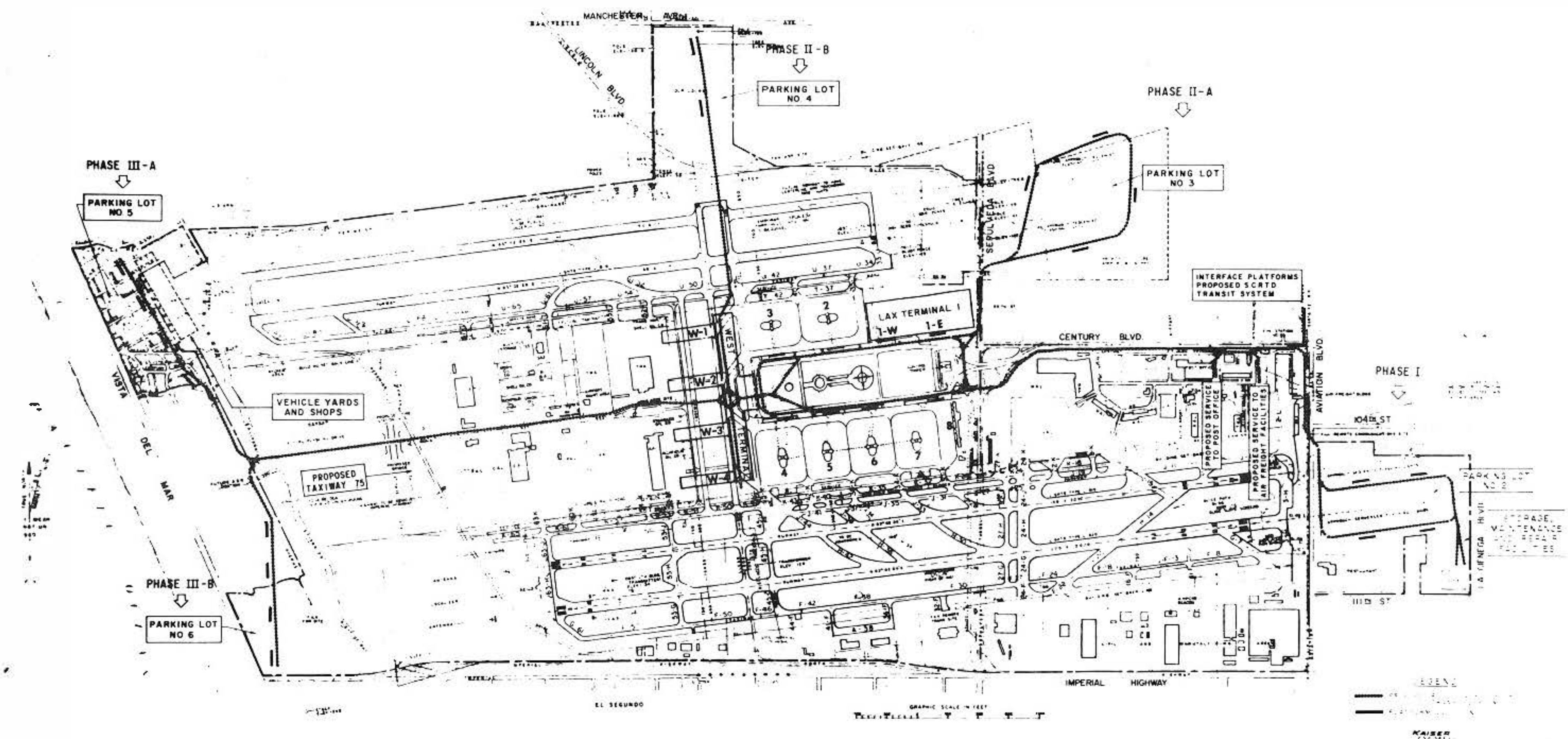
Route Configuration

The recommended route alignment of the total system is shown schematically in Figure 6. Turnouts are provided at all Terminal locations, except 7 and 8, which use a combined station. Four stations are provided in each of the remote parking lots, except Lot #4 which has two stations. A total of twelve passenger terminal stations, and eighteen parking lot stations are presently planned. A relatively constant track level is maintained around the World Way loop at an elevation of +16 feet, or 31 feet above World Way street level. Satellite Terminal platforms are at third deck level. Further

ROUTE ALIGNMENT DRAWING NO 1

PROPOSED LOS ANGELES INTRA AIRPORT TRANSIT SYSTEM

OVERALL PLAN



simplification of the interconnection between the Central Loop and the West Underground Terminal is desirable and will be studied in the next program phase.

Vehicle Configuration

Vehicles should have the following general characteristics:

- Should comfortably accommodate at least thirty seated passengers.
- Should be capable of operating singly, or connecting into variable length trains.
- Bottom supported, either using rubber tires or flanged steel wheels.
- Must be capable of switching.
- Doors should be provided on both sides of the cars.

Guideway Type

- Must incorporate reliable, fast, switching devices of a proven type.

Propulsion and Control

- Propulsion should be electric using conventional rotary motors.
- Should utilize way-side contact rail.
- Electrical system should be adequately shielded to prevent electrical interference with aircraft and airport electronic and communications equipment.
- System should have central management control.

Kaiser Engineers' performance studies indicate that a typical representative system would have an ultimate peak-hour capacity of 26,400 passengers one way. Maximum travel time between most distant stations would be 10.4 minutes. Maximum waiting time would be 8.6 minutes with an expected average station wait of 2.6 minutes for the initial implementation phase and 4.1

minutes when Phase II-B (Lot #4 - West Terminal) is operational.

Expansion Capability

Selection of a representative system type was dictated to a large degree by the potential of the system, through its inherent design characteristics, to not only accommodate wide variations in passenger volume but also to expand as necessary to meet future traffic growth. The recommended system type best satisfies these requirements.

VI

STATION CONFIGURATION

Station platforms can be categorized into three general types -- Remote Parking Area Stations, Satellite Terminal Stations, and Underground Terminal Stations. Schematic diagrams of the three station types are shown in Figure 7. Turnouts are provided at each station to facilitate passenger and baggage loading. Detailed architectural drawings have been prepared by William L. Pereira and Associates who were primarily responsible for station configuration and order-of-magnitude cost estimates for station construction. Results of their studies are contained in Reference 5, which is supplemental to this report.

PLATFORM ARRANGEMENT

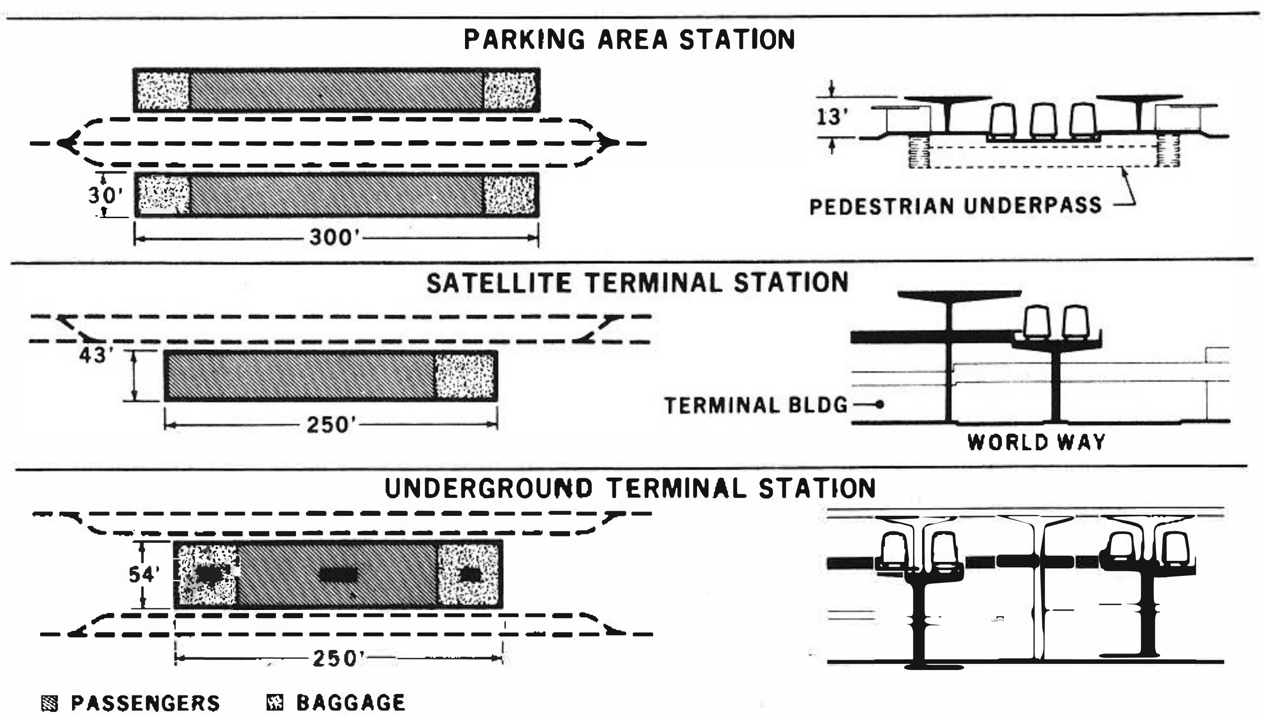


Figure 7.

Remote Parking Area Stations

Stations in each of the remote lots will be essentially identical, although some lots will have four stations, and some as few as two. The station structures will be low in profile -- well under the F. A. A. required 50:1

glide path envelope and will include an underground pedestrian walkway connecting the two station platforms. Baggage loading/unloading will be accomplished at the extreme ends of the platforms. Transit tracks will be on-grade at each of the remote lot stations.

Satellite Station Platforms

A typical Satellite station platform arrangement is shown in Figure 7. The transit system track loop around World Way is at third story level. This elevation provides adequate platform width and optimizes passenger and baggage flow. A lower track elevation, at second story level, also was investigated but was discarded since it had limited width and relatively poor passenger and baggage circulation.

Baggage loading is accomplished at the end of the platform as shown. A platform length of 250 feet is recommended, however, the length can be extended if necessary at a later date. Consideration also is being given to providing a continuous circulation walkway between Satellites at second deck level. The station platform could likewise be continuous if desired. Station platforms are recommended at Satellites 2, 3, 4, 5, 6, with a combined platform at Satellites 7 and 8. These would be constructed in the initial implementation phase.

Underground Terminals

The station platform arrangement of the planned Underground Terminals is shown in the lower diagram of Figure 7. Two arrangements were investigated: (1) a central track routing with turnouts and platforms on either side, and (2) a central station platform with tracks on either side. This second arrangement was selected for the following reasons:

- Simplifies passenger and baggage circulation.
- Wider station platforms. Provides greater flexibility.
- Eliminates requirement for dual escalators and baggage conveyors.

The trackage would be supported by the vertical support columns of the terminal structure itself, eliminating the need for special supporting structure.

Future Ticketing Terminals

It is recommended that consideration be given to the possible future addition of ticketing terminals in the remote lots. An extension of the track loop in the remote parking lot, or an additional turnout, would be the only modification required in the transit system. The remote ticketing terminals would further reduce congestion in the central complex and would provide an important source of additional revenue from concessions, rentals, etc.

Future SCRTD Interchange

Addition of a passenger-cargo interchange station at Century and Aviation Boulevards also is recommended as a possible future development in the event the SCRTD system is constructed. Such a station would provide direct transfer of passengers and off-airport assembled cargo containers from the planned SCRTD line to the Intra-Airport Transit System. Direct rail connection would then be provided to all portions of the city served by the Southern California Rapid Transit District transit network.

VII

FUNCTIONAL OPERATION

Two fundamental considerations exist in the design of an Intra-Airport Transportation System. The first, the mechanical design and system management is well recognized and is fundamental. A second, but equally important design consideration is the capability of the system to function as a transportation device — in other words, its ability to move people, baggage and cargo efficiently and at minimum cost. This second consideration, peculiar to airport transportation, often is unrecognized. Yet, the ability of the system to handle these combined functions efficiently may be the primary factor in its success as an economic investment.

Industry Concept Evaluation

The system concepts of the eighteen responding industry organizations were evaluated with respect to their ability to carry passengers, baggage, and cargo on the system network. Comparative results are summarized in Figure 8.

FUNCTIONAL EVALUATION

BAGGAGE AND CARGO HANDLING CONCEPTS OF THE 18 ORGANIZATIONS --

- **THREE PROPOSED A COMMON SYSTEM NETWORK FOR PASSENGERS/BAGGAGE/CARGO**
- **SEVEN PROPOSED A COMBINED PASSENGER/BAGGAGE NETWORK**
- **FIVE PROPOSED A SEPARATE CARGO NETWORK**
- **SEVEN REQUESTED CONTRACTS TO STUDY THE PROBLEM**
- **ONLY THREE HAD INVESTIGATED THE BAGGAGE HANDLING PROBLEM IN ANY DEPTH**

Figure 8.

The functional capabilities of the various systems evaluated are compared in Figure 9. Detailed examination of the concepts and supporting data indicated that most companies concentrated primarily on passenger transportation, almost to the exclusion of other load carrying capability, including baggage. In fact, seven of the eighteen companies did not specify how they would accommodate baggage — and ten did not describe their cargo carrying capability. This lack of consideration undoubtedly stems from the fact that the requirement for airport ground transportation systems has only recently emerged and most organizations have not previous addressed themselves to the problem. Recognition of this fact, and awareness of the complexity of the airport transportation problem, is well illustrated in the tabulation chart. Seven, or approximately 40% of the companies, suggested they be given preliminary study contracts to conduct a systems analysis before proceeding with system design. It is significant that the seven companies were predominantly those who had given most consideration to the baggage and cargo handling and identification needs of the airport and airlines and recognized the problem complexity. Three of the seven apparently had studied the problems in some depth, as reflected in their presentation material.

Functional Analysis

Due to the importance of defining the system load carrying capabilities, an analysis of airport baggage and cargo operations was made by Transportation Systems Corporation in the Phase II-A program. The objective of the study was to optimize the baggage and cargo handling operations with respect to transit system design. Operational flow charts were constructed to diagrammatically compare passenger, baggage, air mail, and air cargo operations. The charts provide a method of determining optimum handling procedures, transit vehicle types, and station platform configuration and equipment requirements. The study report is reproduced as Appendix I. Key observations and recommendations are summarized in the following paragraphs.

Baggage Handling

With the exception of small carry-on luggage, baggage check-in and claim is recommended to be accomplished in the remote parking lots. Check-in and transit loading of baggage is recommended to be accomplished by the ticketing airline. This procedure will require allocation of specific parking lot areas and station platforms to individual airlines. A plan for accomplishing this is presented as Figure 10 and described in Appendix I. Assignment of baggage handling responsibility and specific parking lot areas to the

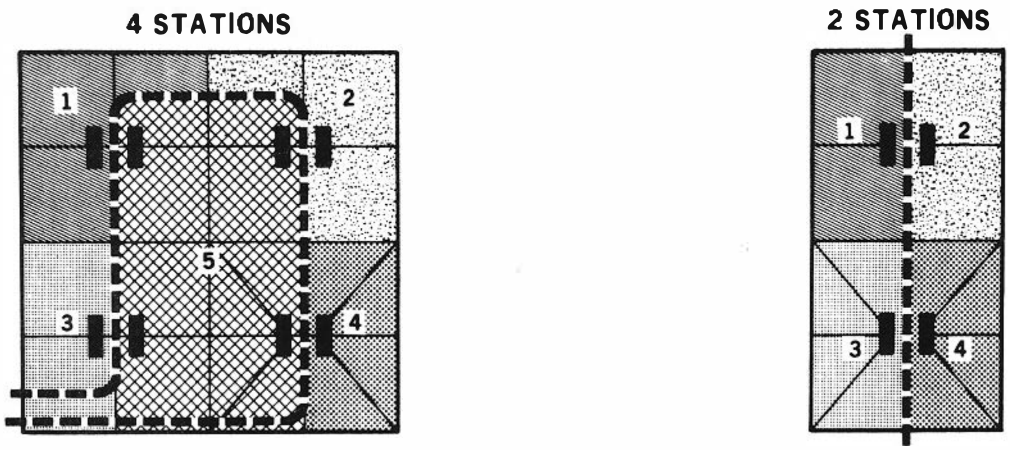
INDUSTRY COMPARISON - BAGGAGE AND CARGO CAPABILITY

CATEGORY	TABULATION
SYSTEM CAPABILITY	12 stated a total capability (passengers, baggage, cargo), however 3 did not specify how baggage would be carried, and 6 did not specify how cargo would be carried.
BAGGAGE NETWORK	7 combined passenger/baggage networks 1 combined baggage/cargo networks 3 separate passenger/baggage/cargo networks 7 not specified
CARGO NETWORK	5 separate cargo networks 3 combined passenger/baggage/cargo networks 10 not specified
VEHICLES	3 proposed separate baggage cars 2 proposed container flat cars
ANALYTICAL STUDY	Recommended by 7 organizations

Figure 9

airlines is consistent with current airport operational procedures and would provide a level of service acceptable to both the passengers and the airlines. Pre-loading of aircraft belly cargo containers with baggage at the remote parking lot stations also is a future possibility.

REMOTE PARKING ASSIGNMENT



- AREAS 1 THRU 4 ASSIGNED TO FOUR DIFFERENT AIRLINES
- AREA 5 SERVES ALL OTHERS
- EACH ASSIGNED LOT IDENTIFIED BY -
  1) COLOR CODE
  2) LOT AND AREA NUMBER
  3) AIRLINE

- AREA BOUNDARY FENCES CAN BE RELOCATED TO CHANGE LOT SIZE
- REMOTE LOTS CAN BE FURTHER SUBDIVIDED INTO SIXTEEN SECTIONS IF REQUIRED

Figure 10.

Cargo Handling

It is strongly recommended that the initially installed system be capable of carrying the B-747 type belly loaded cargo container, which also will be standard for the forthcoming DC-10 and L-1011 aircraft. Movement of fully loaded cargo and mail containers from the Cargo City area to the airline terminals on the transit network not only should result in significant cost savings to the airlines, but should provide an important source of revenue to the airport. Congestion on the ramp areas and airport internal roadways also would be greatly reduced. Providing this capability in the initial system will permit early development of cargo scheduling and handling procedures which will be essential in the later 1975 -80 time period. This capability can easily be provided by installing station platforms and turnouts adjacent to Cargo City and the Airport Post Office. A simple flat car, or gondola car, with a roller surface will be required, and would accommodate baggage, cargo, and mail containers. A single design container loading/unloading device should be suitable for each type container. The device could either be portable, or integral with the station platform. A movable, or truck mounted, device would appear to have most merit. Operational responsibility for cargo and mail handling on the transit system should be assigned to the individual airlines.

Vehicle Types

Three types of transit cars, or vehicles, will be required to achieve full system operational capability, as shown in Figure 11. Car quantity requirements for the various implementation phases are discussed in the Phase II-A Technical Report of Kaiser Engineers.

Operational Procedures

Recommendations on assignment of, and operational responsibility for, baggage and cargo handling are summarized in Figure 12 and are described in Appendix I.

VEHICLE TYPES

PASSENGER CAR	-	INTERNAL BAGGAGE COMPARTMENT FOR HAND LUGGAGE
BAGGAGE CAR	-	MODULAR BAGGAGE/MAIL COMPARTMENTS - EXTERNALLY LOADED
CONTAINER CAR	-	FLAT CAR WITH ROLLER SURFACE FOR BAGGAGE AND CARGO CONTAINERS

Figure 11.

BAGGAGE HANDLING PROCEDURES

- REMOTE PARKING LOTS - AND STATION PLATFORMS - ASSIGNED TO SPECIFIC AIRLINES
- AIRLINES RESPONSIBLE FOR BAGGAGE CHECK-IN AT REMOTE LOTS
- DEPLANING PASSENGERS IDENTIFY BAGGAGE AT CENTRAL TERMINAL BAGGAGE CLAIM AREAS
- AIRLINE LOADS BAGGAGE ABOARD TRANSIT AND DISPATCHES TO PASSENGER-SPECIFIED REMOTE LOT
- BAGGAGE OFF-LOADED BY AIRLINE AND PLACED IN CLAIM AREA AT REMOTE LOT STATION

Figure 12.

VIII

IMPLEMENTATION PHASES

The unique developmental nature of intra-airport transportation; the time-phasing of planned airport access and terminal construction; and the availability of funding — each dictate a carefully planned phasing of system implementation. The implementation plan must be inherently flexible to respond to the constantly changing requirements of the airlines and aircraft and ground transportation technology.

A phased construction and operational program is recommended. The phasing sequence is based on presently known conditions, however, with each stage separately identified, the individual phases can be combined, or their relative timing changed to adjust to future situations. The proposed implementation plan, shown on Figure 13, relates level of service, parking lot construction, and terminal and transit system construction.

IMPLEMENTATION PHASES

PHASE	TRANSIT SERVICE	PARKING LOT CONSTRUCTION	TERMINAL CONSTRUCTION	TRANSIT CONSTRUCTION
I	• SATELLITES NO. 2, 3, 4, 5, 7 AND 8	• REMOTE LOT NO. 2 INCREASED TO MAXIMUM SIZE	• MODIFICATION OF EXISTING SATELLITES	• CENTRAL TERMINAL LOOP • LOT NO. 2 SPUR • POST OFFICE, CARGO CITY, AND SCRTD STATIONS (PROV)
IIA	• EXISTING SATELLITES AND • UNITED TERMINAL	• REMOTE LOT NO. 3	• UNITED TERMINAL STATIONS 1E AND 1W	• LOT NO. 3 SPUR
IIB	• SATELLITES • UNITED TERMINAL • WEST TERMINAL	• REMOTE LOT NO. 4 • REDUCE SIZE OF LOT NO. 1 FOR WEST TERMINAL CONSTRUCTION	• WEST TERMINAL	• LOT NO. 4 SPUR • CENTRAL LOOP INTERCHANGE TO WEST TERMINAL
IIIA	• SATELLITES • UNITED TERMINAL • WEST TERMINAL • WORLD WAY WEST	• REMOTE LOT NO. 5 • TRANSIT SYSTEM MAINTENANCE YARD IN LOT NO. 5		• LOT NO. 5 SPUR
IIIB	• SATELLITES • UNITED TERMINAL • WEST TERMINAL • WORLDWAY WEST	• REMOTE LOT NO. 6		• LOT NO. 6 AND CONNECTION TO LOT NO. 5 SPUR
IV	• SATELLITES • UNITED TERMINAL • WEST TERMINAL • WORLD WAY WEST • IMPERIAL TERMINAL		• IMPERIAL TERMINAL	• LOOP FROM WEST TERMINAL TO IMPERIAL TERMINAL VIA MANCHESTER TUNNEL

Figure 13.

Implementation of the Central Complex Loop and a spur to Remote Parking Lot #2, as an initial step, will provide the earliest relief for the central terminal area congestion. This initial system also will provide a means of developing system management and scheduling procedures directly applicable to the ultimate system. Due to the operational complexity of such a system it is not possible to predetermine all operating procedures. Many of these can best be worked out on a developmental test basis and applied to subsequent portions of the system.

Primary attention has been given to Implementation Phase I since it not only provides the heart of the system but also encompasses all operational aspects of the ultimate system including cargo, mail, including an interface with the planned SCRTD rail transit.

Implementation Phases II-A and II-B will provide maximum relief in the central area parking and circulation congestion. This is substantiated by the large capacity of Remote Parking Lots #3 and #4 and the direct alignment of the system routing to the planned Underground Terminals which will account for a significant portion of system demand.

Phases II-A and II-B should be implemented concurrently with construction of the planned Underground Terminals as they provide the most direct access to those facilities. Timing of Phases II-A and II-B also is related to construction of the Laurel Canyon Freeway since access to Remote Lot #4 is relatively poor at present.

Phases III-A and III-B would be implemented as parking area demand increases and could be combined. The geographical location of Remote Parking Areas #5 and #6, and their proximity to the airline maintenance areas suggests primary assignment of these lots to employee parking. Location of the transit system maintenance and car storage yard in Lot #5 will provide a means of introducing cars to the system prior to the morning peak demand. The early cars also would provide employee transportation to the aircraft maintenance areas and central terminal complex. Parking Lot #6 will become increasingly important in the future as access is improved with construction of the Imperial and Coast Freeways.

Implementation of Phase IV would be concurrent with construction of the Imperial Terminal. Due to the current lack of definition of this program the Phase VI system alignment has not been studied and may change significantly from the route presently identified.

Figure 14 shows the recommended functional development of the remote parking lots, in concert with the proposed system implementation phases.

Sequenced implementation of the transit system poses certain procurement problems involving competitive bid pricing, contract awards by program phase, etc., which will require definition prior to release of the initial bid specifications. A more detailed description of the construction requirements, route alignment, and system performance of each implementation phase is presented in Kaiser Engineers Phase II-A Engineering Report (Reference 4).

FUNCTION - REMOTE PARKING LOTS

PHASE	LOT #1 FUNCTION	LOT #2 FUNCTION	LOT #3 FUNCTION	LOT #4 FUNCTION	LOT #5 FUNCTION	LOT #6 FUNCTION
I	Short term parking plus valet, U-drive, taxis, buses, etc.	. Long term parking plus short term overflow . System maintenance yard				
II-A	Short term parking plus valet, U-drive, taxis, buses, etc.	. Long term parking plus short term . System maintenance yard	Short and long term parking - All terminals			
II-B	Short term parking plus valet, U-drive, taxis, buses, etc.	. Long term parking plus short term overflow . System maintenance yard	Short and long term parking - United and satellite terminals	Short and long term parking - West Terminal		
III-A	Short term parking plus valet, U-drive, taxis, buses, etc.	. Long term parking plus short term overflow . Transit car storage	Short and long term parking - United and satellite terminals	Short and long term parking - West Terminal	. Employee parking . Transit system maintenance yard (Transferred from Lot #2)	
III-B	Short term parking plus valet, U-drive, taxis, buses, etc.	. Long term parking United and satellite terminals plus short term . Transit car storage	Short and long term parking - United and satellite terminals	Short and long term parking - West Terminal	. Employee parking . Transit system maintenance yard	. Employee parking . Short and long term parking - West Terminal
IV	Short term parking plus valet, U-drive, taxis, buses, etc.	. Long term parking United and satellite terminals plus short term overflow . Transit car storage	Short and long term parking - United & satellite terminals	Short and long term parking - West Terminal	. Employee parking . Transit system maintenance yard	. Employee parking . Short and long term parking - West and Imperial Terminals

Figure 14.

IX

PHASE II-B PROGRAM

The scope of the next program phase, Phase II-B, is outlined in this section. The Phase II-B program tasks will include:

1. Investigation and analysis to determine specific design requirements necessary for specification definition.
2. Preparation of technical and management bid specification documents. It is intended that separate specifications be prepared for technical and management requirements. Outlines of the two specifications are contained in Appendices II and III.
3. Develop bid evaluation criteria. It is desirable that general evaluation criteria be developed concurrently with the specification preparation. The specific weighting and evaluation comparison of the submitted bids will be accomplished in program Phase III.

The Phase II-B Program will be accomplished in two steps as shown in Figure 15. The first step, the requirements analysis, will include analytical studies and technical investigation. The subsequent effort will be the writing of the specifications and concurrent establishment of evaluation criteria.

PHASE II-B PROGRAM

CONTRACT TASKS

I. ESTABLISH DESIGN CRITERIA

II. DEVELOP PERFORMANCE SPECIFICATIONS

SCHEDULE

REQUIREMENTS ANALYSIS

PREPARE TECHNICAL SPECIFICATIONS

PREPARE MANAGEMENT SPECIFICATIONS

DEVELOP BID EVALUATION CRITERIA

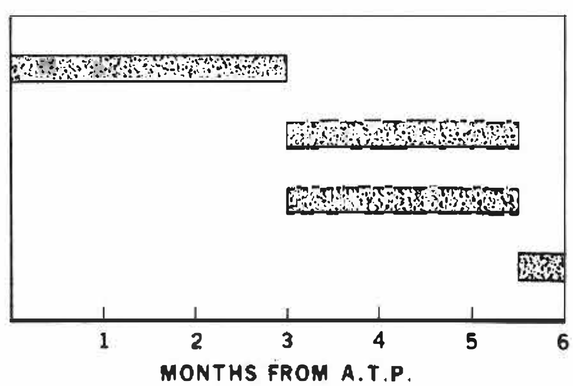


Figure 15.

The Phase II-B Program as presently defined will require a period of approximately six months for accomplishment. It is anticipated that approximately three months will be required for establishment of specific design criteria and three months for specification writing.

The current Phase II-A effort has shown that due to the overall complexity and developmental nature of the system plus the many interfaces presented by current and planned construction programs, many unforeseen problems may become apparent as the work progresses. The six months schedule therefore is based on the work scope as presently defined. A task outline will be prepared at the start of the Phase II-B program to define specific work assignments for each team member and to define a detailed work schedule and milestone events.

X

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APPENDIX I

APPENDIX TABLES

PASSENGER, BAGGAGE AND CARGO HANDLING
INTRA-AIRPORT TRANSPORTATION SYSTEM

An airport transportation system is unique in the field of ground transportation systems in that it must not only move people, but must transport baggage and cargo as well. How well it accomplishes these combined functions will be a major factor in its success as an economic operation. This combined transport capability presents a complex design and operational problem, yet it is no more complex than the requirement of carrying a combined passenger, baggage, and cargo load in a single aircraft.

The airport ground transportation system should be considered as a separate link, or subsystem, in a total door-to-door transportation system — and as such should match the other links on a comparable economic basis. As with an aircraft, total operating cost measured on a passenger/mile, or cargo ton/mile basis is a fundamental economic consideration. A combined passenger/baggage/cargo system has the potential of providing lower total operating cost than separate systems.

Another unique characteristic of an airport ground transportation system is its need for operational flexibility. Not only must the system be capable of expansion to accommodate future traffic growth, but also must accommodate large daily variations in peak hour demand — as well as wide variations in peak hourly demand within a 15 to 20 minute period. Baggage and cargo handling systems must be equally flexible. A cargo carrying capability provides a means of leveling transit system peak loads by moving cargo at off-peak periods, in addition to providing a major source of operating revenue. The following functional criteria, previously established under Phase I, therefore were given primary consideration in the Phase II-A operational evaluation.

1) The System must be capable of carrying people, baggage and cargo.
2) Have low operating cost.
3) Have high operational flexibility.
4) Be capable of future expansion.

Functional Analysis

A primary objective of the Phase II-A program was "To recommend system functional operation." In other words, to determine how the type of system selected can best perform its job of moving people, baggage, and cargo within the airport. In performing this task, Transportation Systems Corporation developed a series of charts for passengers, baggage, air mail, and air cargo flow showing each operational step, or function, from the remote parking lot to the boarding aircraft. Reverse, or deplaning, flows also were examined. The charts provide a means of analyzing:

- Functional operation
- Operational responsibility
- Physical or geographical location
- Incremental, and elapsed time.

Passenger/Baggage Flow

Examination of the Passenger/Baggage Flow lead to the following observations pertinent to design and operation of the transit system:

1. Passengers and baggage have identical origin and destination, therefore routing and timing should be as close together as possible.
2. Enplaning and deplaning flow is identical with the following exceptions:
   a) Passenger check-in and gate check operations are peculiar to enplaning. Baggage assembly also is peculiar to enplaning.
   b) Baggage claim is peculiar to deplaning. International travel functions (i.e. health, agriculture, immigration, customs) also are peculiar to deplaning.
3. Baggage check-in at remote lots offers greater convenience for passengers, but does not offer a significant passenger time saving since the same operations are required whether at remote lot or ticketing building. Remote check-in does permit earlier baggage sorting and assembly.
4. International travel functions, i.e. Government inspection, must be accomplished prior to a deplaning passenger boarding the transit system (or alternatively the entire flight load must be kept isolated until inspection is completed at remote location).
5. Operational alternatives relative to baggage handling and location are:

	Passenger Determination	Function of Airport Operating Procedure
a) Carry-on luggage	X	
b) Baggage check location		X
c) Baggage claim location		X

Air Mail Flow

The following observations were made from the Air Mail flow diagram.

1. Outgoing mail is transported from a single location, the Airport Post Office, to multiple destinations (each airline terminal). Incoming mail is a reverse operation.
2. Mail normally will require escort or surveillance aboard the transit system.
3. A special mail car would appear most desirable, although mail could be transported in a baggage car. The optimum solution would be to design a single car with modular compartment that could be used for either mail or baggage.

Air Cargo Flow

A discussion of present air cargo operations and a forecast of future developments is contained in the prior Phase I Report (Reference 1). The following observations and recommendations relative to the operational flow of air cargo, supplement the referenced report.

1. Air cargo (loose cargo and belly containers) will require transporation from Cargo City to cargo unloading points at the various airline terminals.
2. An interchange with the planned SCRTD system would provide a means of rail transport of off-airport assembled cargo from the L. A. industrial and harbor areas directly to the airport terminals. This would greatly alleviate surface road traffic congestion in the Cargo City area and would provide an additional major source of revenue for both the SCRTD and Intra-Airport Systems.

Passenger/Baggage Operations

Three alternative methods of passenger and baggage operations are shown in Figure 1A.

PASSENGER/BAGGAGE OPERATIONS AND FACILITIES

REMOTE PARKING LOT	TRANSIT SYSTEM	BOARDING TERMINAL	AIRCRAFT
OPERATIONS			
ALTERNATIVES:			
(A) Passenger loads own baggage on transit.	Passenger handles own baggage	Passenger unloads own baggage and check-in.	Airline handles baggage after check-in.
(B) Baggage checked at transit loading station.	Airline (or airport) baggage handling (Prior assembly or container loading possible.)	Baggage routed directly to assembly area (or direct to aircraft if containerized).	Permits direct loading if containerized.
(C) Baggage checked at lot entrance or remote ticketing terminal.	Same as (B) above. (Provides additional assembly time.)	Same as (B) above.	Same as (B) above.
FACILITIES			
ALTERNATIVES:			
(A) Combined passenger baggage loading platform	Passenger Car with integral baggage compartment or rack	Combined passenger and baggage loading platform.	No special handling devices required.
(B) Adjacent (separated) passenger/baggage loading platform areas.	Separate passenger and baggage cars. Flat cars for containerized baggage.	Adjacent passenger/baggage loading platform areas. Container loading devices required at parking and terminal stations.	Handling devices required for containerzied baggage.
(C) Ticketing terminal at remote lots. Station same as (B).	Same as (B) above.	Ticketing must also be retained at boarding terminal.	Same as (B) above.

Figure 1a

Alternative (A) applies to carry-on-baggage as well as instances where remote lot baggage check-in is not provided or is inoperable. The level of service associated with passengers loading their own baggage (other than small carry-on luggage) aboard the transit system is considered unacceptable for high volume operations.

Alternative (B), wherein the baggage is checked and loaded aboard the transit cars by airline or airport personnel is the most desirable operational procedure.

Alternative (C). It is highly probable, as public acceptance of the remote parking concept develops, that the remote lots will be used for passenger drop-off. This will require baggage check-in facilities at the parking lot entrances. A ticketing terminal located in the remote parking lot would provide maximum passenger convenience and would further relieve central terminal area congestion. The remote terminal also would provide a major source of additional revenue since valet parking, car rental, restaurant, bar, gift shops, and other concessions can be located in the remote terminals in addition to the similar concessions in the central terminal complex. Remote ticketing terminals are proposed as a future development as traffic volume increases, and are not included in the initial construction phases.

Although the transit system must accommodate all three alternative operations, Alternative (B) is recommended for initial operation of the transit system.

Passenger/Baggage Facilities

Facilities commensurate with the above operational alternatives also are shown in Figure 1A. Using Alternative (B) as the design case, the following facilities and equipment will be required:

TRANSIT VEHICLES

1.	PASSENGER CARS	Integral baggage compartments within car.
2.	BAGGAGE CARS	Modular compartments for baggage, loose cargo, and mail. Externally loaded.
3.	GONDOLA, OR FLAT CARS	Roller surfaces for handling baggage (or belly cargo) containers.

STATION PLATFORMS — Separate passenger, baggage and cargo loading areas. Separation of baggage and cargo areas to be determined by individual airline handling procedures and equipment.

HANDLING EQUIPMENT — On-loading/Off-loading devices required at station platforms for baggage (or cargo) containers. Baggage and cargo containers will have identical external dimensions.

Operational Responsibility

Responsibility for baggage handling can be assigned to 1) the passenger, 2) the Airport (or airport concessionaire), or 3) the Airlines. Passengers normally would carry small carry-on luggage aboard the transit system. With the anticipated traffic volumes the confusion caused by passengers simultaneously loading and unloading regular luggage on the transit cars would be unacceptable. It will be necessary, however, to have provisions within the passenger cars for a limited amount of baggage to handle emergency situations or light off-peak traffic where operation of a separate baggage car is unwarranted.

Baggage handling responsibility could be assigned to a central operator, i. e., the Airport or its concessionaire. While a single agency could standardize handling procedures, it would add another dimension to an already complicated problem (i. e. baggage identification). The airport or the concessionaire also would be liable for lost or misdirected baggage, the percentage of which would undoubtedly increase with a third party operation. It is possible, with computerized ticketing and baggage identification systems now under development by ATC and IATA (Reference 6) that central baggage assembly may be practical in the future. It should be pointed out, however, that experience has shown that as volume increases decentralization -- not centralization is the optimum solution.

The most logical assignment of baggage handling responsibility for the transit system is the airlines. The ticketing airline already is responsible for baggage once the passenger checks in. Extension of this responsibility to the transit system can easily be accomplished if the airline baggage check point is transferred to the remote parking lots. This procedure will require assignment of parking lot areas and remote lot station platform areasto specific airlines. A method of accomplishing this has been presented as Figure 10 of the Summary Report (Page 24). The four outer lot sections or subdivisions could be assigned to individual airlines with each station platform so identified. The inner section, bounded by the transit rails would be utilized by the remaining airlines as a group, or alternatively the inner section also could be subdivided into four or more sections with portions of the four station platforms assigned to additional airlines. Remote lots would be identified by number and color coding. Remote lot stations would be additionally identified by number and airline. Provisions should be retained for future addition of ticketing terminals (and station platforms) in the remote parking lots as previously discussed.

Recommended Procedure

In summary, it is recommended that operational procedures for baggage handling on the intra-airport transit be established as follows:

1. Parking lot areas and transit stations be assigned to specific airlines and identified accordingly.
2. Ticketing airline to be responsible for enplaning passenger baggage from point of check-in at remote lots to aircraft destination.
3. Returning airline to be responsible for deplaning passenger baggage to point of baggage claim at arrival terminal — baggage re-checked aboard transit by ticketing airline or skycap to remote lot destination specified by passenger. (Should match parking stub.)
4. Baggage to be off-loaded from transit system by cognizant airline employees at remote lot stations and placed in baggage claim area.

APPENDIX II

PRELIMINARY OUTLINE

TECHNICAL SPECIFICATIONS

INTRA-AIRPORT TRANSPORTATION SYSTEM

FOR

LOS ANGELES INTERNATIONAL AIRPORT

I. DESIGN AND PERFORMANCE

1. Operational, functional, environmental requirements.
2. Trackage, roadbeds, and structures.
3. Stations.
4. Vehicles.
5. Power sources.
6. Control and communications.
7. Yards and shops.
8. Operating personnel requirements.
9. Materials specifications.
10. Clearances and dimensional tolerances.
11. System performance.
12. Technical aspects of passenger comfort.

II. CONSTRUCTION AND INSTALLATION

1. Elevated ways and structures
2. On-grade ways and roadbeds
3. Sub-grade ways and structures
4. Parking lot areas
5. Airline terminal areas
6. Power distribution stations
7. Control center
8. Yards and shops
9. Underpinning
10. Utility relocation
11. Tunnel and underpass ventilation

III. TEST AND CERTIFICATION

1. Materials
2. Equipment and components
3. Ways and structures
4. Vehicle performance
5. System performance
6. Communications and control
7. Power distribution system
8. Electro-magnetic interference

IV. EQUIPMENT, DATA, AND SERVICES

1. Contractor furnished equipment
2. City furnished equipment
3. Contractor furnished construction
4. City furnished construction
5. Design drawings and data
6. Operations, training, and maintenance manuals
7. Personnel training
8. Operating and maintenance contract

APPENDIX III

PRELIMINARY OUTLINE

MANAGEMENT SPECIFICATIONS

INTRA-AIRPORT TRANSPORTATION SYSTEM

FOR

LOS ANGELES INTERNATIONAL AIRPORT

I. COMPANY QUALIFICATIONS

1. Organizational history
2. Corporate structure
3. Officers and directors
4. Affiliated companies
5. Management personnel
6. Total company personnel
7. Engineering and test facilities and experience
8. Manufacturing facilities and experience
9. System operational experience
10. Financial statements and bonding capacity
11. Bank references
12. Current active programs
13. Completed contracts (past 5 years)
14. Related transportation programs
15. Patents and licenses

II. MANAGEMENT AND OPERATIONS

1. Program management structure
2. Assigned personnel and qualifications
3. Program subcontractors
4. Prime/subcontractor relationships
5. Cost and progress reporting
6. Engineering liaison
7. Construction liaison
8. Training program
9. Inspection procedures
10. Certification procedures

III. SCHEDULE AND COST

1. Total program schedule
2. Program construction phases
3. Engineering schedule and manpower
4. Manufacturing schedule and manpower
5. Construction schedule and manpower
6. Test schedule and manpower
7. Total program cost and fee
8. Cost breakdown - by element
9. Contingency and escalation factors
10. Operation and maintenance costs

IV. CONTRACT DEFINITION

1. Contract type and format
2. Special terms and conditions - L.A. City
3. Performance bond
4. Insurance coverage
5. Indemnification
6. Labor codes and practices
7. Method of payment
8. Items to be supplied
9. Ownership of data
10. Patents, Licenses, Proprietary items
11. Prime/Subcontract relationship
12. Warranty and replacement
13. Operation and maintenance contract
14. Incentives and penalties
15. Termination
16. Legal and jurisdictional items
17. Foreign suppliers
18. Inspection and certification
19. Regulatory agencies

WILLIAM L. PEREIRA & ASSOCIATES

INTRA-AIRPORT TRANSPORTATION SYSTEM STUDY

LOS ANGELES INTERNATIONAL AIRPORT

PHASE II-A REPORT

December 5, 1968

TABLE OF CONTENTS

I. INTRODUCTION:

This report covers the initial portion (Phase II-A) of the development of specifications for the Intra-Airport Transportation System, a team effort by Transportation Systems Corporation, Kaiser Engineers and William L. Pereira & Associates. The study has been directed to furthering and making more definite those system concepts developed in the Program Definition Phase, taking into consideration the significant contributions made by a number of industrial organizations who have manifested an interest in such a system and demonstrated the capability to design, construct and place one in operation. The purpose of an interim report at this time is to define the nature and extent of the system and its related infrastructure with sufficient clarity to permit the establishment of an overall capital budget.

The specific tasks to which the firm of William L. Pereira & Associates addressed itself at this stage concerned the overall planning concepts, the impact of architectural considerations on right-of-way corridors in the terminal areas, the schematic development of station configurations, and an in-depth analysis of overall parking concepts in and about the airport. Based on these studies, construction-cost figures covering these architectural infrastructure and parking lot development items were prepared.

II. SUMMARY:

A. General

In the development of the system concepts, two prime objectives were established. The first was a level of service which would assure passenger convenience, comfort and acceptance. To this end, time in transit not greater than automobile travel time was achieved, direct point-to-point travel between parking lots and terminals was developed as a possibility, and walking distances at parking lots were held to 700' maximum. The second objective was to configure the system so that each airline terminal would enjoy comparable facilities. Mindful of each airlines' desire to maintain its competitive position with respect to customer access, parking facility availability, curb services and individual identity, each passenger terminal is provided with its own transit station. Similarly, short-term parking spaces in the central area have been programmed into immediately adjoining parking structures, in numbers compatible with the individual airline needs, based on peak-hour activity. Dispersed parking lot configuration envisions parking lots so divided as to have a section of each lot identified with a specific carrier. The transit stations in the several sections will serve individual airlines or groups of airlines.

B. System Capacity

While the basic figures developed in the Project Definition Phase were valid at the time, information subsequently available pointed to the probability that the number of visitors to the airport had been under-estimated. An in-depth review of the projected number of peak-hour system riders, both passengers and their visitors, developed the belief that a maximum of 15,000 people per hour should be provided for.

C. Airport Access

Review of automobile access to dispersed parking lots No. 2, 3 and 4, and to the Central Terminal Complex of the airport, based on the findings of previous traffic studies, reaffirms the probability that projected vehicular traffic will be able to proceed to these several locations, there to park for the discharge and pick-up of airline passengers.

By 1972 it is expected that passenger volumes will exceed 34 million per year, at which time automobile access to parking facilities may, indeed, be limited. This situation will not be relieved until 1974, when the Century Freeway is completed. For the two intervening years, 1973-1974, access may be eased by spreading airline schedules and thus keeping peak operations within manageable bounds.

D. Route Configuration

Further study and detailed consideration of concepts and constraints offered by the industry did not develop any needs for major changes in the basic concept of corridor location. A double-track elevated loop around the Central Terminal Complex, above World Way, with spur lines running to each dispersed parking lot area, was found acceptable. Spurs to Lots 5 and 6 in the westerly part of the airport were established as feasible, when and as required. A line to serve the Imperial Terminal is envisioned, either by tunnel from the West Terminal area, or as an extension of the line to Lot 2, depending upon the final location of the Imperial Terminal.

For the present, the concept of developing cargo-carrying capability for the system has been subordinated at the direction of the Department of Airports, and the inclusion of both passengers and their baggage in a single corridor was adopted as most feasible in the initial stage.

The locating of parking lots and other passenger-related activities in the clear zones, and the routing of the transportation system through these parking lots, are matters which have both been reviewed with the FAA. Their response to the information given them must be received before route location in these areas can be considered firm.

As a result of architectural development in the underground West Terminal, station platform heights were established at 18' below apron level. Likewise, consideration of total-route profile, and study of station development and compatibility with ultimate Master Plan implementation, including pedestrian bridges, indicated the wisdom of locating the stations above World Way at the faces of the several existing ticketing buildings, with the top of the rail set at some 16' above apron level.

E. Station Concepts

The establishment of train lengths, car capacities and baggage handling modes, together with the concept of one-side static loading on sidings at each station, permitted the schematic configuration of the three station types envisioned as part of the system infrastructure. The three station types are: those located in the dispersed parking lots, those at the existing ticketing buildings in the satellite complexes, and those in the undergroung Terminal One and West Terminal structures.

Parking lot station structures will take the form of at-grade platforms with canopy roofs. Minimal rest room and concession areas will be provided, together with baggage check-in counters and hold areas. Stations will probably be paired astride the right-of-way with a connecting subway corridor for minimal crossover.

Stations along World Way will be at the third floor level, which will correspond with the passenger enplaning level when above-apron satellite connections are developed. Vertical transportation by mechanical means will connect to the World Way level where baggage pick-up is programmed. Inbound baggage handling areas will be located at the platform extremities, where loose pre-checked items of luggage will be unloaded from the trains and conveyed to baggage make-up areas at ramp level.

Station configuration in the underground West Terminal will probably take the form of a central platform between two tracks, located one level above the main passenger concourse and connected to it by escalators and elevators. Baggage transfer points at the platform ends will receive passenger luggage, which will be routed to make-up areas by lifts and conveyors. The stations within the underground terminal areas will be air-conditioned.

F. Disposition of Parking Spaces

Departing in certain respects, and for various reasons, from the Dispersed Parking Development concept, the Department of Airports decided that some parking facilities will be needed in the central terminal core area. Toward this end, a program which will provide for three-level (ground level, plus two) parking structures in the central parking lots has been initiated. When completed, these modular structures will provide some 7,000 stalls, total in the central area, all in close proximity ot existing terminals. To maintain equity, it has also been determined that parking must be developed in the underground terminals, this in amount commensurate with individual airline needs.

As a result of studies looking to optimize conditions of airport access and internal roadway circulation, and to hold capital cost to a reasonable minimum, it appears that a policy which limits all central core parking to a maximum of three hours is desirable. All persons desiring to park beyond that limit would be directed to dispersed parking lots. Likewise, dividing the short-term parking spaces equally between the central terminal and dispersed lots seems justified, since to do this divides the incoming airport traffic stream between core and perimeter, reduces traffic density through World Way by one-third, and, if U-Drive and valet parking are retained in the core, develops a reasonable fit between projected peak-hour parkers and stalls available, with 2,600 stalls indicated for the West Terminal and 1,800 for Terminal One.

G. Cost Estimates - System Infrastructure

The total dispersed parking plan involves the costs of installing the transit system itself and constructing those other necessary facilities, mainly stations. A budgetary cost estimate for this ancillary construction is to be found in Appendix A to this report.

H. Economic Considerations

The implementation of the Dispersed Parking Concept, modified to include the retention of some 11,000 parking spaces in the Central Terminal area, will require a capital investment of approximately $112,500,000. This will cover both the transit system and the central and dispersed parking facilities. Of this amount, however, about $12,500,000 represents apportioned costs connected with underground terminal construction, which would not be recoverable by the elimination of parking in these structures. The remaining $100,000,000 represents that projected capital cost which will be recoverable by parking fees. On a 30-year pay-back basis, using a 6% interest rate, this amounts to $7-1/4 million per year. Based on 14.5 million vehicles parked annually at the 45 million annual passengers (MAP) level, the cost, exclusive of operation and maintenance, would appear to be $.50 per car parked.

Previous estimates (prepared for the Dispersed Parking Development study) indicated $112,000,000 as the approximate capital cost of providing total parking requirements in the Central Complex.

III. CONCLUSIONS

An automated transportation system with a high service level can be developed to permit adoption of the Dispersed Parking concept, thereby improving airport access, easing World Way automobile traffic densities during peak-hours, and providing a swift and convenient connection between private vehicles and the airplane. Representative manufacturers have displayed concepts and equipment that is either in operation or capable of being put into operation when and if a market develops. From a functional standpoint they will do the job, and, from an aesthetic point of view, they can be made compatible with airport architectural standards. The overall cost for providing such facilities would appear to be no more than that of developing comparable parking within the terminal areas, and much is to be gained in the way of passenger convenience and alleviation of traffic congestion. Savings which were previously indicated as an adjunct to dispersed parking have largely been absorbed by the added expense of providing some short-term parking capability in the airport central area.

The above conclusions were drawn from data concerning visitor volumes, vehicular loadings and traffic flow which data were the result of studies and field counts made in connection with other and somewhat distantly related surveys of projected airport activity. Also, peak-hour airline volumes, as prognosticated by the major carriers and applied to all carriers, may be subject to some downward modification, as a result of nationwide terminal and airspace congestion.

It should be further appreciated that any satisfactory utilization of the system will necessitate the adoption and enforcement of policies, procedures and pricing policies which are consistent with the operational modes envisioned in the development of the concept. Traffic control and deployment of parkers presumably can be accomplished by adequate graphics, including changeable directional signs and signals along access routes. Scaled parking fees (higher in the Central Complex, lower in the dispersed parking lots) will naturally affect traffic orientation and parking destination. Service levels satisfactory to passengers will involve implementation by the several carriers of adequately manned and equipped service centers at the dispersed parking lots.

IV. TEXT

A. General

The intra-airport transit system is not an end in itself, but rather an integral sub-system designed to service the overall system -- the airport complex. The function of the airport, of course, is to act as an interface between passengers on the ground and in the air, a link in the overall macro-system, public transportation. To the extent that the intra-airport transportation system makes the airport more accessible, less congested, more easily utilized without confusion and delay, its construction is justified, providing its costs are not found to be exorbitant by 1975 standards.

Being a part of a larger system, it is essential to check the compatibility of its function and its fit with those other parts of the airport complex to which it relates. This applies to elements in the dynamic mode such as vehicular access, airport roadway capacity, passenger and baggage flows, etc., and to elements in the static mode of land availability, avigation restrictions, building modifications and architectural compatibility. For this reason the study has ranged well beyond the moving of people, mainly passengers and their visitors, between predetermined origins and destinations by readily apparent routes.

At this stage, little attention has been focused on system equipment configuration, style or amenities. While these and like elements are undoubtedly highly important in terms of erecting something that will ensure user acceptance, enough study has been given the matters and sufficient ideas have been submitted from industry so that, when the time comes for a system to be detailed and decided upon, no problems of significance should be encountered nor should the system concepts and costs be significantly changed.

B. System Capacity

The capacity of the system transporting passengers from dispersed parking locations to the central airline terminals in the design year of 1975 will be influenced by several phases of total airport activity:

1) Total passenger volume in the design year.

2) Significant variations in activity level during the year.

3) Maximum peak-hour activity (be it during predominantly enplaning, deplaning, or mixed-mode time frames) and intra-hour peaking.

4) The number of non-flying individuals expected to be present in the airport precinct during periods of high activity. These would include visitors accompanying or meeting airline passengers, businessmen, service personnel, airline based employees and casual sightseers.

Growth rate projections have placed total airport passenger loads in 1975 as high as 57 million, somewhat above the figure of 47.6 million presently being used by the Department of Airports or the 44.5 million figure arrived at by totaling the individual responses from the various carriers. While this 25% variation might appear sufficiently large to materially affect capacity requirements, such is not believed to be the case, primarily because peak-activity may well not be, or may not continue to remain, a direct function of annual volume. This is particularly likely when a two-and-one-half times expansion is involved, an expansion based on large numbers and classes of people not flying now. Further, it is to be noted that the Department of Airports is forecasting a volume of 57.8 million passengers in 1977, only two years beyond the design year. Similarly the air carriers indicate an annual activity of 61.5 million in 1980. As will be seen, as the rationale of the system rider-carrying capacity requirements are developed, annual numbers will only serve to develop cross-checks in evaluating the reasonableness of peak-hour enplaning figures given by certain airlines, (which carriers are projected to handle 60% of the total annual volume), and in developing plausible peak-hour enplaning figures for those that fail to respond in this connection. The tabulation of projected annual airline passengers, as used in this study, will be found, identified as to airline, in Column 2 of Table I. (See Appendix)

Monthly variations within the year are also significant in that they assist in establishing a base from which to pass judgment on the peak-hour enplaning figures given by, or developed for, the several airlines. (This figure has been defined as the number of anticipated passengers enplaning during a peak hour on an average day in a peak month). The ratios for the separate airlines, were in each case, shown in Column 5 of Table I, and were computed by taking the peak month passenger total in 1967 and dividing it by the average month figure (1/12 of the annual). It is to be noted that in all cases, the peak-month was August, 1967. The ratio thus developed was used as a multiplier applied to the average daily volume of enplaners shown in Column 4, producing daily enplaning figures in a 1975 peak month (shown in Column 6, Table I). The figure in Column 4 is one-half the annual passenger projection (the enplaning portion) divided by 365. Whether inter-month variations in 1975 will closely approximate those of today may be subject to question. Continued study must be given to ever increasing vacation and recreation travel, especially as the totals begin to reach the 45 MAP level.

It may be that factors of influence, including airline pricing structure, excursion fares and vacation packages, and trends toward year-round vacation periods, will tend to exert a leveling influence, and at a higher level of total volume. Here again, numbers will be important only to the extent that they allow comparisons.

While yearly, seasonal, monthly, weekly and daily statistical breakdowns are essential for planning projections, more limited time-spans must be considered as we approach the point of actually designing specific facilities. All segments of the airport system — runways, taxiways, aprons, passenger gates, baggage breakdown and transport devices, service roads, short-term parking spaces, on-airport road system or tributary streets and freeways — including the proposed intra-airport transportation system, must be so sized, deployed and utilized that they meet not only the peak-hour (or few hours) when demand reaches its ultimate level but even meet the quarter-hourly peaks.

The key to airport passenger activity were those peak-hour figures given by the four airlines; United Air Lines, American Airlines, Trans World Airlines and Continental Airlines. These airlines projected 27 million annual passengers in the year 1975 (60% of the anticipated 44.5 million annual passengers). For the balance (airlines that did not furnish peak hour enplaning figures), a direct ratio of 338 peak-hour passengers per million annual passengers (the ratio derived from data from the four reporting carriers) was used. By this method, the numbers found on Lines E through K, Column 3 of Table I, were arrived at, the total being 15,046. It is to be noted that this figure is some 20% lower than the figure of 18,098 previouly developed as the concurrent peak-hour enplaning load. The previous figure was developed by analysis, taking into consideration the number and gate types which would be abailable to non-reporting carriers, but since this method seemed to place unwarranted emphasis on gate capability, as opposed to projected gate use in 1975, the use of straight extrapolation from the airline-produced figures was judged more realistic.

Since it is known that all carriers do not experience complete concurrence of peak enplaning operations now, and since it is reasonable to expect that such will continue to be the case in 1975, a means had to be arrived at for spreading hourly operations, identifying the specific peak-hour of each airline, and then determining concurrent hourly airport activity, the hour and numerical value of the anticipated true peak, and the volumes in neighboring hours. Since the airlines projected no such data, it was decided that a forward projection of today's conditions, when spread over all eleven carriers or groups of carriers and averaged out over today's operating hours, would not be far off. This situation, it was reasoned, would most likely continue, because aircraft speeds will remain approximately the same and travel will continue to be largely oriented towards arrival times.

However, a trend has already been established for airlines to offer inducements to travelers to fly at non-peak months or days. As such a trend grows it will probably be reflected in a leveling off of peak demands on the intra-airport transportation system.

Possessing no basis upon which to evaluate such a possibility, however, it was decided to use today's statistics as a means of forecasting.

One basis used both to identify individual carrier peaks and to spread daily enplaning passenger loads was to use published schedules for March, 1968, covering outbound flights. A spread sheet covering the 24-hours of the day was developed, flights in each hour were listed and the peak hour was determined to be that hour when maximum flights were listed. Where two different hours each had a similarly maximum number of flights, that hour was deemed "peak" which judgement indicated would contribute most critically to the overall.

The results of this method of analysing the critical periods of enplaning are to be found on the "Other Method" line of Table II.

Following the Phase I studies of the Transportation Study, when basic systems concepts were being firmed-up and passenger-load figures were being arrived at along the line described above, a report by Landrum & Brown entitled "Survey of Los Angeles International Airport Scheduled Air Passenger Market" was made available. While directed primarily to passenger origin and destination, it did yield considerable insight into factors involved in airport accessibility and it furnished statistics which were useful in anticipating transportation system loading problems, especially the magnitude of visitor load. It also correlated inbound or deplaning passenger flow with outbound or enplaning flow at the passenger level, something previously capable of being dealt with only in terms of aircraft flights.

While the survey was not extensive enough to answer all the problems or allow for all projections, it was adequate for these current purposes. Two items of prime significance were felt to be Landrum & Brown Table 18 (Figure 1) which showed passenger distribution, both outbound and inbound, by day of the week and hour of the day, and Landrum & Brown Table 20 (Figure 2) dealing with ratio of Total Number in Party to Total Outbound Passengers by Day of Week and Hour of Day. Statistics contained in, or derived from, this data were utilized extensively.

Landrum & Brown data was included in the chart which spread enplaners over the day (in a similar manner and for the same objective as the spread noted above), using number of flights as index numbers. Added accuracy resulted from identifying the busiest flight hours in three-hour time bands based on actual count. The percentages per time band can be picked from the "Total-Out" Column of Figure 1, and are found to be adjusted to the nearest whole percentile, 24%, 20%, 20%, 18%, 14%, and 4%. Coverage did not include the hours from midnight to 7:00 a. m. ; here judgment indicated 10% of total daily activity might occur and an adjusted time band percentile was established as follows:

12:00 a.m.	-	2:00 a.m.	6
2:00 a.m.	-	7:00 a.m.	4
7:00 a.m.	-	10:00 a.m.	22
10:00 a.m.	-	1:00 p.m.	18
1:00 p.m.	-	4:00 p.m.	18
4:00 p.m.	-	7:00 p.m.	16
7:00 p.m.	-	10:00 p.m.	12
10:00 p.m.	-	12:00 a.m.	4

Once again, peak-hour enplaning was picked as that hour haveing the maximum number of departing flights. To this hour was assigned the airline-stated or the derived peak figure, with the remaining peak-month average daily figure spread proportionately to the number of departing flights shown in the other hours of the time band. An adjustment of some 7% was made since distribution did not quite absorb the 79, 500 daily enplaning figure. Comparison of the results by each of the two methods leads to the judgment figure adopted and shown on the line marked "Use" on Table II, which covers the hourly periods of high enplaning activity. Maximum passenger flow in the enplaning direction was projected at 9, 750 between 9:00 a. m. and 10:00 a. m.

The next step involved probable concurrent passenger flows in the opposite direction, i. e. how many people could be expected to deplane in the hours tabulated. Here the Landrum & Brown statistics were the only ones available that gave concurrent counts in both directions. Referring to Figure 1, the weekly total columns show that enplaners represent the below-listed percentages of flow, from which was derived a multiplier which, when applied to the enplaning volume, produced the total hourly passenger volume (enplaning and deplaning combined).

Hour	Percent Enplaning	Multiplier
7:00 a.m.-10:00 a.m.	77	1.30
10:00 a.m. - 1:00 p.m.	45	2.22
1:00 p.m. - 4:00p.m.	52	1.92

Multiplying enplaners by the multiplier corresponding to the hour being processed yields hourly passenger totals. With 12, 700 passengers, 9:00 a.m. to 10:00 a.m. is again determined to be the hour of apparent maximum activity, although a relatively high level of activity exists most of the day. Later it will be shown that midday peaks on certain days of the week surpass substantially the 9:00 a.m. to 10:00 a.m. volumes.

The peak enplaning figure given by the airlines is, as we have seen, the peak-hour on an average day in a peak-month. Therefore, we need to identify this average day and then see how much and how often the average is surpassed. If we assume that the Landrum & Brown passenger spread (Figure 1) repeats itself in succeeding weeks over the month, then the average day they list can, without too much chance of error, be taken as the average day in the month, peak or otherwise. The numbers displayed on Figure 1 would indicate Tuesday, with 13. 64% of the weekly total, as being closest to an average day (a perfectly average day would be 100/7 or 14. 3%). Determination of Tuesday as the average day, and 9:00 a.m. to 10:00 a.m. (with 9, 750 enplaners as the peak hour, establishes a basis on which to compute an average hourly transit system rider demand. Two steps remain: to calculate the average number of visitors per aircraft passenger and to ascertain when the transport system would be subjected to above-average demands.

Visits to the airport by the non-flying public were found to have a significant impact on airport access, on parking space demand, and on potential transportation system loading. Non-flyers include employees at the airport, business people calling on customers among the airport tenants, visitors who accompany departing passengers or meet arriving passengers, and sightseers who find the airport to be an interesting experience in itself. Of all these categories, only the passenger-accompanying visitors are regarded as likely to put above-average demands on the transport system.

Fortunately, Landrum & Brown has statistics relating to the number of visitors accompanying outbound passengers. As shown on Table 20 (Figure 2), the number is 1.56 with each enplaner. The table also provides data as to daily and hourly variations.

Above-average conditions can be ascertained from Table 18 (Figure 1) which data points out time periods in the weekly spread where activities peak. If the percentiles shown are taken as Index Numbers, peak enplaning hours, Sunday 1600/1859 (4:00 p.m. to 7:00 p.m.) rank highest with an index of 5.69. Next is Wednesday, 0700/0959 (7:00 a.m. to 10:00 a.m.) with 5.00. Total activity, on the other hand, ranks Wednesday, 1300/1559 (1:00 p.m. to 4:00 p.m.), as highest, with 4.72, the enplaning fraction being 4.68. This is followed by Sunday p.m. with 4.32, Sunday a.m. with 4.03 and Friday p.m. with 3.87 total activity index and a deplaning index going to 5.91, the highest one-way flow charted.

By multiplying enplane/deplane Index Numbers by associated visitor ratios, we find maximum activity occurring nearly all day on Sunday, followed closely by midday Wednesdays and Friday evening. Pursuing the above indications, Table III, Column 3 lists peak-hour Tuesday, 9:00 a.m. to 10:00 a.m. as having a total activity index of 6.06 (the sum of in and out percentiles), generating a maximum one-way airline passenger flow of 9,700. This 9,700 figure can be projected to a total enplaning/deplaning figure of 12,700. This latter figure can now be converted into visitors attributable to airline passengers by the use of the visitor-to-passenger ration of 1.26 for Tuesday a.m. This produces a total for visitors traveling in one direction of 15,900.

When the visitors are added to the maximum one-way airline passengers, the result is a total of 25,600 people moved on the system in one direction at the peak hour, average day.

Although at this point total activity is being dealt with, later analyses will involve apportionment of the total to drive-through, and to Central Complex and dispersed parking fractions. With the base day and base hour totals established, we now proceed to analyze some of the time frames which, in the proceeding paragraph, appear to be critical. Sunday from 7:00 p.m. to 10:00 p.m. is one such period, since it has an inordinately high visitor load. Using the in-out percentile total of 7.72 as a guage, passengers would total 1.28 times the base of 12,700 which would be 16,200. This can be divided 45% inbound to 55% outbound, with the latter totaling 8,925. With 16,200 people flying, and with 2.39 visitors per passenger, the amount totals 38,750 which added to 8,925 gives 47,675 as the combined one-way total. Similar calculations, tabulated on Table III, are made for other hours of indicated high activity.

The figures so far concern peak hours. Peaks might occur within any hour, however, and the transportation system, since it must deliver on a ten to fifteen minute service time, must be capable of dealing with them. On the basis of information from several airlines, intra-hour peak periods, possibly 15 to 20 minutes in duration, have rates at as much as 30% above hourly averages. For this reason, the Total Column of Table III has been increased by this percentage for design purposes.

Recognition is taken of the fact that it would not be expedient to have appurtenances such as the transit system, involving large capital costs and low utilization factors, configured to handle the absolute maximum that occu for example, on a holiday weekend. At such times, some degree of inconvenience and disruption must be expected and tolerated. Moreover, with a system of the nature contemplated, piling requirement on requirement soon reaches the point of impossible costs, undesirable complexity, and a resultant lowering of the service itself. For this reason, the intra-hour peaks were scaled back to approximate the 30th highest hour conditions, with an Index Number assigned for each of the above-average hours noted. A revised total, equitable for the design, was then arrived at. Even then, numbers some 50% greater than the basic peak enplaning hour of Tuesday a.m. will result, particularly where both inbound and outbound traffic are concurrently high.

In determining the system passenger load, our final objective is to set a design number. This involves a determining what portion of the total flow will be induces to use dispersed parking facilities. Elsewhere in this report, it is proposed that all parking over three hours be restricted to dispersed lots, that drive through volume remain at approximately 45%, and that short-term parking be divided almost equally between central parking and the dispersed lots. If this proposal becomes policy, then the "50% to 50%" column at Table III can be adopted and 15,000 riders per hour can be judged a design figure.

By channeling two out of three short-term parkers to the central core, there would be a reduction in the number of system riders. This figure is listed, for comparison purposes, in the "66% to 34%" column of Table III. Analysis reveals that the transit system is used predominantly by visitors, sometimes totaling as high as 75% of the system's passenger traffic. To bar these visitors, or any segment thereof, would appear difficult. If visitors coming to meet deplaning travelers were given four different possible parking areas, each of very considerable dimensions, they could hardly accomplish their mission unless they could be provided with a dependable transportation system between the parking areas, the remote terminals, and the deplaning gate locations, something which, in view of the projected volumes, cannot be assured. Visitors coming with departing travelers could be separated at dispersed lots while visitors meeting arriving travelers proceed on in, but the inequity and attendant problems of this arrangement are self evident.

One way to cut the system riders materially would be to relegate U-Drive activities to the peripheral lots, since these vehicle occupants could be condidered almost visitor-free. If such a drastic shift in the concept of service locations could be brought about by the airport management, a reduction to 5,000 passengers per hour would seem attainable.

C. Airport Access

According to investigative efforts reported in the Phase I portion of this study, the capacity of the external road and access system to the airport could, under specific conditions, be anticipated to increase. Based on a theoretical factor of 150[1] inbound vehicles per million annual passengers, four definable levels were identified:

1) 24 Million Annual Passenger Level:

   The present road system, including portions of the unused capacities of Sepulveda and Airport Boulevards.

2) 33 Million Annual Passenger Level:

   The present road system, as defined above, with the addition of access roads from the west, north and south, including tunnels to the West Terminal at each of these accesses.

3) 40 Million Annual Passenger Level:

   The configuration identified as the 33 Million Annual Passenger Level, with the addition to the system of the Century Freeway.

4) 50 Million Annual Passenger Level:

   The configuration identified as the 33 Million Annual Passenger Level, with the addition to the system of both the Century Freeway and the Laurel Canyon Freeway.

The factor of 150 inbound vehicles per million annual passengers, as initially used, is associated with the hour of greatest conflict with traffic other than airport-related traffic, the average weekday between 8:00 am and 9:00 am. The terms

1 See "Chronology of the Master Plan Development" Phase IV, "Roads and Access Development", February, 1968.

"24 Million Annual Passenger Level", "33 Million Annual Passenger Level", etc., should thus be construed as referring to a particular road and access system configuration and not necessarily as establishing the airport capacity.

The capacities of the road network available for airport-attributable use associated with the above levels and for the 8:00 am to 9:00 am hour were calculated as follows:

	24 MAP	33 MAP	40 MAP	50 MAP
Vehicular Capacities	3,400	5,000	6,000	7,500

Assuming the 33 Million Annual Passenger configuration to be an established fact, the 40 MAP and 50 MAP level capacities were then projected to hours prior to and following the 8:00 am to 9:00 am period. On the basis of comparative volumes for the four-hour period of 7:00 am to 11:00 am, the system vehicular capacities for the 40 MAP and 50 MAP levels were as follows:

	System Levels	
Hour Beginning	40 MAP	50 MAP
7:00 a.m.	4,890	6,390
8:00 a.m.	6,000	7,500
9:00 a.m.	9,460	10,960
10:00 a.m.	8,800	10,300

As indicated in Table II, the total passenger demands for the same hours were converted into terms of inbound vehicles. For this conversion, a factor of 1.7 airline passengers per inbound vehicle was used (See the section of this report entitled "Parking Space Disposition" for the derivation of the factor).

A comparison of the passenger-generated vehicular demands and the vehicular capacities of the access network indicates that the network can be expected to accommodate the projected peak enplaning hour volumes at both the 40 MAP and 50 MAP system configuration levels.

An examination of Table III, however, indicates that on five separate occasions during the week the total activity (enplaning and deplaning combined) exceeds that of the peak enplaning hour, average day, of 12,700 airline passengers. These excesses range from a 26% increase on Friday, between the hours of 7:00 p.m. to 10:00 p.m., to 56% on Wednesday, from 1:00 p.m. to 4:00 p.m. The latter time peri with a total passenger activity of 19,800, would generate an hourly rate of 11,680 vehicles. It should be borne in mind, however, that the system vehicular capacities computed for the time period of 7:00 am to 11:00 am, specifically 8:00 am to 9:00 a.m., are computed for the period which conflicts most seriously with other traffic. It can be safely concluded, therefore, that the conflict observed is due mainly to the impact of work-destined vehicles generated by local commerce and industry. Of the five periods of high activity referred to, three occur on Sunday; the remaining two occur on weekdays, but during time periods which could be viewed as outside of normal shift-change time and, therefore, not likely to precipitate any conflict with work-destined vehicles. On this basis it could reasonably be assumed that during these periods of lesser conflict there will probably be increases in vehicular capacities commensurate with the increases in passenger demand. Substantiation for this conclusion, however, must depend on a detailed analysis of vehicular capacities during these periods of high airport activity.

If, as discussed more fully in the "Parking Space Disposition" portion of this report, short-term parkers are distributed equally between the Central Complex and the dispersed lots, then 67.37% of the total inbound vehicle would, at peak hours, be destined for the former and 32.63% for the latter. For the peak enplaning hour, 12,700 airline passengers would generate 7,450 inbound vehicles, of which 5,019 would enter the Central Complex and 2,431 would be destined for the dispersed lots. During the period of highest total activity, when 11,680 inbound vehicles per hour could be anticipated, the same ratio of distribution between the Central Complex and the dispersed lots would result in 7,869 and 3,811 vehicles, respectively.

The proportion at which vehicles may be distributed between the Central Complex and the dispersed lots can be considered as quite flexible once they are within the cordon of restraint which surrounds the airport and at which the network capacity is established. Studies indicate, however, that the circulation within the Central Complex (i.e. World Way), as presently configured, is limited to 4,000 vehicles per hour. In the case of the peak enplaning hour, the volume of Central Complex oriented vehicles would exceed this capacity by 1,019; at the period of maximum activity the demand would exceed capacity by 3,869 vehicles.

This would suggest the necessity of utilizing means of access to the terminal area other than the present main entrance at Century and Sepulveda Boulevards. The provision of the three separate means of access to the West Terminal previously discussed (the access system identified as the "33 Million Annual Passenger Level 4"), and a separate means of ingress to Terminal One, could jointly divert more than the excess noted above from circulating through the World Way loop. A study prepared in February, 1968, indicated, as an example, that the provision of separate and direct accesses to Terminal One via Interceptor Street and Sepulveda Boulevard could accommodate 1,790 vehicles in 1975. A study prepared during August of 1968 for the purpose of establishing West Terminal traffic assignment demonstrated that over 4,000 vehicles could, upon completion of the Century Freeway, gain ingress to the terminal by means of the west, north and south tunnels. Worthy of note in this regard is the proportional assignment to these three points of access and the specific assignment to the Imperial Tunnel entrance (south access) of over 53% of the West Terminal oriented vehicular volume. The addition of the Laurel Canyon Freeway can be viewed as contributing 1,500 additional vehicles to the system (entirely from the northeast quadrant) and would impact most directly on the proportional assignment to the Manchester Tunnel (north access). Under this condition the proportional assignment to the Imperial Tunnel would be reduced to approximately 36% without substantial change in volume. For the purposes of proportional assignment between the dispersed lots, their respective access demands were compared. The results, abstracted from a study of July 1968, were as follows: for a given body of vehicles 28.6% would be oriented to lot No. 2, 51.2% to lot No. 3, and 20.2% to lot No. 4. On this basis the 3,811 vehicles destined for the dispersed lots during an hour of the period of maximum activity of the week (Wednesday, 1:00 p.m. to 4:00 p.m.) would be distributed in the following manner:

Lot No.	Vehicles
2	1, 090
3	1, 951
4	770

The addition of the Laurel Canyon Freeway, as previously noted, would add 1, 500 vehicles to the capacity of the airport-attributable system. Since all of these will enter the airport vicinity from the northeast quadrant, the impact will be principally on lot No. 3, and to some extent on lot No. 4.

D. Route Configuration

In order to encourage passenger and visitor acceptance of the intra-airport transportation system, it was determined at the outset that the system should be so routed and its elements so configured as to give the shortest travel time enroute, to reduce walking distance to a minimum, to reduce points of potential confusion to the absolute minimum, and to achieve throughout a pleasant and, if possible, interesting environment. In developing a corridor or route consistent with these ends, constraints in the form of existing construction, planned future development, grade separations, land ownership, consistency with other airport-related functions, and recognition of available options for future or further terminal development potential had to be recognized. In addition, adherence to F. A. A. regulations concerning aircraft operations, clear zones, etc. was recognized as mandatory. Equally important was the architectural acceptability of the system, particularly in the Central Complex.

In the Central Complex interconnection of all terminals was deemed necessary to proved interline se rvice between carriers. The movement of passengers to and from dispersed lots was planned with a minimum use of the space available. Although individual direct lines connecting each terminal with one or more dispersed lots would be theoretically ideal, the fact that we are dealing with some twelve terminals and three lots, each segmented, made it obvious that much of the system trackage should be shared by more than one route. This concept results in a higher utilization of the system and a reduction in redundancy. For that reason a common core corridor was established in the early planning stages. Considering the service level requirements, this concept is adequate as long as it is provided with certain bypass options, crossovers, etc. plus sidings at each station.

The present terminal configuration in the core area is in the form of a loop, with ticketing buildings and boarding satellites located around the airport's central mall. The natural route for the terminal segment at the transportation system thus seemed to be in the form of a similar loop, encircling the mall, interfacing with the same element of each terminal at a logical, convenient and practical point. Of course, consideration would be given to cost and the necessity for continuance of service at the present highly loaded facilities. Although it would be desirable to interface at the satellite centers this would involve a route on, over or under the aircraft apron areas. Since routes at or above grade must be ruled out as conflicting with aircraft maneuvering, this interfacing would be possible only by tunnels under the existing apron areas. Tunnel construction to place the route below grade was not felt advisable since it would disrupt aircraft activity during construction in open cut would necessitate extensive relocation of utilities and would be excessive in cost. Routing on the apron face or the World Way face at the present ticketing buildings was seen as the only practical avenue of penetration. In addition to not hindering aircraft operation, this location creates an early and logical junction of transportation system riders with those others from curb drop-off areas and central parking. From here all passengers would proceed in consort, making use of common facilities. In analyzing which face of the ticketing building would be preferable, parameters dictated by the concepts of the Ultimate Master Plan suggested that the World Way face was to be preferred. At apron level on the apron side of the ticketing building an increase in baggage and possibly freight assembling, processing, and dispatching, plus overhead connections between this building and the satellites, indicated a full utilization of available space and the impossibility of vertical separation which would be possible above World Way. Based on these findings it was decided that the system route would best be developed with passenger routes on the World Way face of the ticketing buildings, and with future baggage and freight corridors being programmed for apron-side siting. In the initial development, when non-containerized passenger baggage may be carried, the program provides for delivery at passenger platforms, and transferred by mechanical means to assembly points on the apron.

Spur tracks radiating out from the central loop to the three parking lots programmed for initial construction will be elevated, to separate them from vehicular traffic. The spur to Lot 2 would proceed on an elevated structure parallel to and south of Century Boulevard, passing over Sepulveda Boulevard and all access roads into Cargo City, but dropping to below grade in an open cut as it proceeded south on Aviation Boulevard, then to be below ground as it crossed the the approach zones and as it passed eastward under Aviation and finally into Lot 2. The spur to Lot 3 would proceed on an elevated structure up the center of Sepulveda then bearing east and dropping to grade as Lot 3 is reached. The spur to Lot 4 would start northward from West Terminal, pass through the Manchester Tunnel, using the two center lanes, then rising on structure to pass over Lincoln Boulevard, returning to ground level and bearing east into Lot 4. Plans for the future include an elevated structure along the north side of World Way West, with a tunnel connection at the West Terminal and surface spurs to the parking lots. Depending upon how soon Lots 5 and 6 will be activated and if they will be connected the core area by system ties, it may be desirable to provide underpass capability in the World Way West structure passing under proposed Taxiway 75. All corridors within the parking lots themselves are to be on grade. In Lot 3, the present major access arterial road along the general route (Interceptor Street) would have to be depressed to pass under the system right of way.

The routes chosen, in addition to providing separation from automobile traffic on the surface and direct connection to terminal buildings, afford the riders outstanding views of many and varied activities at the airport.

Speeding above the confusion of close-in traffic, seated in comfortable, air-conditioned vehicles of tasteful design, riders will be able to look from spacious windows and, day or night, be able to identify themselves with the sight and sound of the air age.

E. Station Concepts

The system is served by platform-type stations at car floor-level elevation. An initial length of 250' is envisioned at terminal stations, either above World Way, as in the case of existing construction, or underground, in the case of West Terminal and possibly Terminal One. Parking Lot stations may need some additional length in order to serve two trains simultaneously and are therefore presently shown as 300' long.

The configuration of the stations at the several locations will be substantially as shown on drawings to be found in the Appendix.

F. Parking Space Disposition

Though the essential mission of the present study was to arrive at a workable design capacity for the intra-airport transportation system, it was evident that the system must be looked upon as only one of the many elements which together constitute a total functioning airport. Since the capacity of the system would be dictated by the total number of vehicles distributed by assignment to the dispersed lots, and in view of the impact that such an assignment would have on the operation of the Central Complex, it became essential to analyze the parking distribution for the total airport.

As originally conceived, the plan for a system of dispersed parking lots called for the removal of all parking from the Central Complex. Various benefits would accrue from such a plan. Vehicle flow into the Central Complex would be reduced and limited to drive - through activity, 45% of the total flow, thus mitigating an anticipated and intolerable future condition of congestion. The development of five surface lots, which could accommodate a projected 42,000 parked vehicles, would further, require significantly less capital investment than the alternate plan of a series of major parking structures within the Central Complex. As an additional major consideration, the deployment of the dispersed lots in relation to the external road and access system was such that the ultimate capacity of the airport, estimated at 56 million annual passengers, could be realized without dependence on future freeway additions. Though the commitment to a Master Plan configuration in which the concept of dispersed parking is a central theme has not been departed from in principal, subsequent considerations have required modifications. The determination on the part of the Department of Airports that three level (ground level, plus two) parking structures be provided within the Central Complex has precipitated the following recommendation. Since the augmented capacity of the central parking area would not be sufficient to provide adequate accomodations for all airlines, and since such parking when considered from the standpoint of proximity and access, placed the tenant carriers of Terminal One and the West Terminal at a disadvantage, it was judged essential to provide parking accommodations within these latter facilities on an equal basis. This, implied, as a matter of course, that the implementation of all five dispersed lots would not be required at the horizon year of 1975, and that Dispersed Lots numbers 2, 3 and 4, with a combined capacity of 31,480 parking spaces, would prove sufficient when balanced against provisions in the Central Complex.

Historically, in computing total required parking for the airport, a factor of 750 spaces per million annual passengers has been used, representing the combined requirements for all parking functions, i. e. public, U-drive, valet service, and employee , official, and public transport. As originally stated by the Department of Airports, this factor was derived by first comparing the total parking spaces required during an actual calendar year to the number of passengers passing through the airport during the same year, and then adjusting the results upwards to produce a factor which would reasonably accommodate the errors in forecasting which are bound to occur under conditions of unprecedented growth.

In any event, since this factor has not exceeded current projections of the Department of Airports, by more than 11 or 12%, it was not deemed necessary to depart from it for the purposes of this study. It should be noted, however, that calculating the total required parking spaces by the use of this factor produces an assessment of parking needs in a static state as opposed to parking flow, or a dynamic state. This distinction is perhaps most clearly seen when the following Department of Airports criteria is considered:

1) In terms of parking flow (inbound vehicles destined to park):

   a. 90% will park less than 24 hours.

b. 10% will park for over 24 hours.

2) In terms of parking lot inventory:

a. 30% of the vehicles parked park for less than 24 hours.

b. 70% of the vehicles parked park for over 24 hours.

From the foregoing it can be seen that, with reference to vehicles parking for over 24 hours, 70% of the parking spaces are required to accommodate an influx of vehicles comprising only 10% of the total inbound vehicles parking. Since the capacity of a given parking area can, therefore, be predicated on the presence of a large static body of vehicles substantially unaffected by peaks within a day, the establishment of total parking spaces on the basis of annual needs can be viewed as valid. On the basis of the ultimate annual passenger capacity of the airport of 56 million annual passengers, and at the rate of 750 parking spaces per million annual passengers, 42,000 total spaces would be required.

During the last nine months of the year 1962, the Department of Airports conducted 69 separate inventories of the airport public parking lots during periods of maximum activity. The highest single count, when compared with total annual passengers and adjusted by an efficiency factor of .85 produced the following relationship: 525 public (fee) spaces are required for each million annual passengers. For 56 million annual passengers, therefore, 29,400 public (fee) spaces would be required. In order to assign spaces per million annual passengers to those functions other than public parking, projections by the Department of Airports were analyzed. From DofA Drawing No. 6804-105 entitled "Critical Factors for Expansion" (dated January, 1968), the projections for the year 1977 were selected on the premise that, with a forecast of 57.8 million annual passengers, the data could be used to ascertain the proportional assignment of parking space for 56 million annual passengers.

The cited document presented the number of parking spaces required for each of the parking functions previously noted. Against the projected 57.8 million annual passengers, these figures were interpreted in terms of both the number of parking spaces per function per million annual passengers, and in terms of the percentage of total parking spaces attributable to each function (See Table IV). These percentages were then applied to the total required 42,000 parking spaces (See Table V) and the results adjusted to the factor of 525 public parking spaces per million annual passengers. Placed in tabular form the results were as indicated in Table VI.

When compared to Department of Airports projections, the above adjustment to 56 million annual passengers did not in its assessment of any parking function exceed the D of A projections by more than 11.5%.

In order to evaluate parking requirements in terms of peak-hour passenger activity, as noted previously it is necessary to establish a relationship between parking vehicles and the volume of inbound vehicles. For this purpose the following criteria were used:

1) Of the total vehicles entering the airport, 45% will drive through while 55% will park. (Department of Airports)

2) Of the total vehicles comprising the parking flow (55%), 90% will park for less than 24 hours, and 10% will park for over 24 hours. These percentages constitute 49.5% and 5.5% of the total entering vehicles, respectively. (Department of Airports)

A more detailed evaluation indicated that the preponderance (90.4%) of the vehicles parking for less than 24 hours parked for a period of 3 hours or less. This relationship was derived from an examination of parking revenues for the week of August 25, 1966.[1] In terms of the number of vehicles parked for up to 24 hours, the data indicated, in abstract, the following:

1 See "Chronology of the Master Plan Development, Phase V, Parking and Circulation Development", February, 1968

Time Parked	Number of Vehicles	%
0 to $\frac{1}{2}$ hrs.	16,049	17.4
$\frac{1}{2}$ to 3 hrs.	67,339	73.0
3 to 4 hrs.	2,730	3.0
4 to 6 hrs.	4,179	4.5
6 to 8 hrs.	1,339	1.5
8 to 24 hrs.	545	.6
Total	92,181	100.0

The sum of the vehicles indicated in the first two entries (0 to $\frac{1}{2}$ hrs.) is 83,388 representing 90.4% of the total vehicles parked for a period of up to 24 hours.

To summarize the foregoing conclusion, it can be said of inbound vehicles that

1) 45% of the total will drive-through

2) 55% of the total will park.

   a. 5.5% of the total will park for over 24 hours.

   b. 49.5% of the total will park for less than 24 hours.

   c. 4.75% of the total will park for less than 24 hours but for more than 3 hours.

   d. 44.75% of the total will park for 3 hours or less.

For purposes of this study, short-term parking is defined as parking for a period of 3 hours or less. It is evident from this that at a peak hour, which is consequently a peak period of vehicular activity, the principal parking requirement would be the accommodation of vehicles parking for 3 hours or less.

To formulate a comprehensive parking plan for the total airport and to effect a balance between dispersed lots and Central Complex parking, distribution in two frames of reference is necessary:

1) Distribution of public parking in terms of duration of parking.
2) Distribution of total parking in terms of function.

From the standpoint of required area alone, it was concluded that long-term parking should be excluded from the Central Complex. The inclusion of long-term parking in the Central Complex could be viewed as reducing vehicular flow during the peak hour, but as we have seen, the greatly reduced rate of turnover would precipitate a significantly lower level of parking service and would create an inflexible condition during off-peak hours, at which time a greater flow towards the Central Complex could be anticipated.

Distribution of short-term parkers was then considered on the basis of two plans. The two plans are characterized by the proportion at which short-term parkers are distributed between the Central Complex and the dispersed lots:

1) The first plan provided for the assignment of 100% of the short-term parkers, and all drive-through traffic to the Central Complex, with only the long-term parkers assigned to the dispersed parking lots. In

terms of total inbound vehicular flow:

A)	Central Complex	Dispersed Lots
Drive-Through	45.00%	-0- %
Long Term	-0-	10.25
Short Term	44.75	-0-
Total	89.75%	10.25%

2) The second plan provided for the assignment of 50% of the short-term parkers, and all drive-through traffic, to the Central Complex with the remaining short-term parkers and all the long-term parkers assigned to the dispersed parking lots. In terms of total inbound vehicular flow:

B)	Central Complex	Dispersed Lots
Drive-Through	45.00%	-0-%
Long-Term	-0-	10.25
Short-Term	22.37	22.38
Total	67.37%	32.63%

The assignment of all short-term parkers to the Central Complex was computed as generating 89.75% of the total inbound vehicular flow into the Central Complex and only 10.25% to the dispersed lots.

On the other hand, a 50% to 50% distribution of short-term parkers between the Central Complex and the dispersed lots reduced the calculable flow into the Central Complex to 67.37%, and increased the vehicular flow to the dispersed lots to 32.63%. Even without recourse to further calculation, it can be said, with respect to the former level, that an admission to the Central Complex of 89.75% of the total inbound vehicles would not provide the desired relief from congestion, particularly when one considers the access problems currently viewed against a background of 100% influx at half the projected volume. By the same token a flow into the lots of only 10.25% cannot be viewed as providing for the transportation system a design capacity adequate to justify its construction.

The next step, then, was to analyze, in terms of the projected passenger volumes, the numbers of vehicles generated thereby and to compute the required parking capacities of both the Central Complex and the dispersed lots. For the purposes of converting total passengers to total inbound vehicles a factor of 1.7 passengers per vehicle was used. This ratio is derived from Department of Airports Drawing No. 6804-105, "Critical Factors for Expansion". Line 14 of that document states in essence that 1.18 vehicles enter and exit the airport for each enplaning and deplaning passenger. Since all vehicles are in this case, counted twice, once upon entering and once upon exiting, it would be equally true to say that

.59 (1.18 ÷ 2) vehicles enter for each enplaning and deplaning passenger. Taking the reciprocal of .59, the converse of the foregoing statement can be made: 1.7 airline passengers is associated with each inbound vehicle.

On the basis of the above considerations, the 12,700 passengers, associated with what previously has been defined as the peak hour for the average day of the week (See Table III, Tuesday, 9:00 a.m. to 10:00 a.m.), would generate a total of 7,450 inbound vehicles. Assuming the 50% to 50% distribution of short-term parkers between the Central Complex and the dispersed lots, 5,019 vehicles would enter the Central Complex and 2,431 would be destined for the dispersed lots. Based on the previous assertions relative to parking flow, of the 5,019 vehicles entering the Central Complex, 3,354 would drive through, and 1,665 would park. It could be assumed that this latter figure which represents the influx of vehicles destined to park during the peak hour, also represents the maximum number of public parking spaces required in the Central Complex. It is evident, however, that the accumulation of vehicles parked during the hours preceeding must be added to this figure to arrive at a total number of vehicles requiring accommodation during the hour in question. This would imply, of course, the necessity of ascertaining a rate of flow of vehicles during a 3-hour period, from which could be deduced the cumulative number of short-term parkers. In the absence of comprehensive data relating to rate of entrance , it was decided to analyze rates of departure conclusions concerning which could be calculated from the parking revenue data, of the week of August 25, 1966, previously examined. From this data, two observations applicable to the matter at hand were abstracted as a point of beginning:

1) 17.4% of the vehicles parking park for a period of 0 to ½ hour.

2) 73% of the vehicles parking park for a period of ½ to 3 hours.

Since the only group of parking vehicles to be dealt with was a group parking for 3 hours or less, the above data was then transposed into a time scale which would reflect the movement of such a body of vehicles. Assuming that the percentages between the end of the first ½ hour and the end of the third hour are proportional (in terms of vehicles parking 14.60% per ½ hour), then the duration of parking for the 3 hour period, at ½ hour intervels would be:

0 to ½ hr.	17.40% of vehicles
0 to 1 hr.	32.00% of vehicles
0 to 1½ hr.	46.60% of vehicles
0 to 2 hr.	61.20% of vehicles
0 to 2½ hr.	75.80% of vehicles
0 to 3 hr.	90.40% of vehicles

If we take the 90.40% as 100% and invert the above scale, we have a second scale which indicates the percentage of the total body of 3 hour parkers still remaining after each ½ hour of the 3 hour period.

		0	hr.	100.00% parked vehicles
0	to	$\frac{1}{2}$	hr.	80.75%
$\frac{1}{2}$	to	1	hr.	64.60%
1	to	$1\frac{1}{2}$	hr.	48.45%
$1\frac{1}{2}$	to	2	hr.	32.30%
2	to	$2\frac{1}{2}$	hr.	16.15%
$2\frac{1}{2}$	to	3	hr.	00.00%

The rate of departure for a 3 hour period, therefore, would be:

During the first $\frac{1}{2}$ hour:	19.25%
During each of the five remaining $\frac{1}{2}$ hour periods:	16.15%
or	
During the first hour:	35.40%
During each of the two remaining one hour periods:	32.30%

Applying the departure rate above to the number of vehicles parking in the Central Complex at the peak-hour, on an average day, a scale reflecting the departure rate in terms of attributable vehicles at $\frac{1}{2}$ hour intervals would be as follows:

$\frac{1}{2}$ hour Beginning		
9:00 a.m.	100.00%	1,665
9:30	80.75%	1,345
10:00	64.60%	1,077
10:30	48.45%	809
11:00	32.30%	541
11:30	16.15%	273
12:00	00.00%	0

The total vehicles for all of the hours indicated in Table II were then distributed on the same basis as those associated with the 9:00 a.m. to 10:00 a.m. interval. The departure rate scale was now applied to the number of vehicles parking in the Central Complex attributable to each of these hours, and all of the resulting scales were superimposed to produce a composite from which could be extracted the total accumulated vehicles parked in the Central Complex at any ½ hour interval of the time period from 7:00 to 4:00 p.m. As a result, the highest accumulation of parked vehicles was seen to be 2,997 occuring during the 10:00 a.m. to 10:30 a.m. time period. This figure could now be taken as the number of public parking spaces required during the peak hour of the average day of the average week. In terms of total activity, however, the average week would on five occasions (as shown on Table III) exhibit volumes significantly higher than that of the average day. The highest of these was Wednesday, during the hours 1:00 p.m. to 4:00 p.m., during which time total activity could be expected to be 1.56 times that of the peak hour of an average week. On this basis, and in order to accommodate within the Central Complex at least the peak volume of the average week, the total public spaces required would be 4,675.

In terms of function (employee, U-drive, and valet service) the following conclusions were made. First of all, since employee parking must be considered as long-term in nature, its inclusion in the Central Complex would precipitate the same consequences as long-term public(fee) parking, as previously discussed. The operation of U-drive and valet parking services, on the other hand, require centralization, for reasons of managerial efficiency, and so should be included in the Central Complex . It could also be concluded that of the various categories of passengers, the passenger wishing to avail himself of U-drive or valet services would be the most disadvantaged by being required to ride a secondary system of transportation in order to achieve his aims.

Considering the inclusion within the Central Complex of 50% of the short-term parkers (on an accumulated basis: 4, 675) and all U-Drive and valet parking (from Table VI: 4, 704 and 1, 904 respectively) the total parking requirement would be 11, 283 spaces.

In order to make specific assignments of parking spaces, it was now necessary to establish the percentage of the total spaces attributable to each terminal and satellite. It was evident that the most equitable basis upon which to establish such a relationship would be a comparison of the maximum passenger activity of all the terminals and satellites. The peak-hour enplaning volumes of the individual airlines on the average day, and viewed concurrently, provided such a basis. As previously indicated in Table II, the sum total of the projected peak-hour enplaning volumes for the total airport would be 15, 046 passengers. The peak-hour enplaning volume associated with each airline was then expressed in terms of percentage of this total and satellite and terminal assignments made per Phase I conclusions, as follows:

Terminal One	23.4%
Satellite 2	6.7%
Satellite 3 and W-1	10.8%
W-2	5.8%
W-3 and W-4	16.7%
Satellite 4	10.2%
Satellite 5	3.3%
Satellite 6	14.1%
Satellite 7 and 8	9.0%
	100.0%

Combining these figures into groups:

Terminal One	23.4%
* West Terminal	33.3%
Satellites	43.3%
	100.0%

* West Terminal: W-1, W-2, W-3, W-4 and Satellite 3 (by association).

Applying these percentages to Table VI, the number of parking spaces per function per terminal and satellite grouping was calculated, and the resulting assignments entered in Table VII establishing the parking figure for the total airport.

For direct assignment to the Central Complex, the accumulated public spaces were then distributed on the same percentage basis. This produced the following results: The West Terminal would require 1,556 public spaces; Terminal One would require 1,094; and the balance of the satellites would require 2,025. When these public space demands were added to the U-Drive and valet service parking requirements, the total attributable demand was as follows:

	Total Demand
West Terminal	3,757 spaces
Terminal One	2,640 spaces
Satellites	4,886 spaces
TOTAL	11,283 spaces

On the basis that vehicles parking within the Central Complex should associate geographically with the terminal or satellites to which such vehicles are attributable, it could be said that the "total demands" noted above would, in the case of the terminals, dictate the size of the parking accommodations within the terminals and, in the case of the satellites, determine the extent to which parking facilities (structures and/or surface) would be required in the central parking area. The projected Department of Airports plan for the erection of parking structures in the central parking area, however, would, when fully implemented, provide a total of 6, 776 spaces, 1, 890 spaces in excess of the projected demand of 4, 886 generated by the satellites. Since the capital investment in parking structures can be presumed to be less than the provision of equivalent parking facilities in the underground terminals, it was decided to reduce the parking accommodations in such terminals by relegating a portion of their attributable U-Drive and valet service requirements to the central area. The distribution of the excess 1, 890 spaces between the West Terminal and Terminal One was made on the basis of a comparison of their maximum activity. Since their combined demand represented 56. 7% of the total airport demand, and taking this combined demand as 100. 00%, the West Terminal and Terminal One would compare at a percentage ratio of 58. 7% to 41. 3%. On the basis of a combined reduction of 1, 890 spaces, the West Terminal would be reduced by 1, 109 spaces, and Terminal One by 781. While the reductions did not affect the number of public spaces in either terminal, all of the valet service parking and 30% of the U-Drive were reassigned to the central area.

The adjusted demands for the Central Complex would, on the basis of such reductions in terminal parking capacity, be as follows:

	Adjusted Demand
West Terminal	2, 648 spaces
Terminal One	1, 859 spaces
Satellites	6, 776 spaces
TOTAL	11, 283 spaces

The final steps were the distribution of public, U-Drive and valet service spaces, attributable to the balance of the satellites, to the parking structures in the central parking area. Since U-Drive and valet functions are curb-side services, only the public parking was allocated on the basis of satellite and parking structure proximity. Once again, on the basis of comparative demand, the 2, 025 public spaces attributable to the balance of satellites were distributed on an individual satellite basis and, as seen on Chart I, assigned to the parking structure closest at hand.

As has been shown, the parking distribution predicated on a 50% to 50% assignment of short-term parkers between the Central Complex and dispersed lots generates a total parking-space demand within the Central Complex of 11,283. Based on the total requirement of 42,000 spaces, the balance of parking accommodations required in the dispersed lots would be 30,717. As previously reported, the combined capacity of dispersed lots Nos. 2, 3 and 4, when fully implemented, would be 31,480. From this it can be reasonably concluded that the parking distribution judgments made herein before, do, in fact, achieve the desired equitable balance between the Central Complex and the dispersed lots.

G. Economic Considerations

Consideration of the concept of dispersed parking would normally involve cost comparisons between two alternate, equally viable alternatives, the creation of either of which was within the control and economic capacity of the decision maker, in this instance the Department of Airports. In this instance, the alternatives are (1) concentrated central core parking (with seven story garages, multi-level roadways and, most importantly, assured access to airport perimeters) and (2) parking further out in dispersed lots. The costs directly associated with central core parking, previously estimated at $100,000,000, can be largely accepted as valid in the event interior parking is decided on. Ease or even possibility of access in peak hours, however, is not certain for another ten or twelve years or until the freeway loop exists. For the present, therefore, the decision seems to rest not on possible economic trade-offs, but only on a fair evaluation of costs to the airport and consequent costs to each passenger in terms of service rendered, service which is apparently available in no other assured way. The costs involved both in providing and in operating and maintaining a system such as is visualized, would include the following elements:

1. The transportation system itself.
2. Transportation system stations, including modifications to existing buildings.

3. Multi-level and underground central core parking structures.

4. Spine road and its interchange connections.

5. Dispersed parking lot development.

These capital costs, when analyzed, will yield a figure to be either recovered from revenues or considered a cost of service on a yearly or on a per-passenger basis. This can be further broken down to cost per person or passenger using the system itself, but this refinement approaches the specific s of rate-making studies, which beyond the scope of the present analysis.

The system operating costs, viewed on an annual basis, involve:

1. Transportation system operation, maintenance and repair.

2. Parking facility operation, maintenance and repair.

3. Transit station operation, maintenance and repair.

Beyond the scope of this phase of the subject study, but of vital concern, will be a detailed economic analysis prepared in terms of these preceding considerations.

APPENDIX A

Parking Distribution and Costs:

New Modular Parking Structures - Central Complex

2 garages @ 810 cars each = 1,620		
2 garages @ 1,900 cars each = 3,800		
	5,420 spaces	
5,420 spaces @ $2,500/space =		$13,550,000

Underground Terminals:

Terminal One	1,859 spaces	
West Terminal	1,648 "	
	4,507 spaces	
4,507 spaces @ $5,000/space =		$22,535,000

Parking Lots - Dispersed:

30,717 cars @ $250/per car =	$ 7,679,250

Station Costs

World Way

Platform @ + 16'

250' x 40' = 10,000'

80' x 20' = 1,600'

Lobby @ 0'

80' x 40' = 3,200'

15,000 sq. ft. @ $19/sq. ft. =	$285,000	
Escalator		
4 Flights - 18' rise @ $45,000/each =	180,000	
Elevator		
1 - 3-stop - 36' rise @ $35,000 =	35,000	
	$500,000	$ 500,000

Underground

54' x 250' = 13,500 sq. ft. @ $30/sq. ft. =	$ 900,000	
Escalators - 4 @ 18/sq. ft. each =	180,000	
2 Elevators =	70,000	
	$1,150,000	$1,150,000

Dispersed Lots

33' x 300' = 10,000 sq. ft. x 2 =

20,000 sq. ft. @ $10/sq. ft. =	$200,000	$ 200,000

Station Costs (Cont'd)

Summary:

6 World Way Stations @ $500,000/each	=	$ 3,000,000
6 Underground Stations @ $1,150,000/each	=	6,900,000
10 Dispersed Lots @ $200,000/each	=	2,000,000
	TOTAL	$11,900,000

System Costs:

For Phase I, Phase IIA and Phase IIB including: trackage, structures, electrical, control and vehicles $53,000,000

Summary:

Capital Costs:

System	$53,000,000	
Stations	11,900,000	
Parking, Dispersed Lots	7,679,250	
	$72,579,250	$ 72,579,250
Parking, Underground Terminals	$22,535,000	$ 22,535,000
Parking, Modular Structures	$13,550,000	$ 13,550,000
		$108,664,250

TABLE I

PASSENGER VOLUME PROJECTIONS

ENPLANING

DAILY

1 Airlines		2 Annual Passengers	3 Peak-Hour Peak-Month	4 Average - Month	5 Ratio	6 Peak - Month	7 Percentag
A.	United	13. 200	3, 500	18, 100	1. 29	23, 300	29. 0
B.	American	4. 800	2, 515	6, 580	1. 43	9, 400	12. 0
C.	Trans World	5. 620	1, 615	7, 700	1. 37	10, 550	13. 0
D.	Continental	3. 460	1, 531	4, 740	1. 28	6, 050	7. 5
	Sub-Totals	27. 080	9, 161	37, 120	1. 34*	49, 300	61. 5
E.	Delta	0. 911	308	1, 250	1. 39	1, 740	2. 0
F.	National	0. 594	200	815	1. 20	980	1. 5
G.	Pan Amerìean	2. 600	878	3, 570	1. 49	5, 300	6. 5
H.	Pacific Southwest	4. 600	1, 555	6, 300	1. 21	7, 648	10. 0
I.	Western	4. 000	1, 350	5, 480	1. 21	6, 625	8. 5
J.	Air West	1. 700	574	2, 330	1. 27	2, 967	3. 5
K.	International	3. 00	1, 020	4, 115	1. 20	4, 940	6. 5
	TOTALS	44, 485	15, 046	60, 980	1. 30*	79, 500	100. 0

* Average

Table I Notes:

Column 2: Annual passengers in millions as projected by the airlines.

Column 3: The peak-hour enplaning volume, average day, peak-month. Volumes on Lines A through D are as given by the airlines; volumes on Lines E through K were calculated by the ratio of peak-hour enplaning passengers to millions of annual passengers derived by comparing sub-total Column 2 to sub-total Column 3 (i. e. 9, 161 ÷ 27. 080 = 338 peak-hour enplaning passengers per million annual passenger). Example: Line E, Delta, .911 x 338 = 308.

Column 4: The arithmetic average, total daily enplaning volume, average month. Millions of annual passengers, Column 2, halved (assumed: 50% enplane) and then divided by 365. Example: Line A, United, 13. 200 ÷ 2 = 6. 600 ÷ 365 = 18, 100.

Column 5: The ratio between average and peak month volumes, derived from the Department of Airports' Drawing No. 6826-90 "1967 Monthly Airline Passengers for Each Terminal Building." From that document, the yearly total for each airline was divided by 12 to produce an arithmetic monthly average for the year. This figure was then compared to peak-monthly activity, which in all cases occurred in August. Example: United Airlines had a peak-month volume of 497, 361 passengers and a total for 12 months of 4, 634, 858. Therefore: 497, 361 ÷ (4, 634, 858 ÷ 12) = 1.29.

Column 6: The total daily enplaning volume, peak-month, Column 4 x Column 5.

Column 7: The percentage of the total daily enplaning volume for the total airport projected for each airline. Example: Line A, United Airlines: 23, 300 ÷ 79, 500 = 29. 0%.

TABLE II

ENPLANING PASSENGER VOLUMES

HOURS

AIRLINES	7:00AM to 8:00AM	8:00AM to 9:00AM	9:00AM to 10:00AM	10:00AM to 11:00AM	11:00AM to 12:00 N	12:00 N to 1:00PM	1:00PM to 2:00PM	2:00PM to 3:00PM	3:00PM to 4:00PM	24-Hour Totals
United	4 872	7 1,530	8 3,500	5 1,470	3 888	4 1,180	6 1,220	4 818	5 1,017	21,258
American	1 200	4 800	4 2,515	2 325	2 325	5 810	3 540	1 180	3 540	9,859
Trans World	0 ---	4 1,080	7 1,615	4 454	5 568	5 568	3 585	1 195	3 585	9,987
Continental	3 207	3 207	3 208	4 1,531	2 306	4 610	0 ---	1 395	1 395	5,881
Delta	0 ---	2 166	0 ---	0 ---	1 245	4 308	1 53	3 157	0 ---	1,342
National	0 ---	1 62	1 63	0 ---	2 200	1 183	1 78	1 79	0 ---	998
Pan American	1 135	1 135	2 270	1 198	2 394	1 198	0 ---	1 680	4 878	4,235
Pacific Southwest	4 474	7 1,555	3 356	4 488	3 366	3 366	3 315	5 525	2 210	6,875
Western	5 235	4 188	6 282	3 259	4 347	5 434	2 445	8 1,350	2 445	6,824
Air West	2 193	1 97	0 ---	1 107	1 107	2 214	2 245	1 123	3 574	2,547
International	1 135	1 135	2 270	1 198	2 394	1 198	0 ---	1 680	4 1,020	4,586
Totals	2,451	5,955	9,079	5,030	4,140	5,069	3,481	5,177	5,664	74,392
Adjusted	2,520	6,400	9,704	5,390	4,426	5,425	3,721	5,500	6,075	79,500
Other Method	3,336	6,735	9,794	5,326	4,330	5,446	3,879	4,562	5,639	
Use	3,000	6,500	9,750	5,375	4,375	5,425	3,800	5,000	6,000	
Activity Factors	1.30	1.30	1.30	2.22	2.22	2.22	1.92	1.92	1.92	
Total Passengers	3,900	8,450	12,700	11,900	9,700	12,200	7,300	9,600	11,500	
Inbound Vehicles	2,290	4,950	7,450	7,000	5,700	7,175	4,290	5,650	6,750	

SUPPLEMENTARY TABLE S-I
ENPLANING PASSENGER DISTRIBUTION

	Time Interval	12:00 M to 2:00AM	2:00AM to 7:00AM	7:00AM to 10:00AM	10:00AM to 1:00PM	1:00PM to 4:00PM	4:00PM to 7:00PM	7:00PM to 10:00PM	10:00PM to 12:00 M	24-Hou Totals
	Percentage Enplaning	6%	4%	22%	18%	18%	16%	12%	4%	100%
	Total Enplaning	4, 800	3, 200	17, 500	14, 300	14, 300	12, 700	9, 500	3, 200	79, 50
	Fixed Enplaning	---	---	9, 200	2, 100	3, 800	---	---	---	15, 10
	Balance Distributed	4, 800	3, 200	8, 300	12, 200	10, 500	12, 700	9, 500	3, 200	64, 40
Airline	**Percentage**									
United	29. 0	1, 384	928	2, 402	3, 538	3, 050	3, 698	2, 748	928	18, 67
American	12. 0	576	384	1, 000	1, 460	1, 260	1, 524	1, 140	384	7,72
Trans World	13. 0	626	416	1, 080	1, 590	1, 365	1, 646	1, 233	416	8, 37
Continental	7. 5	362	240	622	916	790	948	712	240	4, 83
Delta	2. 0	96	64	166	245	210	253	190	64	1, 28
National	1. 5	72	48	125	183	157	190	143	48	96
Pan American	6. 5	313	209	540	790	680	825	620	209	4, 18
Pacific Southwest	10. 0	480	320	830	1, 220	1, 050	1, 270	950	320	6, 44
Western	8. 5	409	270	705	1, 040	890	1, 076	814	270	5,47
Air West	3. 5	169	112	290	428	368	445	330	112	2, 25
International	6. 5	313	209	540	790	680	825	620	209	4, 18

Table II Notes:

General: Enplaning passenger volumes indicated are accompanied by the number of departing flights associated with each airline and hour, based on an examination of March, 1968 schedule. Such departing flight numbers are used in this instance as indices of activity. Volumes underlined are peak-hour, average day, peak-month enplaning volumes from Column 3 of Table I, and are assigned to a particular hour on the basis of the departing flight indices.

Supplementary Table S-I: Assignment in Table II of enplaning passenger volumes to hours other than those in which peak-hour, average day, peak-month volumes occur was based on the distribution developed in Supplementary Table S-I. For each of the time periods displayed, this latter table indicates the following:

Line - "Percentage Enplaning": Based on the Landrum and Brown "Survey" Table 18 (Figure I).

Line - "Total Enplaning": The percentages from the preceding line applied to the total daily enplaning volume, peak-month, of 79, 500 (Total, Column 6, Table I).

Line - "Fixed Enplaning": The sum of the peak-hour, average day, peak-month enplaning volumes, from Column 3 of Table I.

Line - "Balance Distributed": "Total Enplaning" less "Fixed Enplaning," producing the enplaning volume which must be distributed, within the time interval indicated, to those hours in which a peak-enplaning figure (fixed) does not occur.

The volumes representing the "Balance Distributed" were then, in turn, distributed to the airlines on the basis of the percentages exhibited in Column 7, Table I. As an example, the "Balance Distributed" for the hours 7:00 am to 10:00 am is indicated as 8,300; for United Air Lines, therefore, the "share" of that total activity would be 8,300 x 29% = 2,402.

Table II: Continuing, into Table II, the above example, United Air Lines peak enplaning volume of 3,500 "fixed" at the hour 9:00 am to 10:00 am; the balance of 2,402 was then distributed to the two remaining hours of the time interval on the basis of the ratio of their respective departing flight indices. In this instance, of the eleven flights departing between 7:00 am and 9:00 am, seven departed between 8:00 am and 9:00 am; the distribution to the latter hourly period would be 7/11 x 2,402 = 1,530.

Column, "24 Hour Totals" associates with the table extended to the entire day. Only the nine hour interval during which the eleven fixed peak-hour enplaning figures occur are shown.

Line - "Totals": The sum of enplaning volumes, distributed and fixed, during each of the nine hours displayed. These totals associate with a 24-hour total of 74, 392 enplaned passengers, approximately 7% less than the average daily peak-month figure of 79, 500 from Table I.

Line - "Use": An approximate arithmetic average of lines "adjusted" and "Other Method."

Line - "Activity Factors": The relationship between total activity (enplaning <u>and</u> deplaning combined) and enplaning, derived from the Landrum and Brown "Survey," Table 18 (Figure I). Example: For the time period "7:00 am to 10:00 am," the weekly total "In" is 7. 16, the total "Out" is 23. 91, and the total "In and Out" 31. 07. Therefore, 31.07 ÷ 23. 91 = 1. 30, i. e., total activity is equivalent to 130% of enplaning activity.

Line - "Total Passengers": Enplaning volumes from line "Use" multiplied by the "Activity Factors."

Line - "Inbound Passengers": "Total Passengers" divided by 1.7 (see section of this study entitled "Parking Space Disposition").

TABLE III
TOTAL ONE-WAY TRANSPORT SYSTEM RIDES

1 Day	2 Time Period	3 "A"	4 Total Passengers	5 Enplaning/ Deplaning Percentages	6 Maximum One-Way Passengers	7 "VR"	8 Visitors	9 Visitors Plus Passengers	10 Intra-Hour Peak Rate	11 "I"	12 Total	13 System Riders 50%-50%	13 System Riders 66%-34%
Tues.	9:00am to 10:00am	6.06	12,700		9,700	1.25	15,900	25,600	33,280	1.00	33,280	10,900	8,250
Sun.	7:00pm to 10:00pm	1.28 / 7.72	16,200	55.0/45.0	8,925	2.39	38,750	47,675	62,000	0.84	52,000	16,900	13,000
Sun.	4:00pm to 7:00pm	1.43 / 8.64	18,100	66.0/34.0	12,000	1.89	34,200	46,200	60,000	0.84	50,500	16,400	12,600
Sun.	10:00am to 1:00pm	1.33 / 8.06	16,900	57.0/43.0	9,475	1.77	30,000	39,475	51,500	0.93	48,000	15,600	12,000
Wed.	1:00pm to 4:00pm	1.56 / 9.43	19,800	49.5/50.5	10,000	1.45	28,800	38,800	50,000	0.88	44,500	14,500	11,000
Fri.	7:00pm to 10:00pm	1.26 / 7.74	16,000	23.5/76.5	12,250	1.39	22,400	34,650	45,000	0.95	42,250	14,000	10,700

Table III Notes:

Column 3: "A" activity indices from Landrum and Brown, Table 18 (Figure 1). As an example, for Sunday 7:00 pm to 10:00 pm, the table cited indicates an "In" component of 3.48 and an "Out" component of 4.24, for a total of 7.72. Figures above the line compare the day and time period in question with Tuesday, 9:00 am to 10:00 am, (the peak-hour, average day). For Sunday, 4:00 pm to 7:00 pm, 8.64 ÷ 6.06 = 1.43.

Column 4: Total passengers, enplaning and deplaning combined. For Tuesday, 9:00 am to 10:00 am, the figure is from Table II; for the subsequent days and hours indicated, the figures are arrived at by multiplying 12,700 by the respective comparison factors. Example: Sunday, 4:00 pm to 7:00 pm, 12,700 x 1.43 = 18,000 total passengers.

Column 5: From Landrum and Brown Table 18 (Figure 1). For Sunday, 7:00 pm to 10:00 pm, the table indicates a total ("In" plus "Out") activity index of 7.72 and an enplaning index of 4.24; therefore, 4.24 ÷ 7.72 = .55 = 55%.

Column 6: Total passengers from Column 4 multiplied by the highest percentage (enplaning or deplaning) of each day and hour from Column 5.

Column 7: "VR", visitor ratio, the number of visitors per airline passenger from Landrum and Brown, Table 20 (Figure 2).

Column 8: Total passengers, Column 4, multiplied by the visitor ratio, Column 7.

Column 9: Total visitors, Column 8, plus maximum one-way passengers, based on the assumption that visitors attributable to enplaning and deplaning passengers ride on both the inbound and outbound legs of the round trip.

Column 10: Total maximum one-way visitors plus passengers, Column 9, multiplied by a factor of 1. 3. The factor represents the 30% increase in hourly rate necessary to reflect potential intra-hour surges 15 to 20-minutes in duration.

Column 12: Column 10 multiplied by Column 11.

Column 13: The sub-column designations "50%-50%" and 66%-34%" refer to the percentage distribution of short-term parkers (defined, for the purposes of this study as parking for three hours or less), between Central Complex and dispersed lots. Since the ratio between vehicles, passengers, and visitors are constant, the percentage distribution can be applied to system riders, as well.

Column 13 (Cont'd): As covered in the section of this report entitled "Parking Space Disposition," a "50%-50%" distribution of short-term parks would generate a flow of over 32% of the total passengers and visitors) to the dispersed lots. A "66%-34%" distribution on the other hand would generate analogous flow of somewhat over 15% to the dispersed lots. System riders indicated in Column 13 are arrived at by multiplying the totals from Column 12 by the percentages of total flow (32% or 15%) to the dispersed lots.

TABLE IV

Based on 57.8 million annual passengers (MAP) and 39,129 parking spaces given and required ("Critical Factors for Expansion," January, 1968):

	Vehicles	% of Total	Spaces/MAP
Public (Fee Spaces)	26,761	68.4	464
U-Drive	4,508	11.7	78
Valet Service	1,890	4.9	33
Employee and Official	5,219	13.0	89
Taxis, Buses, and Limousines	751	2.0	13
Totals	39,129	100.0	677

TABLE V

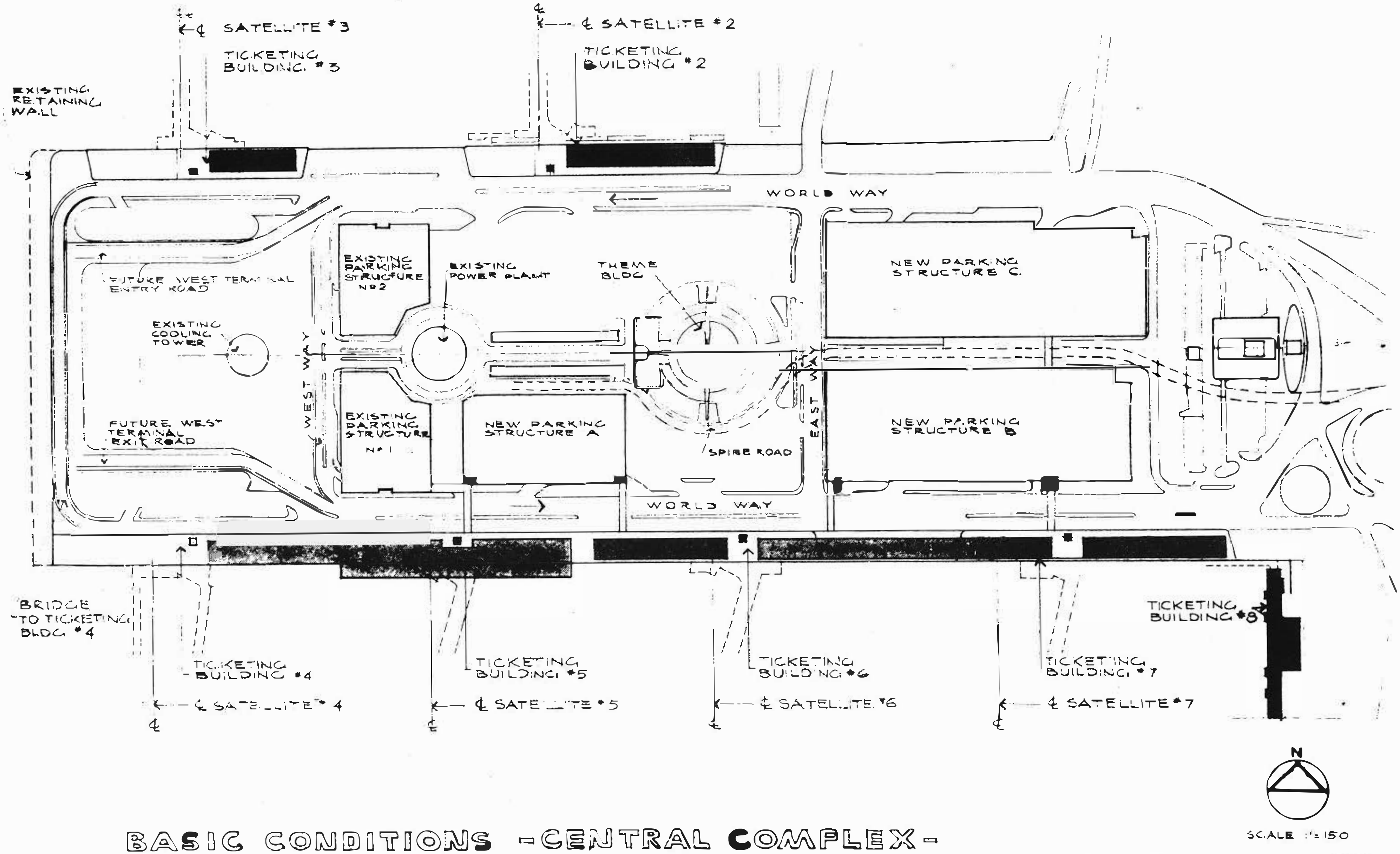
Based on 56 million annual passengers (MAP), at 750 parking spaces per million, in 1975:

	Vehicles	% of Total	Spaces/MAP
Public (Fee Spaces)	28,728	68.4	514
U-Drive	4,914	11.7	87
Valet Service	2,058	4.9	37
Employee and Official	5,460	13.0	97
Taxis, Buses, and Limousines	840	2.0	15
Totals	42,000	100.0	750

TABLE VI

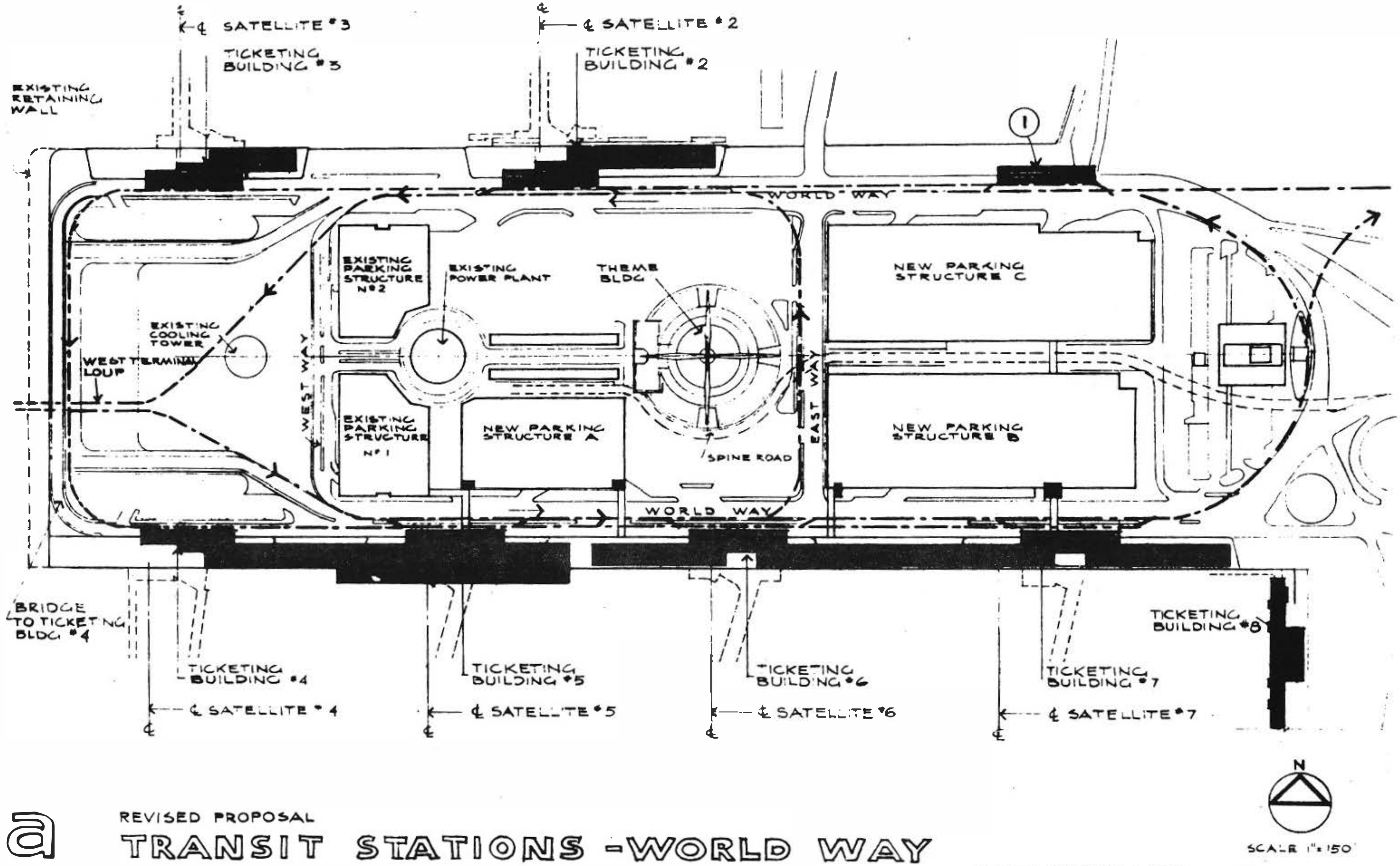
From "Data Sources and Planning and Design Criteria": "525 public parking spaces are required for each one million annual passengers." Adjusting Table V to 56 million annual passengers:

	Vehicles	% of Total	Spaces MAP
Public (Fee Spaces)	29, 400	70. 0	525
U-Drive	4, 704	11. 2	84
Valet Service	1, 904	4. 5	34
Employee and Official	5, 208	12. 4	93
Taxis, Buses and Limousines	784	1. 9	14
	42, 000	100. 0	750



BASIC CONDITIONS -CENTRAL COMPLEX-

LOS ANGELES INTERNATIONAL AIRPORT
TRANSPORTATION STUDY JOB # 68503
10-15-1968 G.P.



REVISED PROPOSAL

TRANSIT STATIONS - WORLD WAY

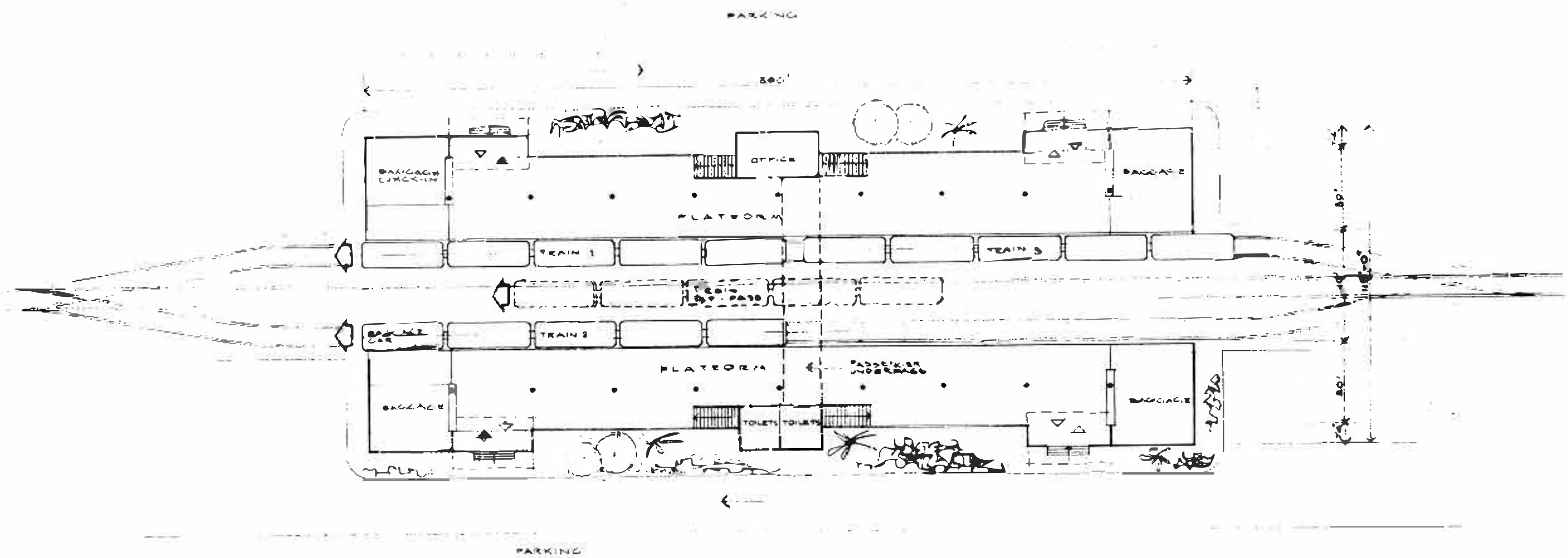
LOS ANGELES INTERNATIONAL AIRPORT
TRANSPORTATION STUDY
JOB # 68503
10-15-1968 G.R.

133

EXISTING 2 STORY TICKETING BLDG

2 STORY TICKETING BLDG PROJECTED OR UNDER CONSTR'N

TRANSIT STATION



GROUND FLOOR LEVEL EL. + 2'
PARKING LOTS 2+3

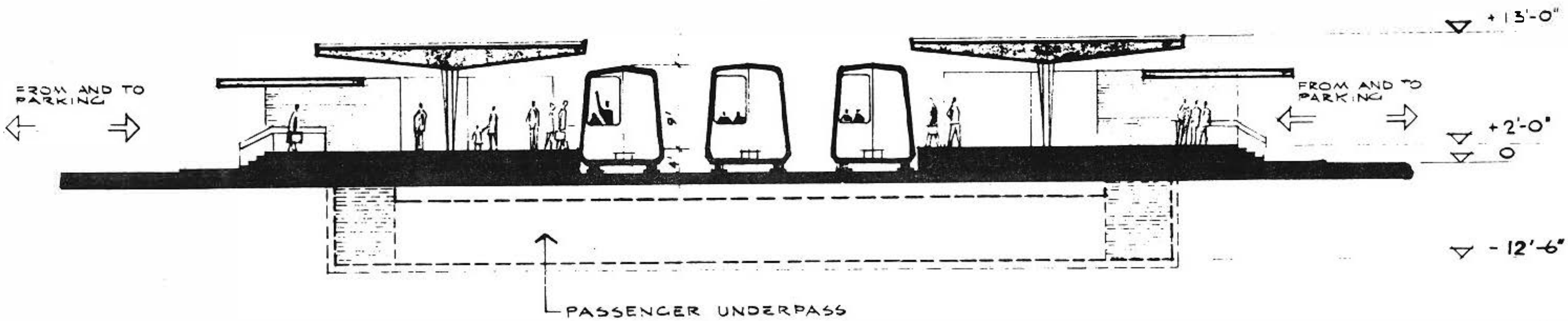
SCALE

LOS ANGELES INTERNATIONAL AIRPORT
TRANSPORTATION STUDY

WILLIAM L. PEREIRA & ASSOCIATES
PLANNING & ARCHITECTURE

TYPICAL TRANSIT STATION
PARKING LOTS # 2 + 3

137

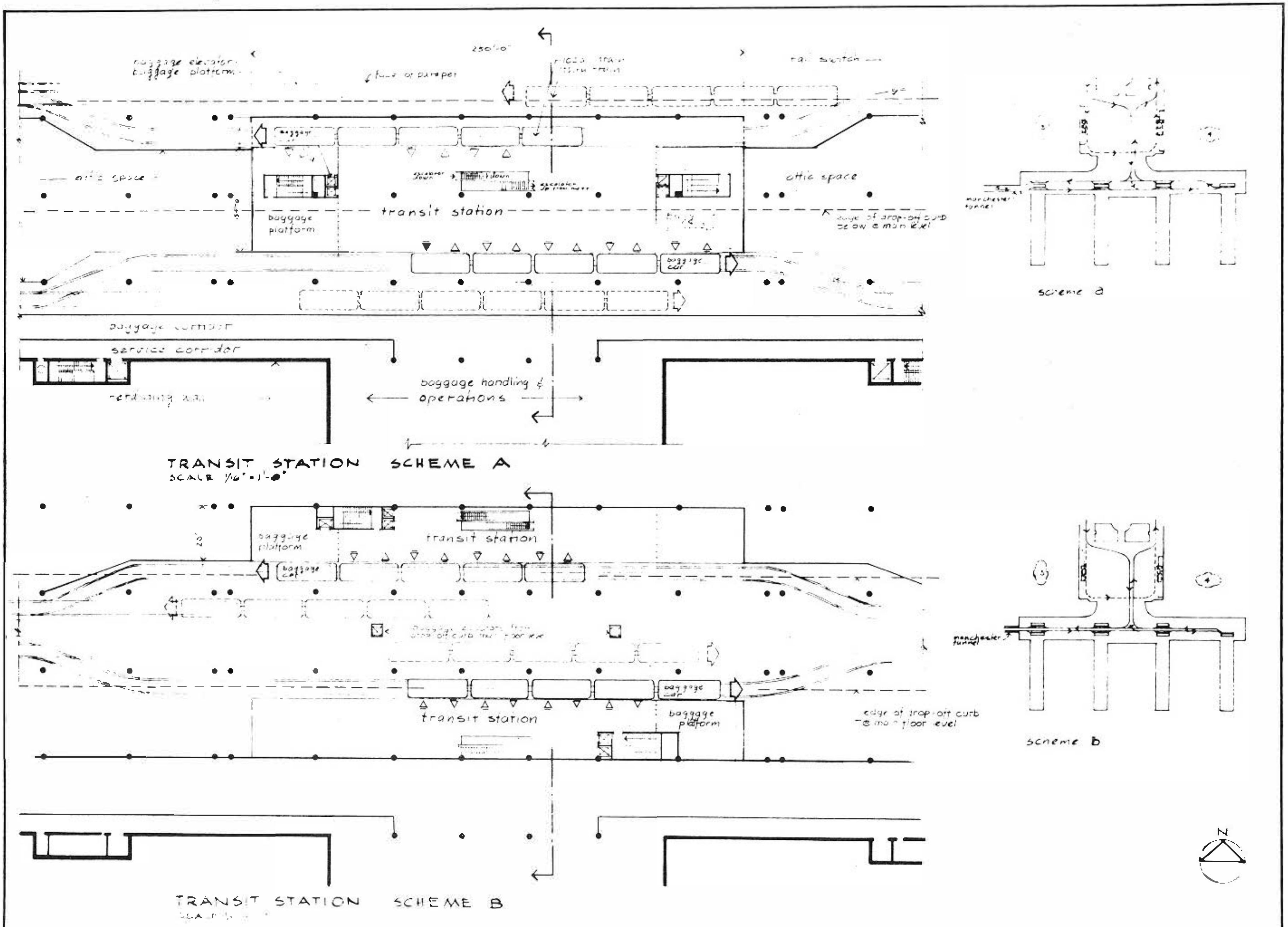


SECTION THRU TRANSIT STATION
PARKING LOTS 2 & 5

LOS ANGELES INTERNATIONAL AIRPORT
TRANSPORTATION STUDY JOB #68503

SCALE 1/8" = 1'-0" 10-15-1968 G.P

[redacted]

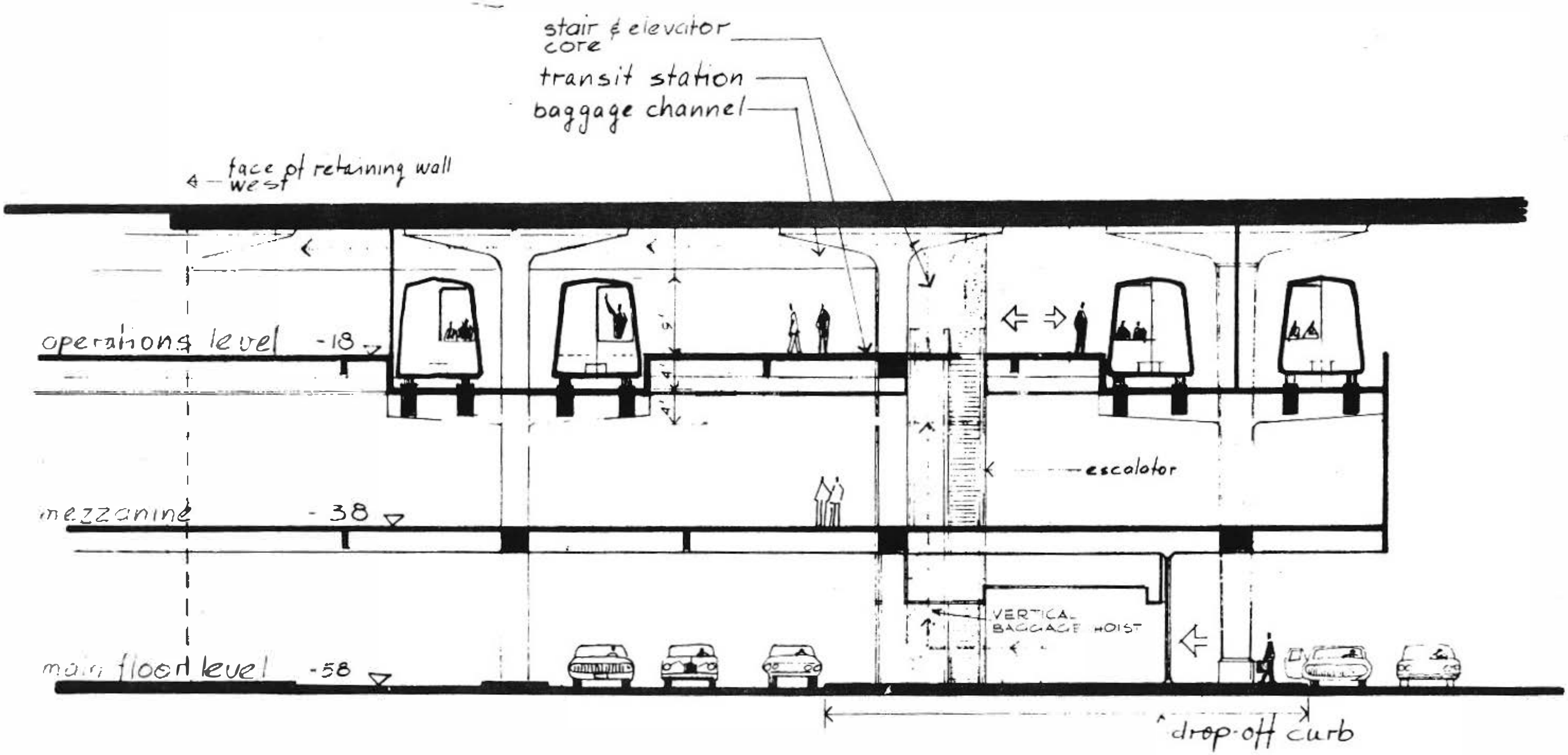


LOS ANGELES INTERNATIONAL AIRPORT
TRANSPORTATION STUDY

WILLIAM L. PEREIRA & ASSOCIATES
PLANNING & ARCHITECTURE

WEST TERMINAL
TRANSIT STATION

63503
129



SECTION THRU TRANSIT STATION

SCALE 1/8" = 1'-0"

SCHEME A

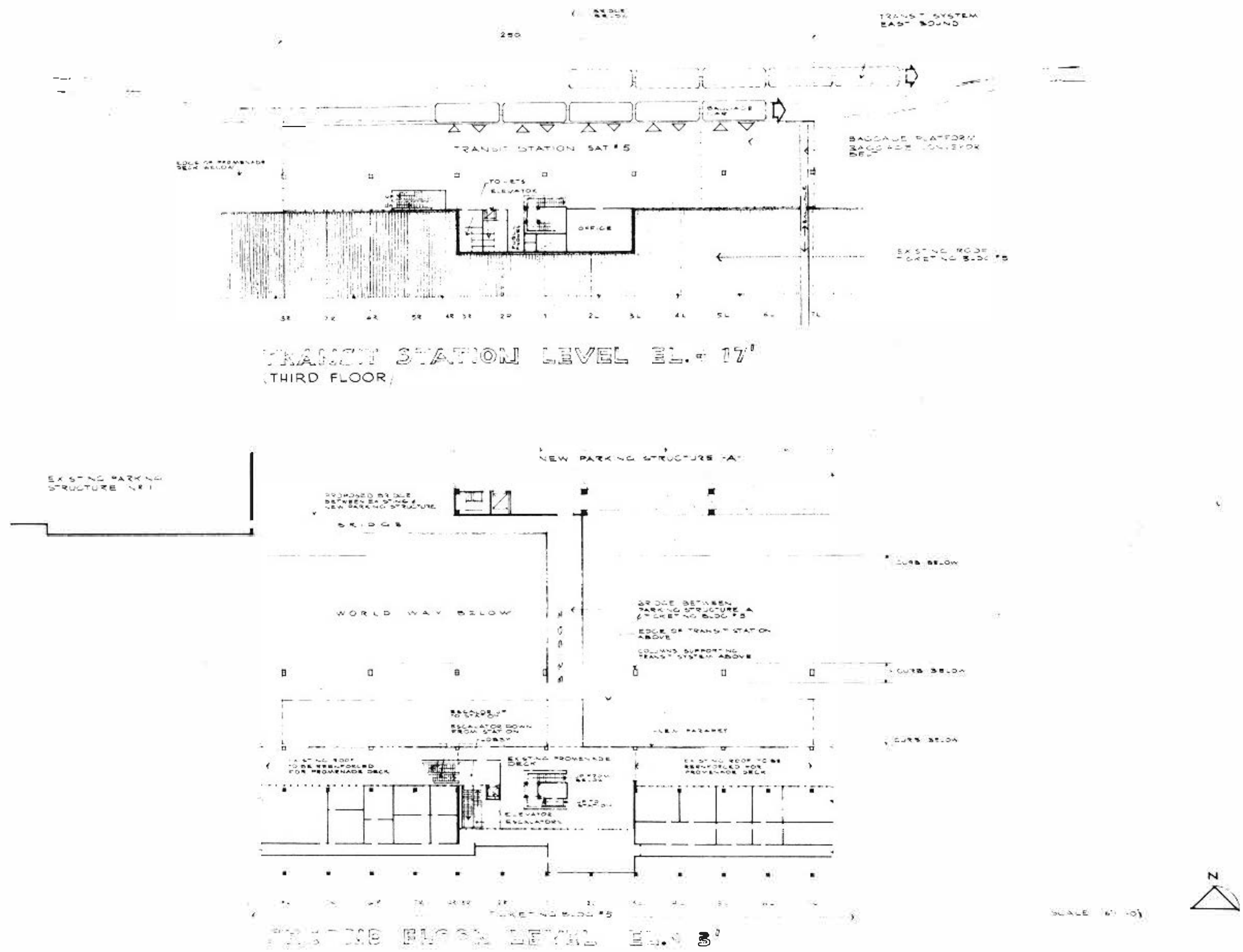
LAX

WEST TERMINAL TRANSPORTATION STUDY

JOB # 68503 9-30-1968

SH. Nº 130

[redacted]

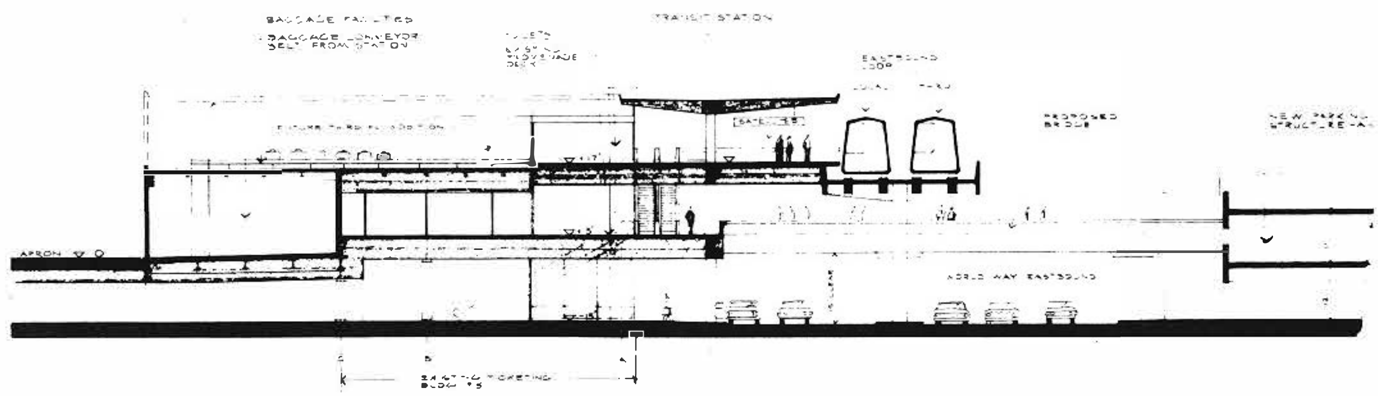


LOS ANGELES INTERNATIONAL AIRPORT
TRANSPORTATION STUDY

WILLIAM L. PEREIRA & ASSOCIATES PLANNING & ARCHITECTURE

TRANSIT STATION
TICKETING BLDG. #5

65303
135



CROSS SECTION (LOOKING WEST)

LOS ANGELES INTERNATIONAL AIRPORT
TRANSPORTATION STUDY

WILLIAM L. PEREIRA & ASSOCIATES
PLANNING & ARCHITECTURE

SECTION THRU TRANSIT STATION TICKETING BLDG #5

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Figure 1

PERCENT OF PASSENGERS BY DAY OF WEEK AND HOUR OF DAY

TABLE 18

Hour	Sunday			Monday			Tuesday			Wednesday			Thursday			Friday			Saturday			Total		
	In	Out	Total	In	Out	Total	In	Out	Total	In	Out	Total	In	Out	Total	In	Out	Total	In	Out	Total	In	Out	Total
0700-0959	1.55%	4.77%	3.16%	.32%	1.29%	.81%	1.05%	5.00%	3.03%	2.09%	5.17%	3.63%	.54%	2.12%	1.33%	.76%	3.09%	1.92%	.85%	2.47%	1.66%	7.16%	23.91%	15.54%
1000-1259	3.49	4.57	4.03	3.29	2.26	2.77	4.06	2.58	3.32	3.65	3.40	3.52	2.09	2.70	2.39	4.85	1.91	3.39	2.89	2.47	2.68	24.32	19.89	22.10
Subtotal	5.04%	9.34%	7.19%	3.61%	3.55%	3.58%	5.11%	7.58%	6.35%	5.74%	8.57%	7.15%	2.63%	4.82%	3.72%	5.61%	5.00%	5.31%	3.74%	4.94%	4.34%	31.48%	43.80%	37.64%
1300-1559	2.86%	3.36%	3.11%	3.42%	3.61%	3.52%	1.75%	1.43%	1.59%	4.75%	4.68%	4.72%	1.49%	2.33%	1.91%	1.61%	2.53%	2.06%	3.14%	2.24%	2.69%	19.02%	20.18%	19.60%
1600-1859	2.95	5.69	4.32	.83	2.12	1.47	2.85	1.84	2.34	1.52	2.62	2.07	1.30	3.33	2.32	4.38	2.04	3.22	3.04	1.04	2.04	16.87	18.68	17.78
1900-2159	3.48	4.24	3.86	1.84	1.48	1.66	2.21	2.43	2.32	2.89	.41	1.65	2.85	1.87	2.36	5.91	1.83	3.87	4.00	1.34	2.67	23.18	13.60	18.39
2200-2359	2.54	.77	1.66	.03	.55	.29	1.84	.23	1.04	1.94	.89	1.41	1.11	.36	.73	1.01	.58	.79	.98	.36	.67	9.45	3.74	6.59
Subtotal	11.83%	14.06%	12.95%	6.12%	7.76%	6.94%	8.65%	5.93%	7.29%	11.10%	8.60%	9.85%	6.75%	7.89%	7.32%	12.91%	6.98%	9.94%	11.16%	4.98%	8.07%	68.52%	56.20%	62.36%
Total	16.87%	23.40%	20.14%	9.73%	11.31%	10.52%	13.76%	13.51%	13.64%	16.84%	17.17%	17.00%	9.38%	12.71%	11.04%	18.52%	11.98%	15.25%	14.90%	9.92%	12.41%	100.00%	100.00%	100.00%

Figure 2

RATIO OF TOTAL NUMBER IN PARTY TO

TOTAL OUTBOUND PASSENGERS BY DAY OF WEEK AND HOUR OF DAY TABLE 20

Hour	SUN	MON	TUE	WED	THU	FRI	SAT	TOTAL
0700-0959	2.72	2.20	2.26	2.12	2.31	2.34	2.33	2.34
1000-1259	2.77	2.32	2.54	2.70	2.75	2.47	2.90	2.66
Subtotal AM	2.75	2.28	2.35	2.35	2.56	2.39	2.61	2.49
1300-1559	2.64	2.22	2.59	2.45	2.21	2.66	3.13	2.53
1600-1859	2.89	3.19	2.15	2.20	2.65	2.10	3.82	2.68
1900-2159	3.39	2.63	2.29	2.35	2.16	2.40	2.89	2.73
2200-2359	2.65	2.60	3.00	2.23	2.06	1.79	2.82	2.34
Subtotal PM	2.97	2.57	2.35	2.35	2.38	2.36	3.19	2.61
Total	2.88	2.48	2.35	2.35	2.45	2.37	2.90	2.56

DATE DUE
