TENTATIVE RESEARCH REPORT ON

A HIGH EFFICIENCY PASSENGER TERMINAL (UCAT)

AND SUBSEQUENT EFFECTS ON AIRPORT LAYOUT

WENDELL ROSSMAN & ASSOCIATES

ARCHITECTS

4601 EAST McDOWELL ROAD • PHOENIX, ARIZONA 85008

TENTATIVE RESEARCH REPORT ON

A HIGH EFFICIENCY PASSENGER TERMINAL (UCAT)

AND SUBSEQUENT EFFECTS ON AIRPORT LAYOUT

CONTENTS:

RESEARCH PROJECT R 661

WENDELL ROSSMAN and ASSOCIATES

ARCHITECTS

4601 E. McDOWELL ROAD, PHOENIX, ARIZONA 85008

1969 - 1970

FOREWORD

For all human activities there exist optimum environments where functions can be performed to their greatest possible advantage. To arrive at optimum environments, it's determinants must demand complete subordination to human needs, capabilities and desires.

Passenger air terminal planning has not recognized this as yet. Today's planning parameters submit to the preponderance of the aircraft. Therefore, a direct progress leading to an optimum geometry of terminals has so far been inhibited. Hence, the brief history of terminal building has produced nothing but the continued rearrangements of the landside-airside contact line. The presently preferred model - the linear concept - can claim no essential improvement over the finger plan of 20 years ago. No one could possibly call today's larger airports a success.

One could indeed ask whether there is a solution. Can an airport be fully compatible with its intrinsic purpose or must it, by nature, remain an assemblage of compromises?

The purpose of the research was to find an answer to this question. To do so, a series of axioms were set down. Of determining significance are:

Complete subordination to human needs;

An upper limit to capacity;

A single, high efficiency terminal structure, internally expandable;

Separation of major functions;

Equalization of capacities of all systems.

The research results propose:

1) A fully circular air terminal with twin level aircraft parking.

2) A two coordinate access system for both land and air side.

Employing these two design principles, basic order and compatability is achieved.

I. AIRPORT TERMINALS: A SOBER EVALUATION

In all discussions and studies about airports, one must fully accept the premise that the passenger terminal is neither built for airplanes nor carrier activities, but solely for the passenger.

What matters to him, regardless of size and location of the airport, is how long it will take from his office or home until he is in the air, how fast he can transfer en route, depart from the airport, and how many hours will remain for business or pleasure.

Today's Status

Airports as a functional complex are one of the most recent additions to the sphere of transportation structures. So recent is the development, in fact, that almost no pattern exists. Airports have grown from nothing to today's collossi in a breathless progression of trial and error.

The development has never, and still does not, follow clear directives. No determinable demarcation of priorities between passengers, aircraft, servicing, automobiles, and public land transportation exist. The limits of physical size are indefinite.

While all other architectural planning of large complexes has historically and practically recognized the limits of human abilities, the airport has not. Beyond a capacity of 4,000,000 passengers, the physical expanse of airports is such that all acceptable walking distances are exceeded. To make the system tolerable again, the concept of mechanical people movers was created. This has led planners to increase physical dimensions far beyond any and all human abilities, even before technology and organization could produce a truly functional people mover, or the correctness of the solution could be verified.

People movers as a concept are not a solution, since they still demand additional time from the passenger. To this day it has not been demonstrated that effective people movers can be created. Because of the complexity of the problem (in many aspects contradictory within) the likelihood for a solution is very small.

A further consequence of largeness is the necessity for mechanical transportation of baggage. Passengers are capable of handcarrying their luggage some distance, but distances that demand people movers require baggage movers first. Automation of baggage handling again is not a solution but a further complication. Effective systems must automatically perform the highly intricate, simultaneous movements of thousands of pieces of luggage. If technically solvable, automatic baggage systems promise to be very complex, expensive and not wholly reliable.

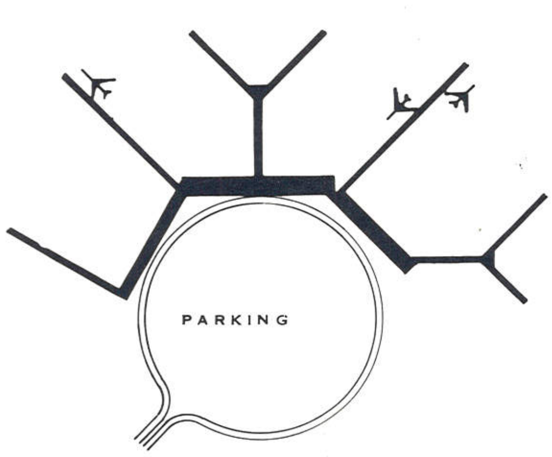
The acceptance of people movers and baggage handling systems as the two greatest adverse consequences manifest the complete subordination of the passenger to the aircraft. As a result, aircraft parking area, staging and maneuvering space now dictate the expanse of the terminal and with it all time losses of passengers.

Who is concerned over the fact that today's airports demand at least fifteen additional minutes from each en- and deplaning passenger, because of its physical arrangement? That time loss at a 10,000 passenger-a-day terminal reaches 900,000 hours a year? With a projected 167 million domestic passengers by 1970, the loss nationwide will reach the staggering height of 42 million hours, increasing to 100 million (11,400 years) by 1980!

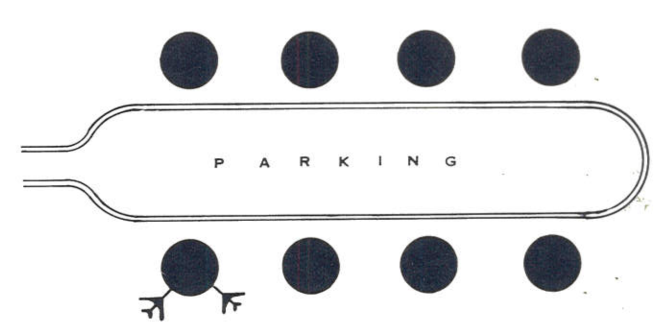
It is the belief of many planners that there is no final answer to the airport terminal, not even an optimum solution. It is precisely this thinking which has shaped today's paradoxial and highly problematic designs, designs which fundamentally are all alike, even though they claim ever new advances in the state of the art. However, the new proposals pay little more than lip service to the passengers' basic needs and desires. The solutions claimed are, in fact, relocations of the same problems.

<u>Today's Concept</u>

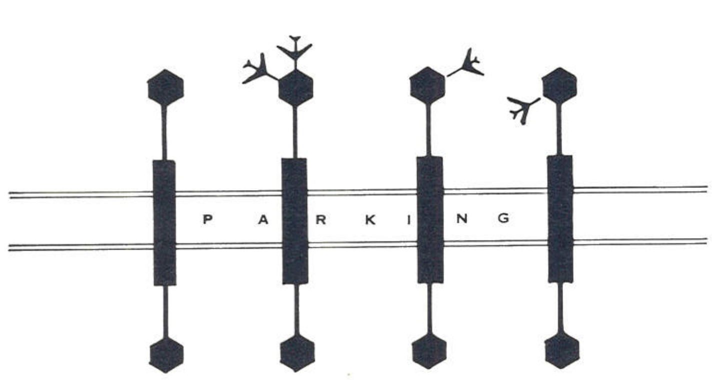
The traditional finger (Ill.1.a) plan and its many straight line derivatives attempt to solve the distance problem by placing as many parking positions as possible onto a given area, and to make them accessible by a branching system of concourses. Dockside contact line is not shortened and the plan is a complicated maze to the passenger. It also induces heavy passenger concentrations along concourses. Walking distance of 2500 feet or 14 minutes are the rule.



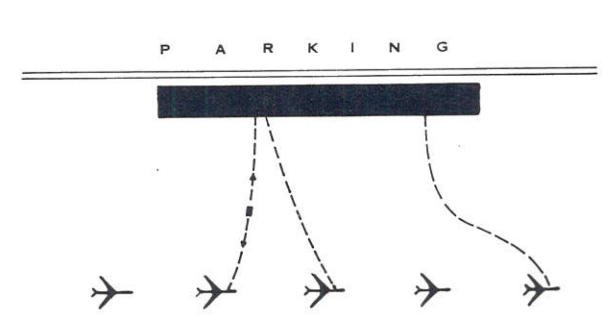
ILL. 1A THE FINGER PLAN



ILL. 1B
THE UNIT TERMINAL PLAN



ILL. 1C THE LINEAR CONCEPT



ILL. 1D
THE MOBILE LOUNGE SYSTEM

The unit terminal plan (Ill.1.b) and its subspecies of clusters has solved the distance problem for a small number of gates, but is related to other units only through mechanized transportation. All such mechanical aides have two intrinsic characteristics: neither distance nor time is reduced.

The linear concept (Ill.1.c) is a mixture of in-line, cluster and unit terminal, and solves no distance problems at all. It too relies wholly on people movers.

The only departure is the mobile lounge concept (Ill.1.d). Nevertheless, the system lengthens the passenger time at the terminal. Also, for larger aircraft, several lounges or one equal to the capacity of the aircraft itself, are necessary. The fallacy of this philosophy is that a second vehicle, of the size of the aircraft, but minus wings, is employed for something the aircraft itself can perform very well.

A Case for the Large Airport

Although a growing paradox of undesirable necessity, there are very compelling reasons which point with favor towards the large airport.

1. Most important from the passenger's viewpoint, it is extremely desirable to have one location of departure to all destinations, one point to return to, and one point only at which to transfer, all as related to one given community.

2. The noise problem exists at one locality only.

3. Air traffic becomes simplier and safer with fewer airports in a given area.

4. Ground transportation systems can be built more effectively once firm reference points are established.

These and reasons of more technical and economic nature are of sufficient importance to encourage the development of large, all encompassing airports.

II. AXIOMS OF ACCEPTABILITY

The airport terminal should, therefore, be subject to the following parameters to combine largeness and acceptability:

a) In all facets, the passengers physiological abilities, his time and convenience must be recognized before anything else.

b) In the near proximity of the passenger terminal, the aircraft with all its operational functions must completely subordinate itself to passengers.

c) All distances without and within must be short enough to be walked, even with baggage, yet accommodate the greatest possible number of gates.

d) Baggage should remain in the passenger's possession up to a point as close as possible to the aircraft to avoid timeloss and complexity.

e) Curbs should be longer and not required for car parking passengers.

f) Automobile parking should have free space indication, separate walking lanes and escalators.

g) The arrangement and functions of the building must be readily understood by the passenger.

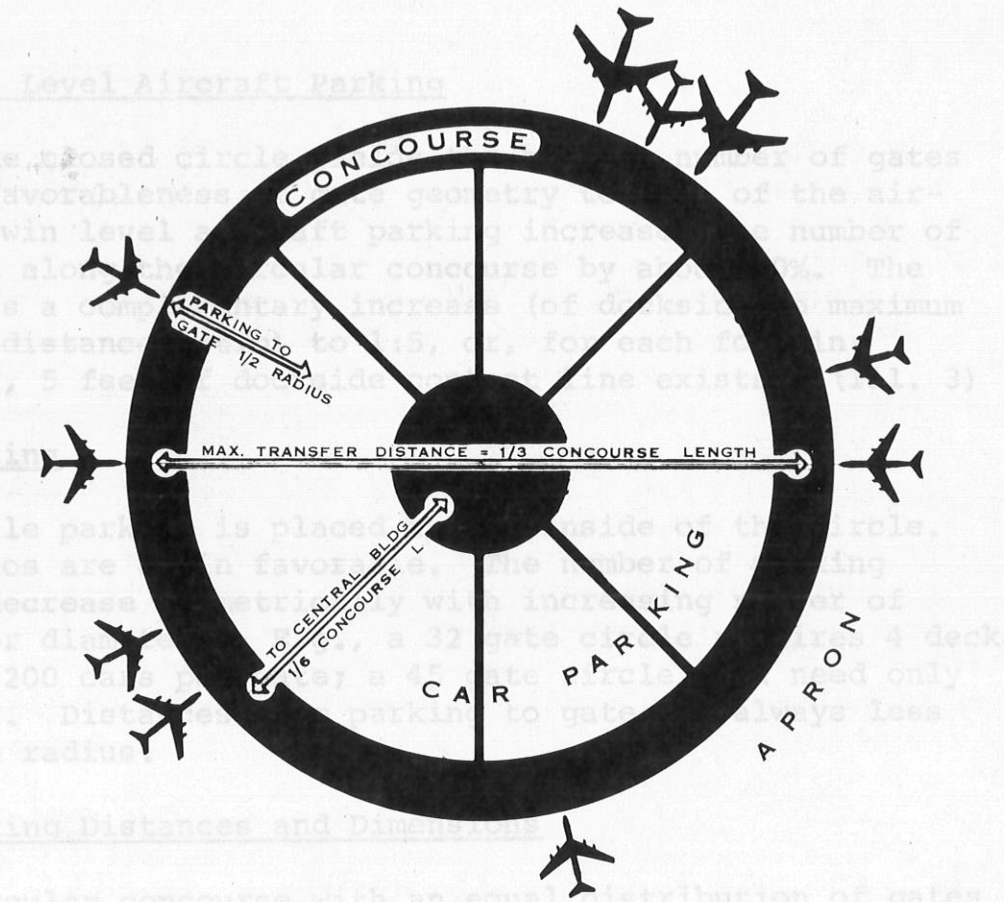
h) If required to wait out delays, the passenger must be able to entertain himself or rest in comfort.

III. THE ULTRA COMPACT AIRPORT TERMINAL

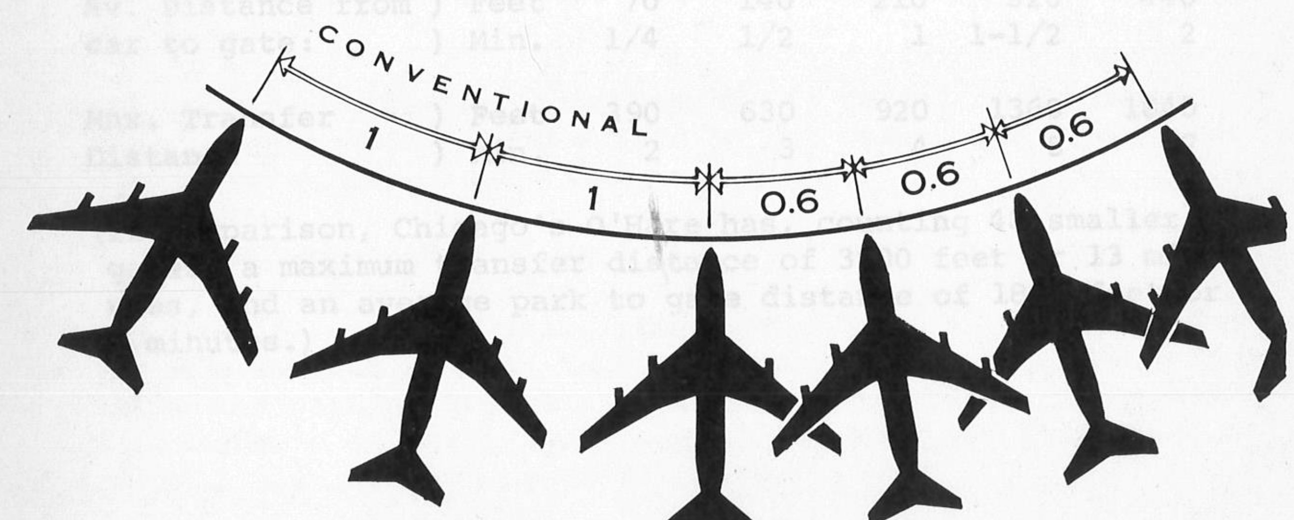
A. System Elements

Geometry

The geometric configuration which satisfies the two cardinal demands - shortest walking distances yet longest dockside contact line - is the closed circle. A closed circle concourse has, as longest distance, its diameter. The ratio of dockside contact line to walking distance has changed from 1:1 to 1:3. The average walking distance is less than the radius. (Ill. 2)



ILL 2 CIRCULAR TWIN-LEVEL AIRPORT TERMINAL



ILL 3 TWIN LEVEL AIRCRAFT PARKING

Twin Level Aircraft Parking

While the closed circle yields the highest number of gates due to favorableness of gate geometry to that of the aircraft, twin level aircraft parking increases the number of aircraft along the circular concourse by about 60%. The result is a complementary increase (of dockside to maximum walking distance ratio) to 1:5, or, for each foot in diameter, 5 feet of dockside contact line exists. (Ill. 3)

Parking

Automobile parking is placed in the inside of the circle. The ratios are again favorable. The number of parking levels decrease geometrically with increasing number of gates (or diameter). E.g., a 32 gate circle requires 4 decks to park 200 cars per gate; a 45 gate circle will need only 3 levels. Distances from parking to gate are always less than the radius.

Walking Distances and Dimensions

In a circular concourse with an equal distribution of gates for 747, DC-8 and airbuses, the average gate width is 95 feet. Therefore, the following basic relationships exist:

Number of Gates		16	24	32	48	64
Million Passengers/Year (5 hours/day)		18.4	27.6	36.8	55.2	73.6
Concourse Length in Feet		1520	2280	3200	4560	6080
Av. Distance from car to gate:	Feet	70	140	210	320	440
	Min.	1/4	1/2	1	1-1/2	2
Max. Transfer Distance	Feet	390	630	920	1360	1840
	Min.	2	3	4	5	7

(In comparison, Chicago's O'Hare has, counting 48 smaller gates, a maximum transfer distance of 3200 feet or 13 minutes, and an average park to gate distance of 1800 feet or 7 minutes.)

Limit of Largeness

As a reasonable limitation of size, the Ultra Compact Air Terminal should not impose greater maximum transfer distances than 7-1/2 min.walking. Therefore, the capacity should reach its ceiling at 54 gates, all for aircraft of 200 seats plus. Annual passenger capacity can reach a practical level of 60,000,000. This should be the regional airport's size, beyond which others must be built. At present, such airports are capable of serving population centers of 4 to 6 million.

B. The Terminal Building

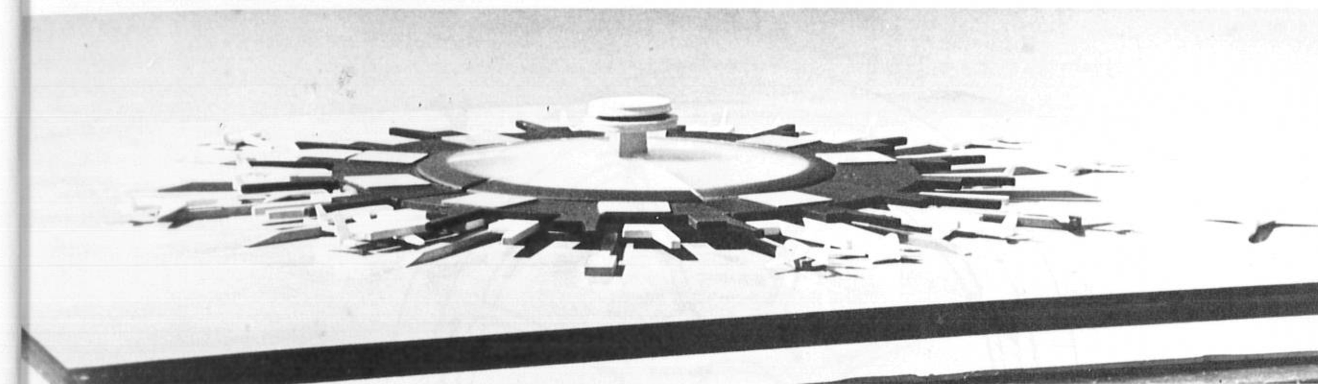
The terminal, therefore, becomes a complete island, consisting of an outer 3 level circular concourse, connected via radial walkways to the hub or central facilities building. Automobile parking is located between the concourse ring and the central building. The control tower may practically be located above the hub. (Ill. 4 and 5)

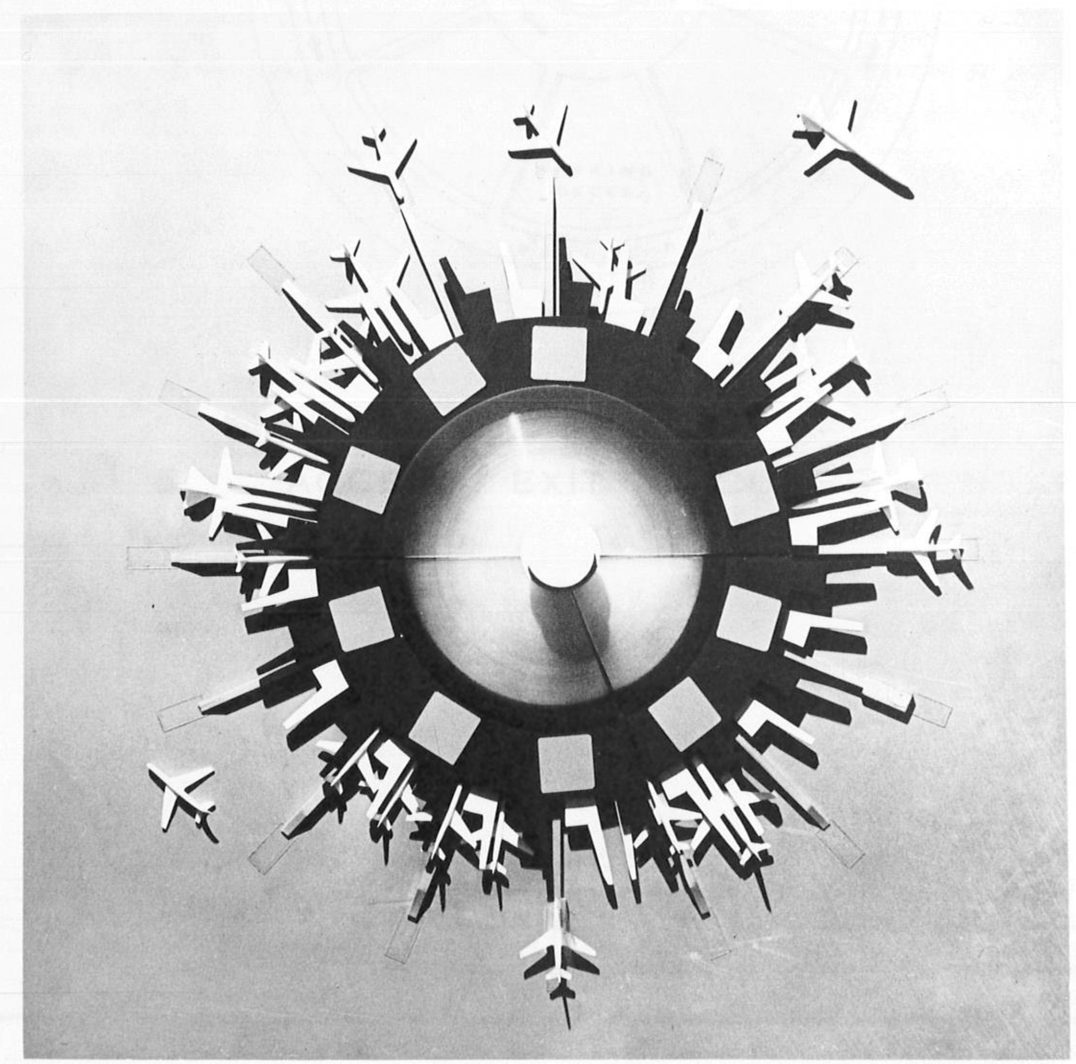
Landside

Arriving passengers enter the terminal at a level below the apron via road, subway or rapid transit system. Once inside the concourse ring the road is ramped up into a circular drive with a curb on the inside. At multiple intervals, radial roads and continued curbs lead to the hub and from there through spiral ramps to a through-road. Thus curb length is tripled. (Ill. 6) Service vehicles to the central building arrive at a loading area below, located on the through-road, thus never entering the passenger areas. At ground level, near the hub, are located rental cars, taxis and buses.

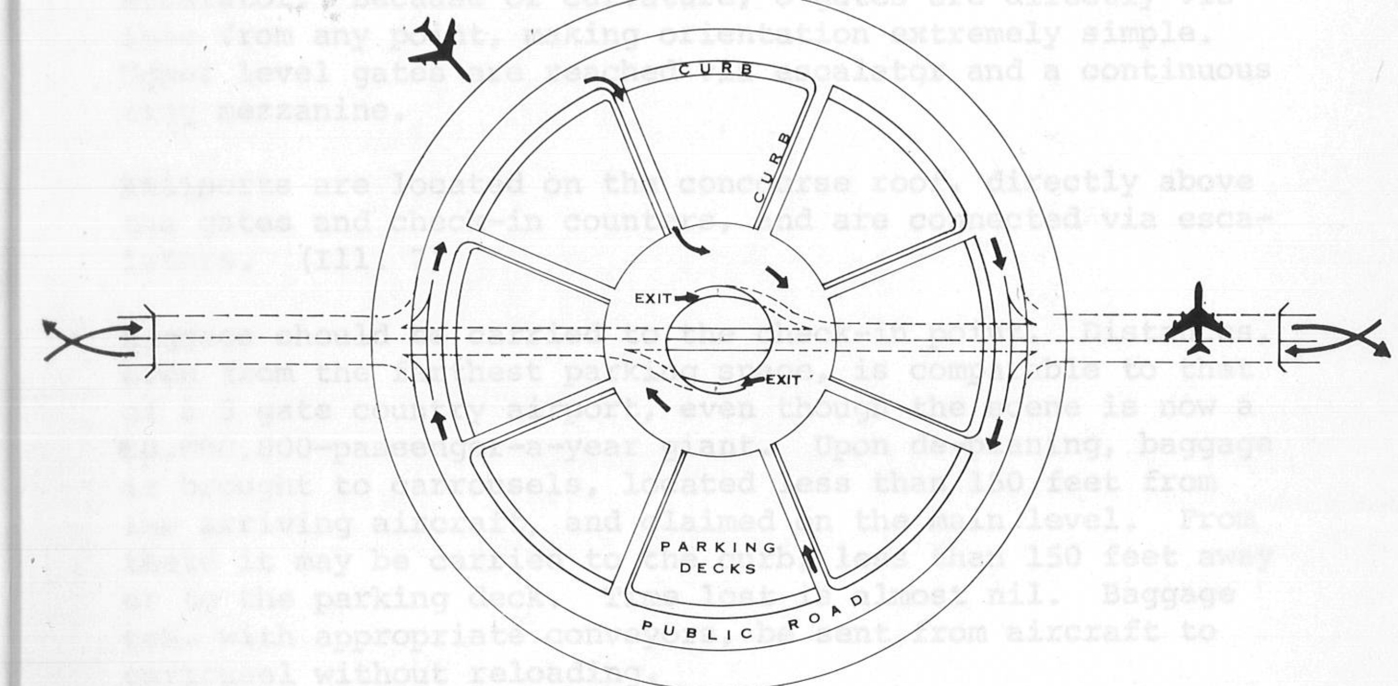
The parking decks are also entered via radial roads on one side of each segment and exited on the other side toward the spiral exit ramps at the hub.

From the curbs and parking decks, escalators and stairs lead to the main terminal level. Thus passengers will not cross any traffic lanes, causing intermittency of flow. Also, due to this feature and the extremely short walking distance between car parking and gate, arriving and leaving passengers will be able to carry their baggage to and from their cars, largely eliminating use of the curb.

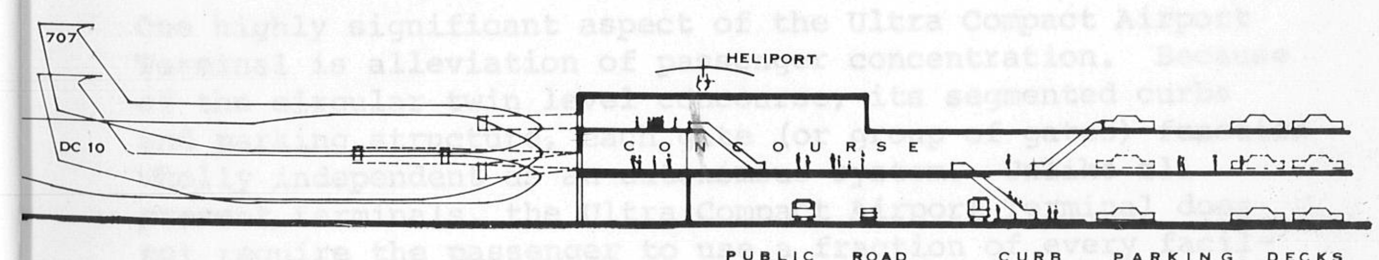




ULTRA COMPACT AIRPORT TERMINAL



ILL. 6 ACCESS, EXIT & CURBS



ILL. 7 CROSS SECTION AT CONCOURSE

Check-in occurs on the main level. Due to compaction, 6 gates are within 230 feet of the nearest curb-to-concourse escalator. Because of curvature, 8 gates are directly visible from any point, making orientation extremely simple. Upper level gates are reached via escalator and a continuous ring mezzanine.

Heliports are located on the concourse roof, directly above the gates and check-in counters, and are connected via escalators. (Ill. 7)

Baggage should be carried to the check-in point. Distances, even from the farthest parking space, is comparable to that of a 5 gate country airport, even though the scene is now a 60,000,000-passenger-a-year giant. Upon de-planing, baggage is brought to carrousels, located less than 150 feet from the arriving aircraft, and claimed on the main level. From there it may be carried to the curb, less than 150 feet away or to the parking deck. Time lost is almost nil. Baggage can, with appropriate conveyors, be sent from aircraft to carrousel without reloading.

From the circular concourse, the central facilities can be reached by traversing through radial corridors. The central building houses all facilities for the comfort and convenience of the passengers, restaurants, lounges, shops, snack bars, dayrooms, post office, travel offices and so on; administration offices for airport management and airlines. A restaurant is suitably located in the central tower overlooking the airport. Air traffic control and tower should top the hub. Distances from any gate to the central building are again very short. At 48 gates, it means a walk of about 600 feet or less than 3-1/2 minutes.

One highly significant aspect of the Ultra Compact Airport Terminal is alleviation of passenger concentration. Because of the circular twin level concourse, its segmented curbs and parking structure, each gate (or group of gates) function wholly independent as an autonomous system. Unlike all present terminals, the Ultra Compact Airport Terminal does not require the passenger to use a fraction of every facility, if in no other way but having to walk through. Because of this and functional autonomy, passenger dispersion is near perfect.

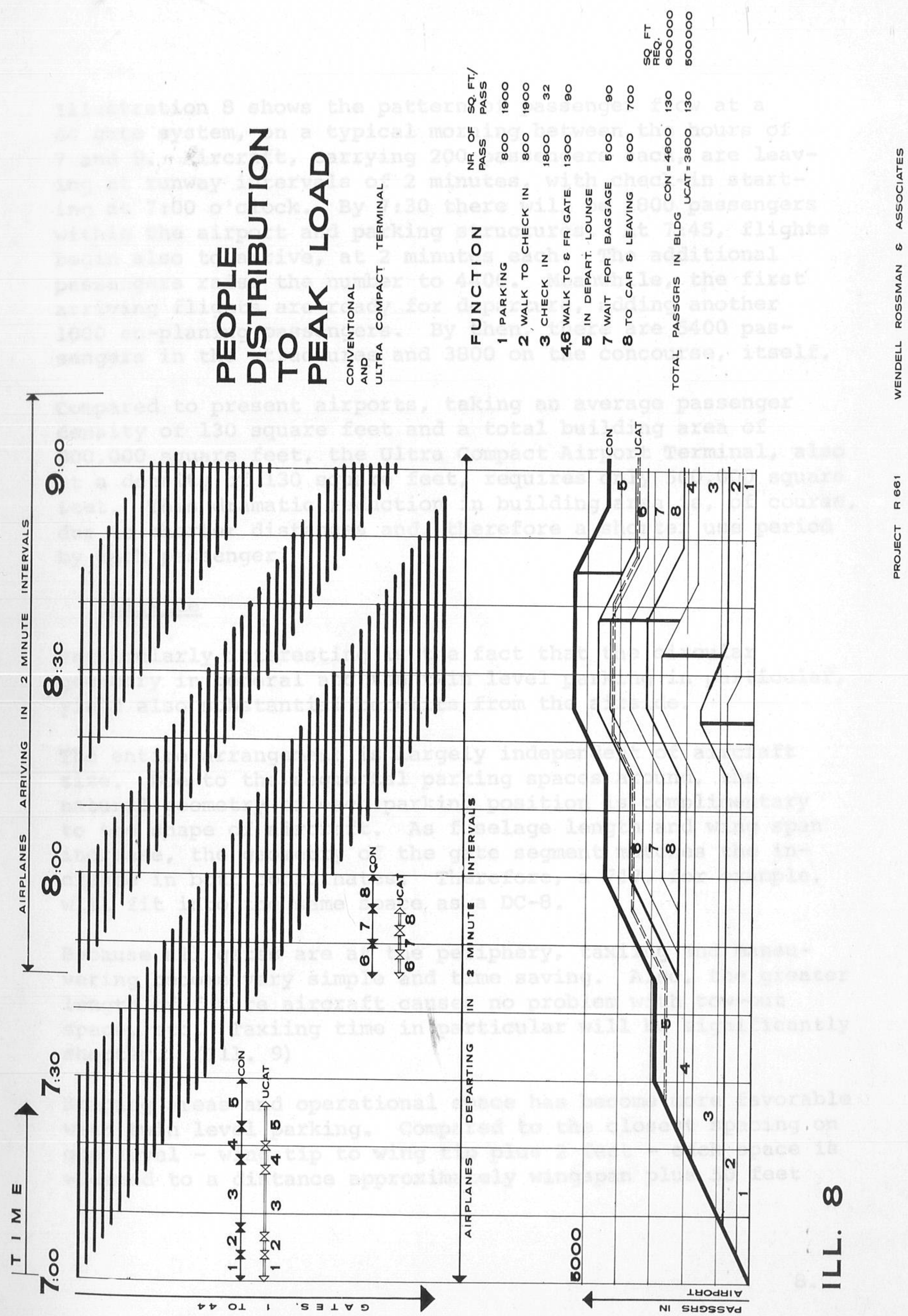
Check-in occurs on the main level. Due to compaction, 6 gates are within 230 feet of the nearest curb-to-concourse escalator. Because of curvature, 8 gates are directly visible from any point, making orientation extremely simple. Upper level gates are reached via escalator and a continuous ring mezzanine.

Heliports are located on the concourse roof, directly above the gates and check-in counters, and are connected via escalators. (Ill. 7)

Baggage should be carried to the check-in point. Distances, even from the farthest parking space, is comparable to that of a 5 gate country airport, even though the scene is now a 60,000,000-passenger-a-year giant. Upon de-planing, baggage is brought to carrousels, located less than 150 feet from the arriving aircraft, and claimed on the main level. From there it may be carried to the curb, less than 150 feet away or to the parking deck. Time lost is almost nil. Baggage can, with appropriate conveyors, be sent from aircraft to carrousel without reloading.

From the circular concourse, the central facilities can be reached by traversing through radial corridors. The central building houses all facilities for the comfort and convenience of the passengers, restaurants, lounges, shops, snack bars, dayrooms, post office, travel offices and so on; administration offices for airport management and airlines. A restaurant is suitably located in the central tower overlooking the airport. Air traffic control and tower should top the hub. Distances from any gate to the central building are again very short. At 40 gates, it means a walk of about 600 feet or less than 3-1/2 minutes.

One highly significant aspect of the Ultra Compact Airport Terminal is alleviation of passenger concentration. Because of the circular twin level concourse, its segmented curbs and parking structure, each gate (or group of gates) function wholly independent as an autonomous system. Unlike all present terminals, the Ultra Compact Airport Terminal does not require the passenger to use a fraction of every facility, if in no other way but having to walk through. Because of this and functional autonomy, passenger dispersion is near perfect.



ILL. 8

PROJECT R 661 WENDELL ROSSMAN & ASSOCIATES

Illustration 8 shows the pattern of passenger flow at a 44 gate system, on a typical morning between the hours of 7 and 9. Aircraft, carrying 200 passengers each, are leaving at runway intervals of 2 minutes, with check-in starting at 7:00 o'clock. By 7:30 there will be 2800 passengers within the airport and parking structures. At 7:45, flights begin also to arrive, at 2 minutes each. The additional passengers raise the number to 4400. Meanwhile, the first arriving flights are ready for departure, adding another 1000 en-planing passengers. By then, there are 5400 passengers in the structures and 3800 on the concourse, itself.

Compared to present airports, taking an average passenger density of 130 square feet and a total building area of 600,000 square feet, the Ultra Compact Airport Terminal, also at a density of 130 square feet, requires only 500,000 square feet. This dramatic reduction in building area is, of course, due to shorter distances and, therefore a shorter use period by each passenger.

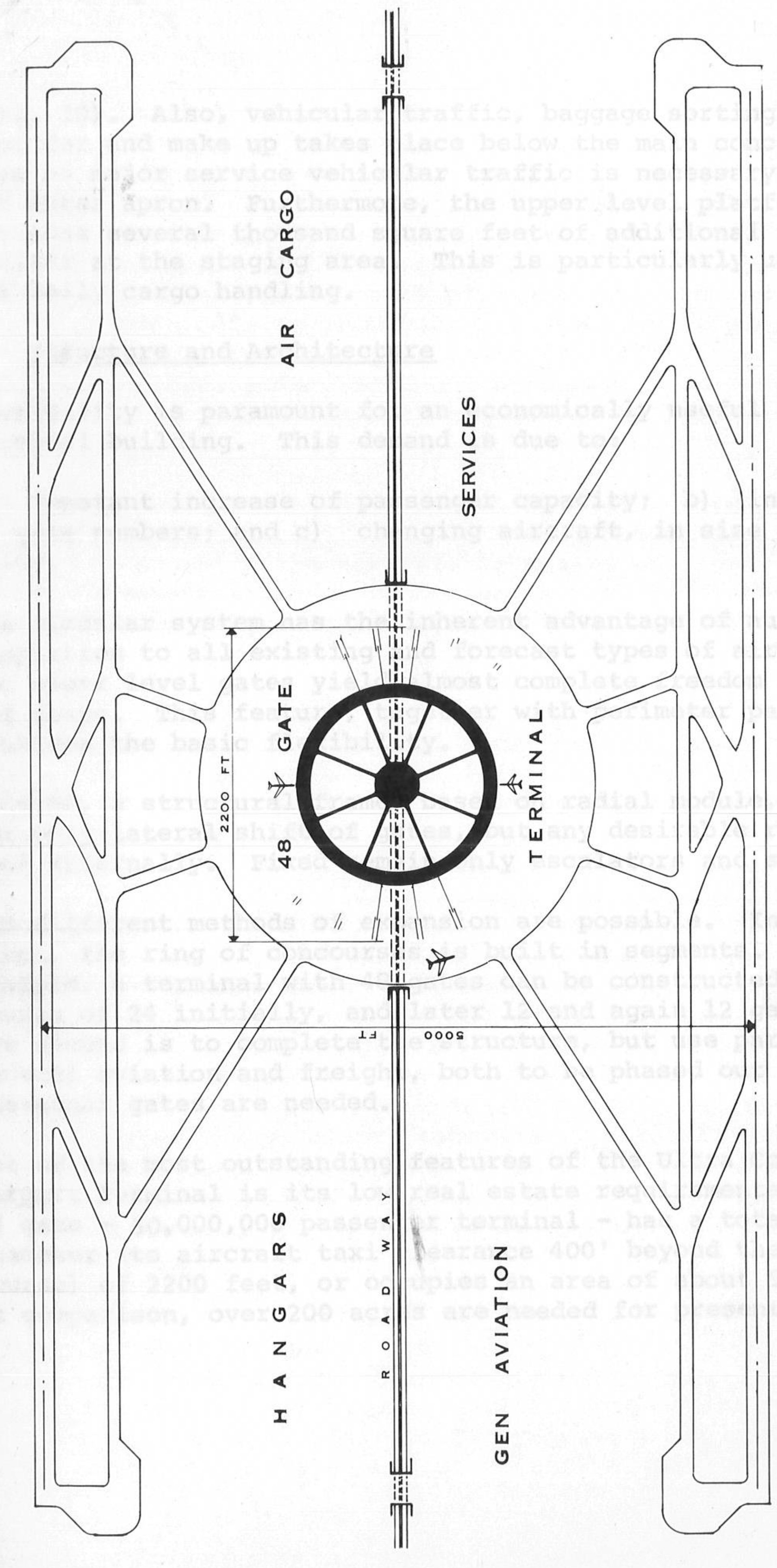
<u>Airside</u>

Particularly interesting is the fact that the circular geometry in general and the twin level parking in particular, yield also substantial benefits from the airside.

The entire arrangement is largely independent of aircraft size. Due to the segmental parking spaces around, the natural geometry of each parking position is complimentary to the shape of aircraft. As fuselage length and wing span increase, the geometry of the gate segment matches the increase in both coordinates. Therefore, a 747, for example, will fit into the same space as a DC-8.

Because all gates are at the periphery, taxiing and maneuvering become very simple and time saving. Also, the greater length of future aircraft causes no problem with tow-out space, etc. Taxiing time in particular will be significantly shorter. (Ill. 9)

Staging areas and operational space has become more favorable with twin level parking. Compared to the closest spacing on one level - wing tip to wing tip plus 2 feet - each space is widened to a distance approximately wingspan plus 50 feet



ILL. 9 ULTRA COMPACT TERMINAL RELATED TO AIRPORT

(Ill. 10). Also, vehicular traffic, baggage sorting, transfer and make up takes place below the main concourse. Thus no major service vehicular traffic is necessary on the outer apron. Furthermore, the upper level platform provides several thousand square feet of additional vehicle shelter at the staging area. This is particularly useful for belly cargo handling.

<u>Structure and Architecture</u>

Flexibility is paramount for an economically useful airport terminal building. This demand is due to:

a) Constant increase of passenger capacity; b) increase in gate numbers; and c) changing aircraft, in size and capacity.

The circular system has the inherent advantage of automatic adaptation to all existing and forecast types of aircraft. The upper level gates yield almost complete freedom to size and shape. This feature, together with perimeter parking, provides the basic flexibility.

However, a structural frame, based on radial module, allows not only lateral shift of gates, but any desirable rearrangement internally. Fixed remain only escalators and stairs.

Two different methods of expansion are possible. In the first, the ring of concourses is built in segments. For example, a terminal with 48 gates can be constructed in three phases of 24 initially, and later 12 and again 12 gates. The second is to complete the structure, but use part for general aviation and freight, both to be phased out as more passenger gates are needed.

One of the most outstanding features of the Ultra Compact Airport Terminal is its low real estate requirements. A 44 gate - 50,000,000 passenger terminal - has a total diameter (to aircraft taxi clearance 400' beyond the concourse) of 2200 feet, or occupies an area of about 90 acres. In comparison, over 200 acres are needed for present layouts.

C. The Lift Sled

The Ultra Compact Airport depends for its economy on an aircraft lifting device. Several such mechanisms have been developed theoretically, such as hydraulic lift platforms and a system based on giant, eccentric wheels. Because the methods solve the problem only partially and are most uneconomic ($350,000. to $600,000. per gate), a simpler mechanism which overcomes the technical difficulties of others, yet costs a fraction, has been developed. It serves as the second systems element to accomplish lifting of aircraft.

In summary, the lift sled is a device to lift aircraft to an elevated parking position. In principle, it consists of a platform on which the aircraft is pulled up along an inclined system of rails by cables and winch, and a return downward by gravity. (Ill. 11.a, 11.b, 11.c, 11.d)

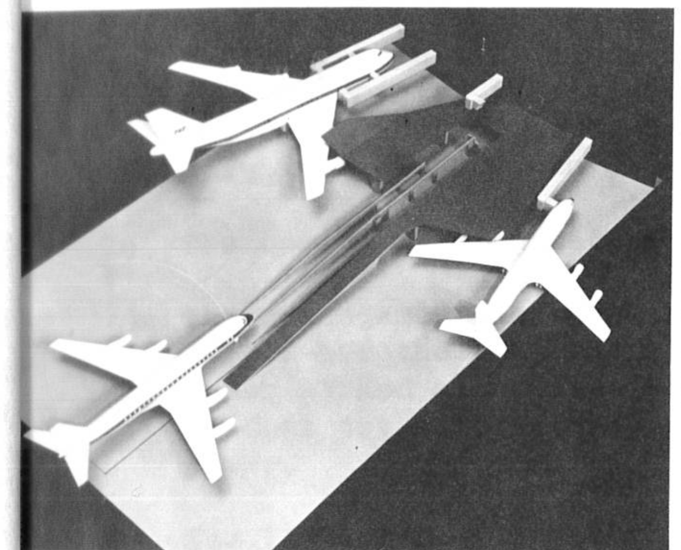
<u>Function</u>

The arriving aircraft will taxi under its own power to a standstill on the lift sled platform. The platform then begins its rise from the ground along a steep, first stage incline, thus elevating the aircraft very rapidly to a height necessary to clear adjacent aircraft. The platform then continues at a shallow ascent through the second stage until the aircraft has reached its uppermost terminal position, where it overlaps the wings of adjacent aircraft. At this position the loading bridges connect for de- and en-planing. Also, the aircraft can receive necessary servicing.

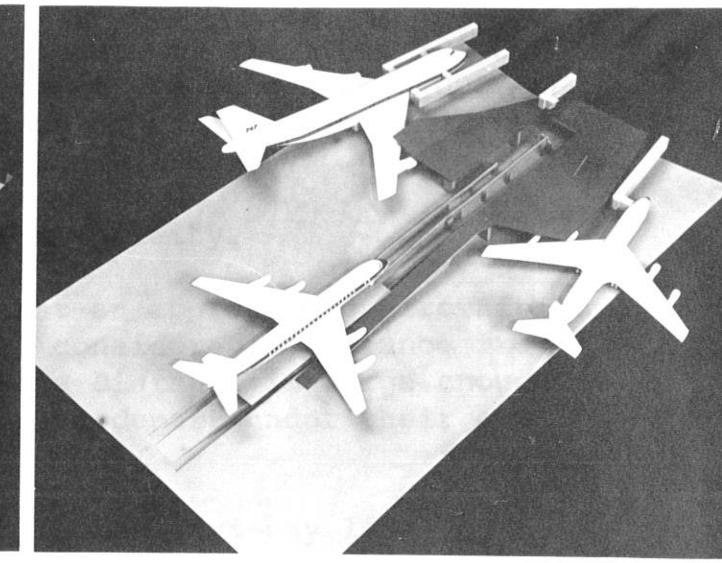
In its terminal downward position, the platform fully covers the pit. It may then be traversed by other aircraft, trucks or cars. When the platform, together with the aircraft, is in the upward terminal position, a shallow pit of about 10", with 2 parallel trenches 12" wide, is left open, constituting neither hazard nor inconvenience to operations.

<u>Drive Mechanism</u>

The drive mechanism of the platform consists of a double cable winch powered through appropriate reduction gears for controlled forward and reverse motion. The return of the platform to its floor position is by gravity and controlled by the particular arrangement of a self-braked cable winch.

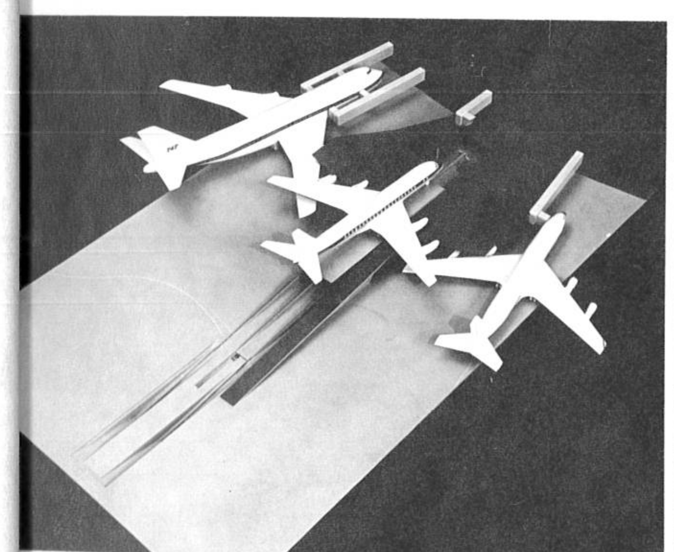


SLED ON APRON LEVEL. AIRCRAFT POSITIONED

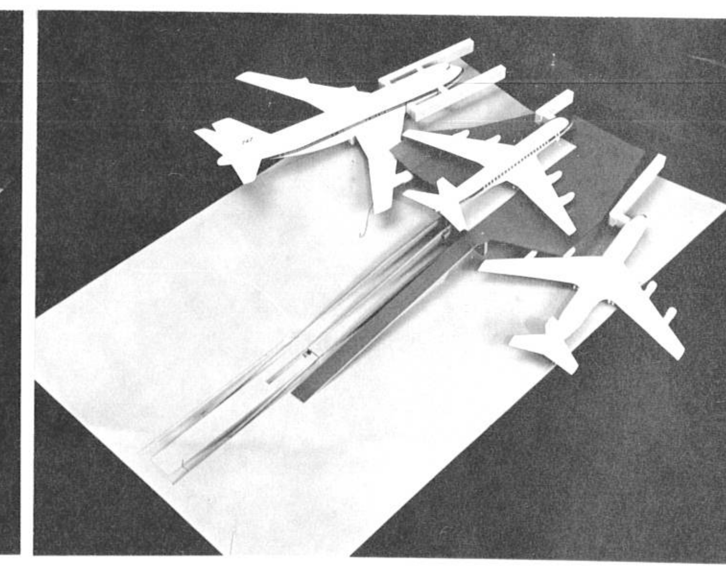


STEEP ASCEND STAGE

B



G OVERLAP IN SECOND ASCEND STAGE



AIRCRAFT IN UPPER TERMINAL POSITION

D

THE LIFT SLED

Significant Features of the Lift Sled

a) The cost of a lift sled, capable of elevating 300,000 pound aircraft, is estimated to be between $65,000. and $75,000. Cost of upper deck depends on size, but may vary from $50,000. to $75,000. (1969).

b) The design is of greatest simplicity.

c) The arrangement is such that an approaching aircraft is lifted off the taxi-way at considerable distance from other parked aircraft. This distance is large enough so that jet aircraft may also depart under their own power.

d) The lift sled will return to the taxi-way level by gravity. Lifting as well as returning can be controlled by one man, similar to the position adjustment of the present day jetways. Towing equipment is eliminated.

e) Motor and winch are located behind fire walls in the terminal building, eliminating any fire hazard created by electric equipment.

IV. A 44 GATE EXAMPLE OF THE ULTRA COMPACT AIRPORT TERMINAL

The following arbitrary program has been chosen:

11 Gates for Boeing 747 or SST
33 Gates for DC-10, L-1011 or 707 - 44 gates

Capacity: **50**,000,000 passengers per year.

The Terminal Building

The structure is a closed circle with 3 levels:

Upper Concourse

Main Concourse, central building, parking

Apron, street and parking

The roof provides heliports directly above concourse and gates. Concessions, restaurants, shops, services, offices, tower, (hotel) are located in the central building.

Parking is provided for between the concourse ring and central building at the rate of 2100 cars per level. (4 diagrammatic drawings appended; 3 plans, 1 section)

Function

All road vehicles arrive via 2 multi-lane access roads below apron level and enter the public ring road. The curb (platform type) lies between ring road and parking, eliminating any pedestrian traffic on the ring road. Escalators for each 4 gates lead up to the main concourse. Passengers who must park their cars will enter directly into parking area, hand-carrying their luggage to the escalators.

Check-in occurs on the main concourse with counters for any combination up to 16 gates. Departure lounges, baggage carrousels, airlines offices, are also located on this level.

The upper concourse is reached via escalators, one for each 2 gates. It contains primarily departure lounges and circulation space. Heliports above can be reached via elevators from this level.

Aircraft park on apron and upper levels. An operational ring road connects all gates along the circumference. Vehicular access to the upper level is via a ramp along the lift sled rails.

General Data

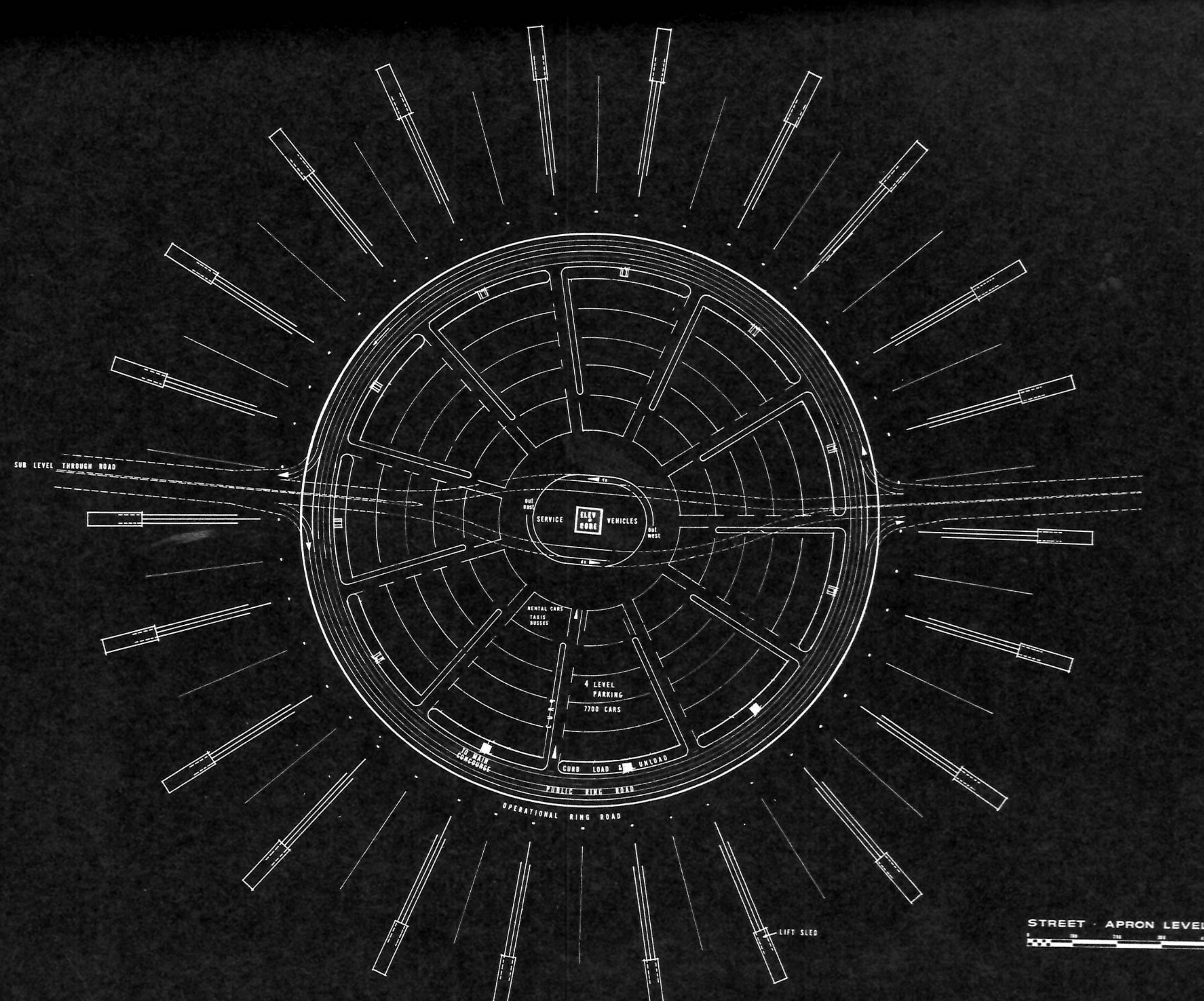
Average distances:	(feet)
Car parking to departure lounges	240
Maximum horizontal distance for transfer passengers	1200
Radial walkways	450
Average diameter	1200
Diameter at perimeter wall	1400
Mean circumference of concourse	3900
Diameter to Lift Sled pits	2000
Diameter to taxi clearance	2240
Height, Apron to main concourse	12
Main to upper concourse	16
Apron to upper aircraft parking level	19
Ground Area, (Diameter plus 400 feet)	59 Acres

Capacity: 11 gates - Boeing 747 or SST
33 gates - DC10, L-1011 or 707

V. COMPARISON OF A 44 GATE COMPACT SYSTEM WITH CONTEMPORARY AIRPORTS

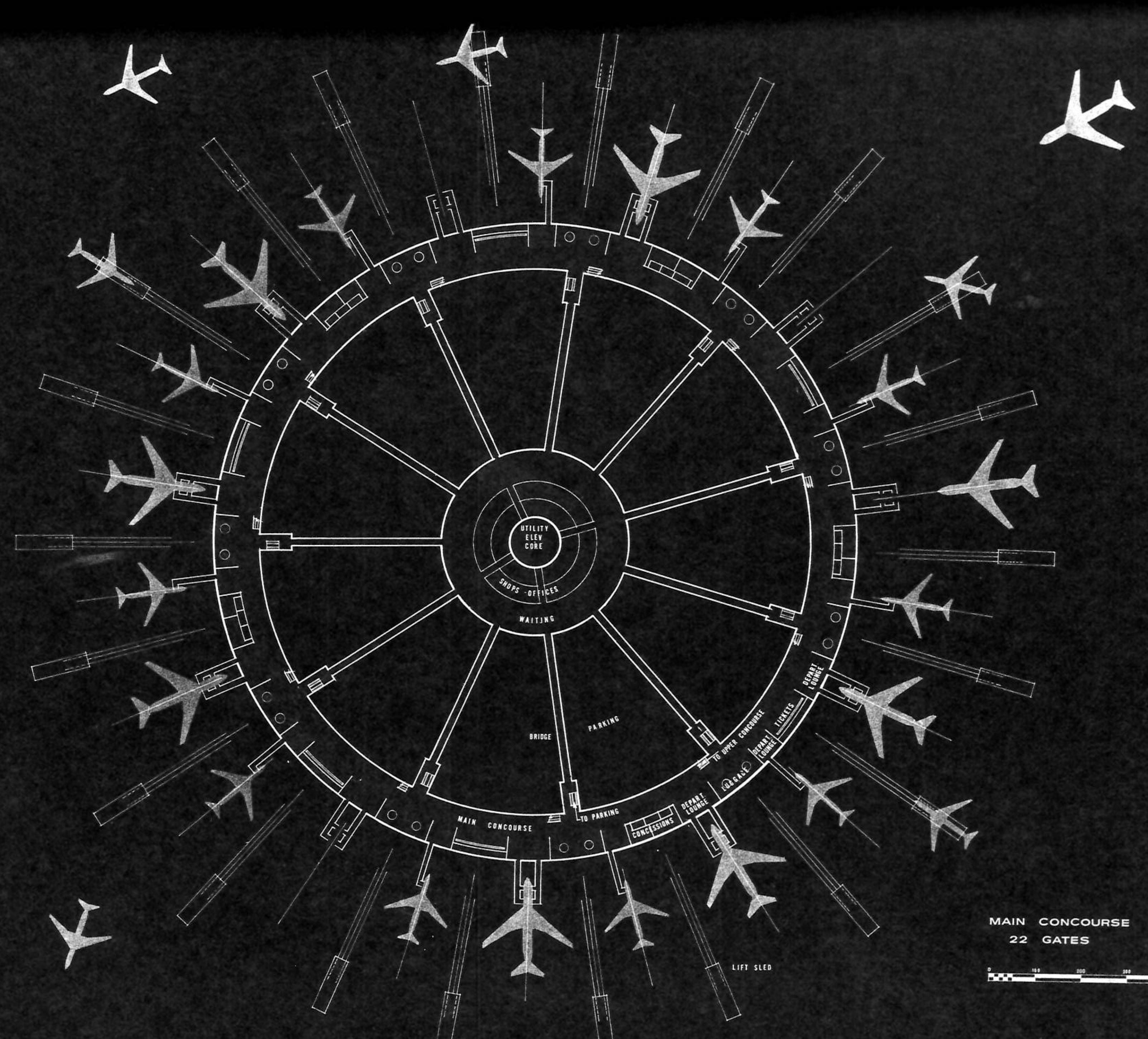
The following 4 sets of diagrams represent a comparative analysis of the physical area, between the Ultra Compact Airport Terminal and existing, as well as projected contemporary airports:

	Ultra Compact Air Terminal	Sky Harbor	San Francisco International	Kansas City	Dallas Fort Worth
Average distance, parking to gate	240	1000	1300	250	300
Maximum Transfer Distance	1200	2600	3200	4000 +	4000 +
Ground Area, Acres (44 gate equivalent)	59	90	250	120	232



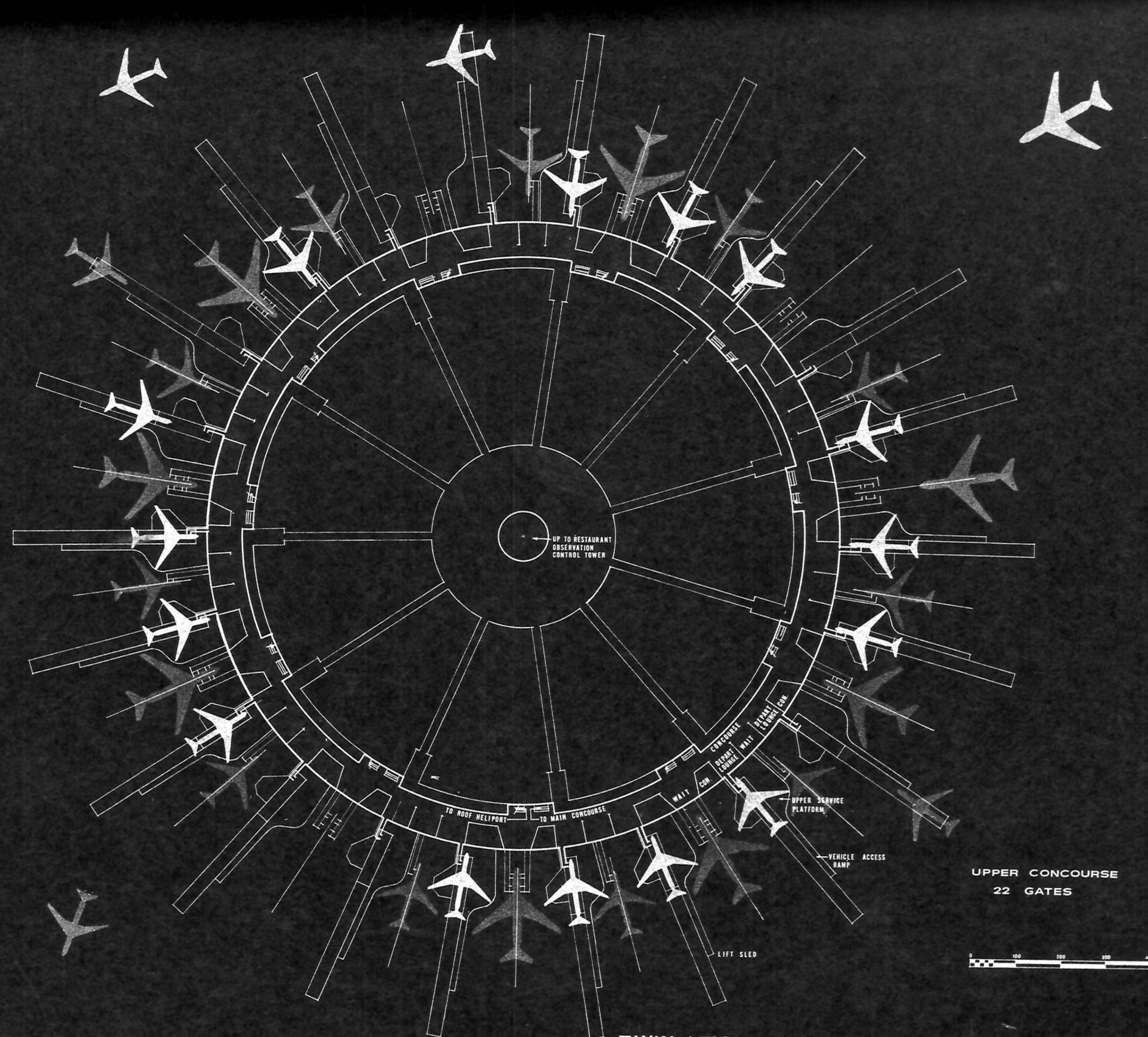
TWIN LEVEL AIRPORT · TERMINAL SYSTEM

PROJECT R 661 WENDELL ROSSMAN & ASSOCIATES



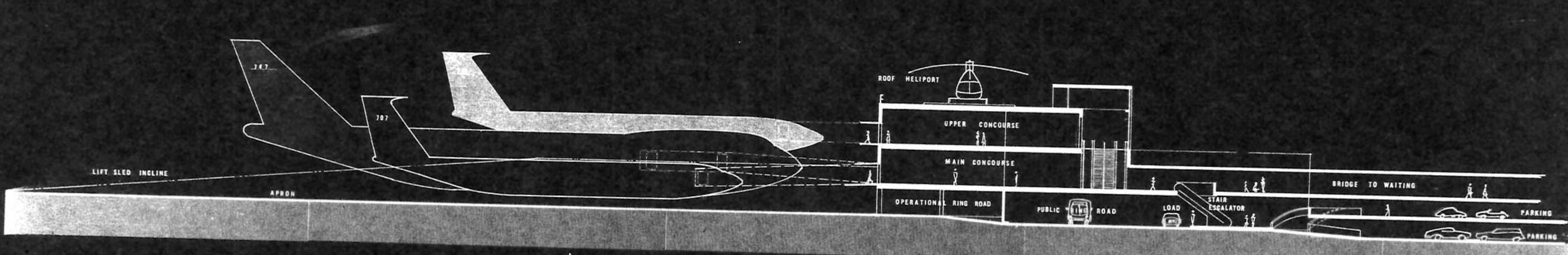
TWIN LEVEL AIRPORT · TERMINAL SYSTEM

PROJECT R 661 WENDELL ROSSMAN & ASSOCIATES



TWIN LEVEL AIRPORT · TERMINAL SYSTEM

PROJECT R 661 WENDELL ROSSMAN & ASSOCIATES



DIAGRAMMATIC SECTION

TWIN LEVEL AIRPORT · TERMINAL SYSTEM

PROJECT R 661 WENDELL ROSSMAN & ASSOCIATES

V. PASSENGER CAPACITIES

The high efficiency single passenger terminal, in which the longest walking distance between transfer points is 1500 feet (7-1/2 minutes) distinguishes itself by the previously cited advantageous characteristics.

Nevertheless, the circular UCAT can only then be useful if, expanded to its fullest capacity, it will indeed serve the numbers of passengers expected by future projection.

The capacity depends on a fully balanced system where each division permits unrestricted flow to the adjacent ones.

Ground and VSTOL transit systems must have the basic capacities; roads, rails and VSTOL ports must match this capacity. Transfer interface of curb, rail platform and VSTOL gates again have to permit the same flow. Next, terminal check-in, baggage handling and boarding must meet this capacity.

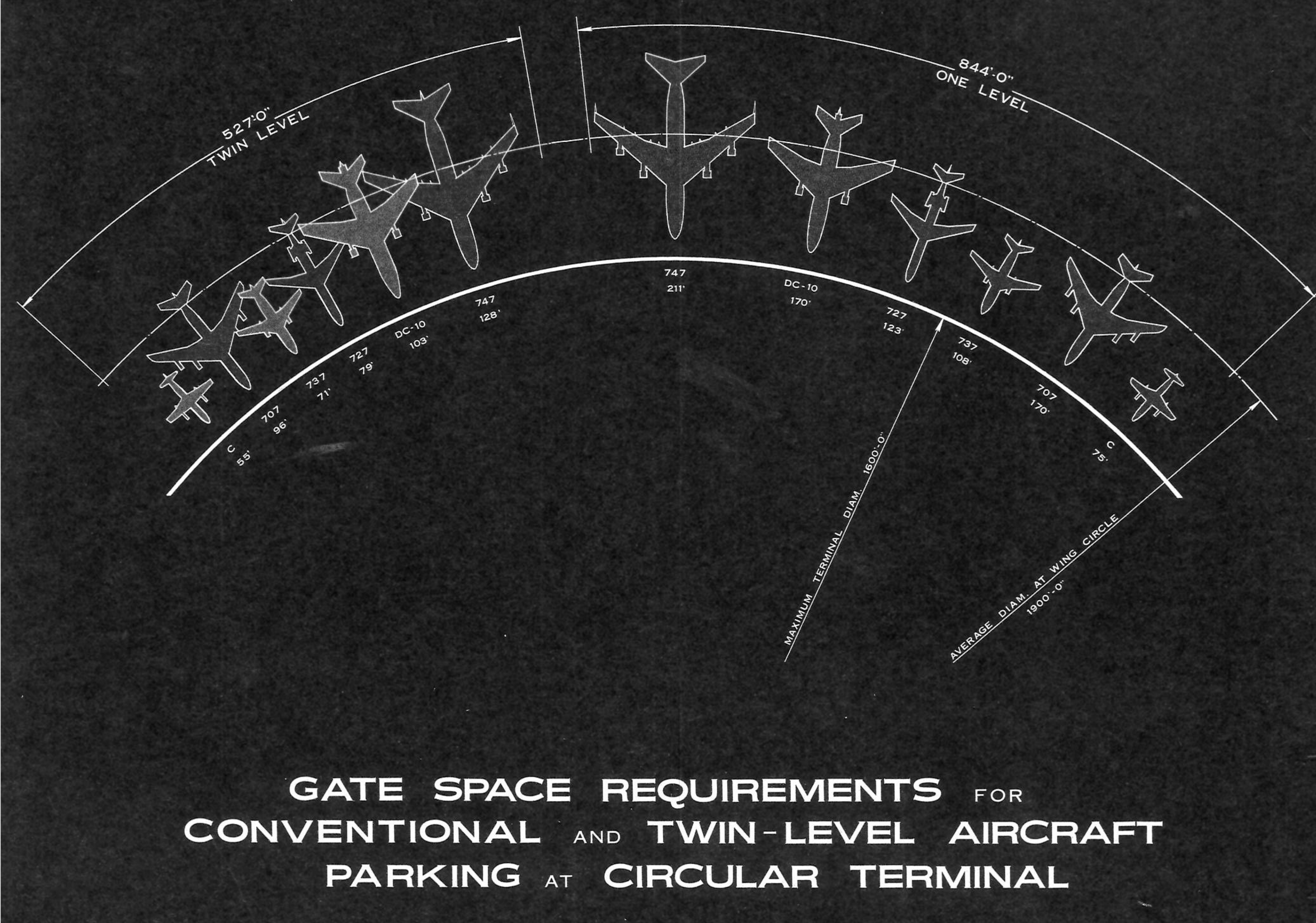
All divisions must function two-directionally.

In the determination of UCAT capacities, it is assumed that the air space and runways (4 independent) have a capacity of 160 (IFR) and 190 (VFR) operations. Hence, the UCAT may process 80 arriving and departing airplanes per hour.

Furthermore, it has been assumed that ground and VSTOL transit systems will match the airside of 160 airplane operations. Also, the gate capacity is taken as compatible to all other interfaces. The actual gate capacity depends on: a) airplane servicing time (taken at 60 minutes), b) Airplane capacity, and c) the number of gate uses per day. (Airplane capacities are taken at average maximum; gate uses, 5 per day.)

A significant capacity determinant is the combination of various airplane types. For this analysis, mix combinations with 6 types (one hypothetical commuter "C") are employed. (See PASSENGER CAPACITY TABLE)

The study includes two conditions: parking of airplanes on the apron only, and additional elevated parking with wing overlap. The latter increases the available gate space by 65%. (See GATE SPACE REQ. DIAGRAM)



GATE SPACE REQUIREMENTS FOR CONVENTIONAL AND TWIN-LEVEL AIRCRAFT PARKING AT CIRCULAR TERMINAL

EQUIPMENT				MIX 1		MIX 2		MIX 3	
AIRPLANE TYPE	GATE SPACE, ft. (ONE LEVEL)	GATE SPACE, ft. (TWIN LEVEL)	AV. PASSENGER CAPACITY	NO. OF AIR-PLANES ONE LEVEL	NO. OF AIR-PLANES TWIN LEVEL	NO. OF AIR-PLANES ONE LEVEL	NO. OF AIR-PLANES TWIN LEVEL	NO. OF AIR-PLANES ONE LEVEL	NO. OF AIR-PLANES TWIN LEVEL
C	75	55	40	27	37	5	7		
737	108	71.5	90	8	12	13	18		
727	123	79	120	6	9	7	11		
707	157	96	140	6	10	8	15		
DC10	170	102.5	280	5	7	6	11	17	27
747	211	123	350	3	4	5	7	15	27
NUMBER OF AIRPLANES				55	79	44	69	32	54
PASSENGERS/HR., ONE ARRIVAL AND ONE DEPARTURE				11,620	16,800	13,520	21,700	20,020	34,420
PASSENGERS/DAY (5 HOURS)				58,100	84,000	67,600	108,500	100,100	172,100
PASSENGERS/YEAR (IN MILLIONS)				21.2	33.3	24.6	38	36.7	62.4

PASSENGER CAPACITIES TABLE: Circular Terminal with 1600 Ft. Maximum Gate to Gate Distance, for Single and Twin Level Airplane Parking.

The results show a range from 11,620 passengers per hour with 55 airplanes of Mix 1, to 34,420 with 54 airplanes of Mix 3. (See PASSENGER CAPACITIES TABLE) The full circle with one level parking has a capacity range of 21.2 to 37.7 million passengers per year. Similarly, twin level parking ranges from 33.3 to 62.4 million. The latter figure is the maximum capacity for 5 operations per gate per day, employing wide body jet transports only.

The maximum capacity is therefore predicated on a gate which en- or de-planes 315 passengers every 30 minutes.

In summary, the ultimate capacity of a circular UCAT based on 5 gate uses per day is, with 62.4 million passengers per year, large by comparison. For the year of 1970, Chicago's O'Hare will en- and de-plane 32,000,000 passengers. Los Angeles International is projected to serve 56,000,000 by 1985. By 1985, all of the United States' largest airports, with the exception of JFK (108 million) and O'Hare (150 million), are expected to be of less than 60 million passenger capacity.

Concluding, it can be said that the circular UCAT, with a maximum diameter of 1600 feet (no internal transport system) is likely to be of greater capacity than the demand caused by a tributary urban area.

VI. INTRA-TERMINAL TRANSPORTATION SYSTEMS

When the size of terminals of any of the four basic plans (Finger Plan, Unit Terminal, Linear Concept and Mobile Lounge) exceeds about 15 gates, distances become so large that passengers can no longer walk and carry their luggage over agerage, inter-terminal distances. Recent airport design has therefore relied on two concepts:

the people mover, and

mechanical baggage handling systems.

Existing people movers may be categorized into:

moving sidewalks,

inter-terminal busses,

landside-airside mobile lounges.

Proposed systems are:

landside-airside fixed rail trams,

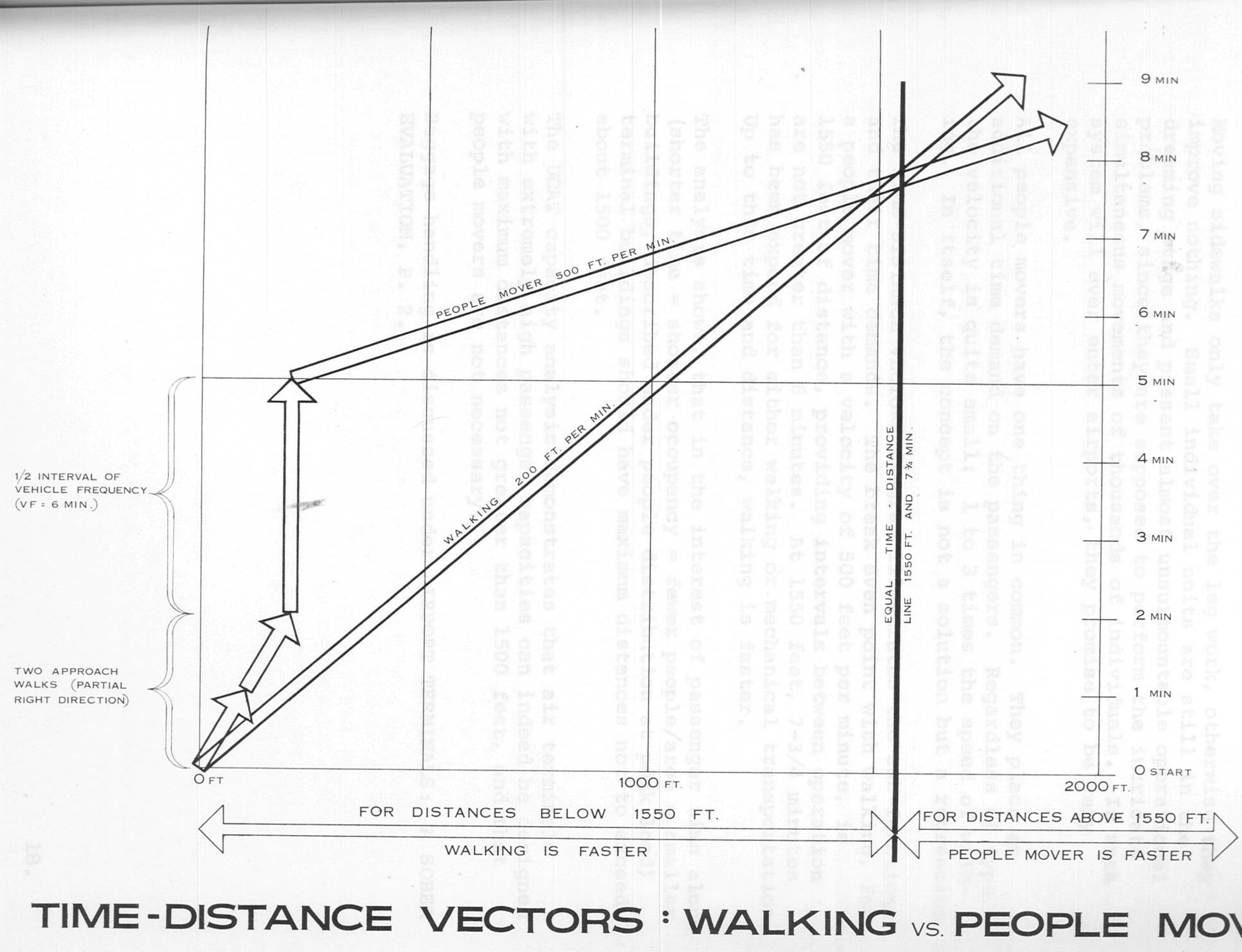
self powered mini-trains,

"mini-rails, dashveyors, conveyors,

teletrams, transveyors, etc."

(Houston proposes the mini-train; 500 feet per minute, 1200 people per hour, estimated cost $370,000; DFW, a rail system, initial cost $18,000,000; both plans wholly depend on people movers; Budd announces a lounge, 100 seated - 60 standing, 19 MPH, $200,000 before taxes.)

The function of the presently used systems has considerable drawbacks. The type that moves a large number at once operates also at lengthy time intervals, causing the additional waiting period.



TIME-DISTANCE VECTORS : WALKING VS. PEOPLE MOVER

Moving sidewalks only take over the leg work, otherwise they improve nothing. Small individual units are still in the dreaming stage and present almost unsurmountable operational problems, since they are supposed to perform the intricate simultaneous movements of thousands of individuals. If such system will ever enter airports, they promise to be very expensive.

All people movers have one thing in common. They place an additional time demand on the passengers. Regardless of type, the velocity is quite small: 1 to 3 times the speed of walking. In itself, the concept is not a solution but a regression.

The TIME-DISTANCE VECTORS diagram illustrates the sub-functions and their time demands. The break even point with walking, for a people mover with a velocity of 500 feet per minute, is 1550 feet of distance, providing intervals between operation are not greater than 6 minutes. At 1550 feet, 7-3/4 minutes has been expend for either walking or mechanical transportation. Up to this time and distance, walking is faster.

The analysis shows, that in the interest of passenger time alone (shorter time = shorter occupancy = fewer people/area = smaller buildings, described under people distribution at peak load) terminal buildings should have maximum distances not to exceed about 1500 feet.

The UCAT capacity analysis demonstrates that air terminals with extremely high passenger capacities can indeed be designed with maximum distances not greater than 1500 feet, and that people movers are not necessary.

Baggage handling is discussed under AIRPORT TERMINALS: A SOBER EVALUATION, P. 2.

VII. TIME PATTERN

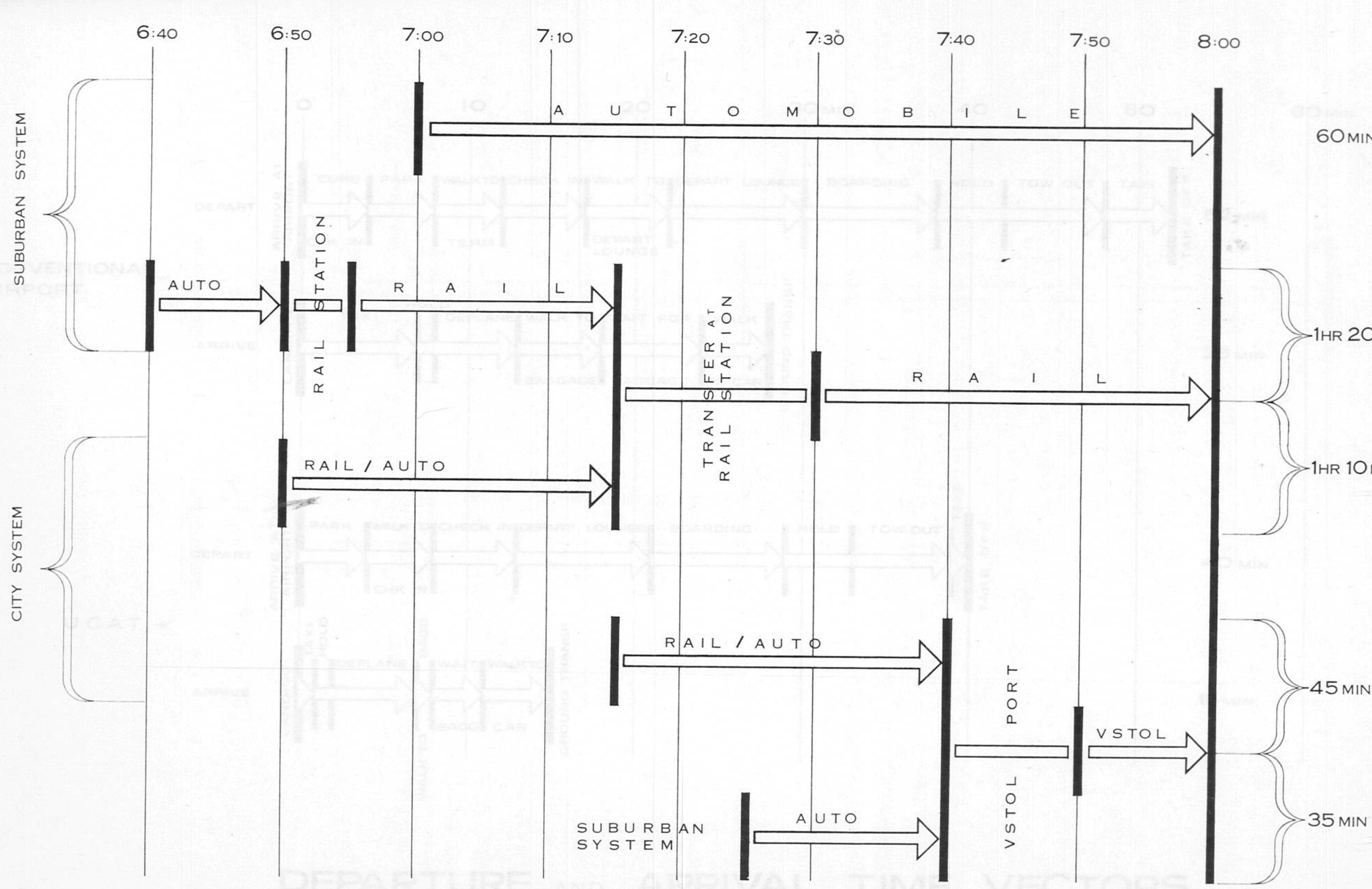
For the planning of air terminals in particular, and to a large degree the entire airport, one must be acutely aware of the two greatest shortcomings in all existing and even proposed plans: the seemingly endless walking distances, or time losses, or both.

Nothing else draws the traveler's criticism as much as these deficiencies. And, analyzing the situation, matters are usually worse than would appear on the surface. In contrast, the circular UCAT and its consequences on the entire airport layout are emphatically proposing the shortening of all distances, including airplane taxiing, and most of all, the reduction of time demands per function.

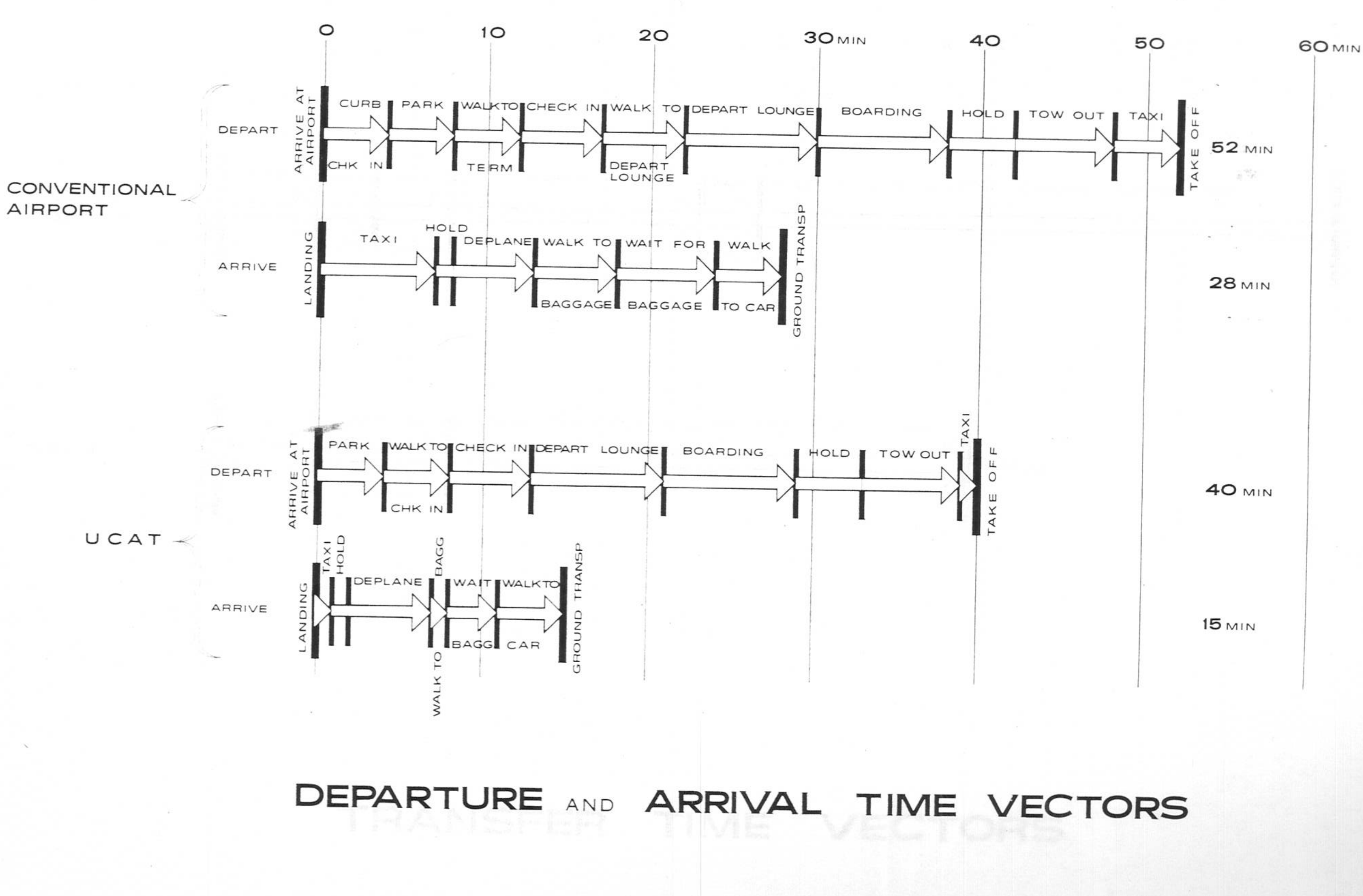
In the present airports, the number of people to be served is not really as staggering as it would seem. Other human activities deal with similar problems, such as the traffic at entering, leaving and using assembly centers, from concert hall of 2500 to a stadium of 50,000. Vehicular access, walking and time delays are acceptable to patrons. Even transport terminals of other kinds are not the source of criticism airports are. Grand Central in New York handles almost one million passengers per week, exceeding O'Hare by 15 million per year. Yet its corresponding physical facilities (for passengers only) are but a fraction of that of O'Hare.

A look at GROUND ACCESS TIME VECTORS shows the requirement for various modes of transit. (The example is based on an airport 30 miles from the geographical center of the tributary community.) It is obvious, that the only mode compatible to the basic premises is VSTOL. All others are, due to distance, either time consuming or retarded by intermediate transfer. The distances are unfortunately a consequence of largeness. Noise and larger real estate needs pushed the airport farther away from population centers. Since this trend is inevitable, if for no reason but its highly political nature, ground access becomes a matter of first concern. Airport planning must therefore include every possible device to avoid further time losses in its area of control.

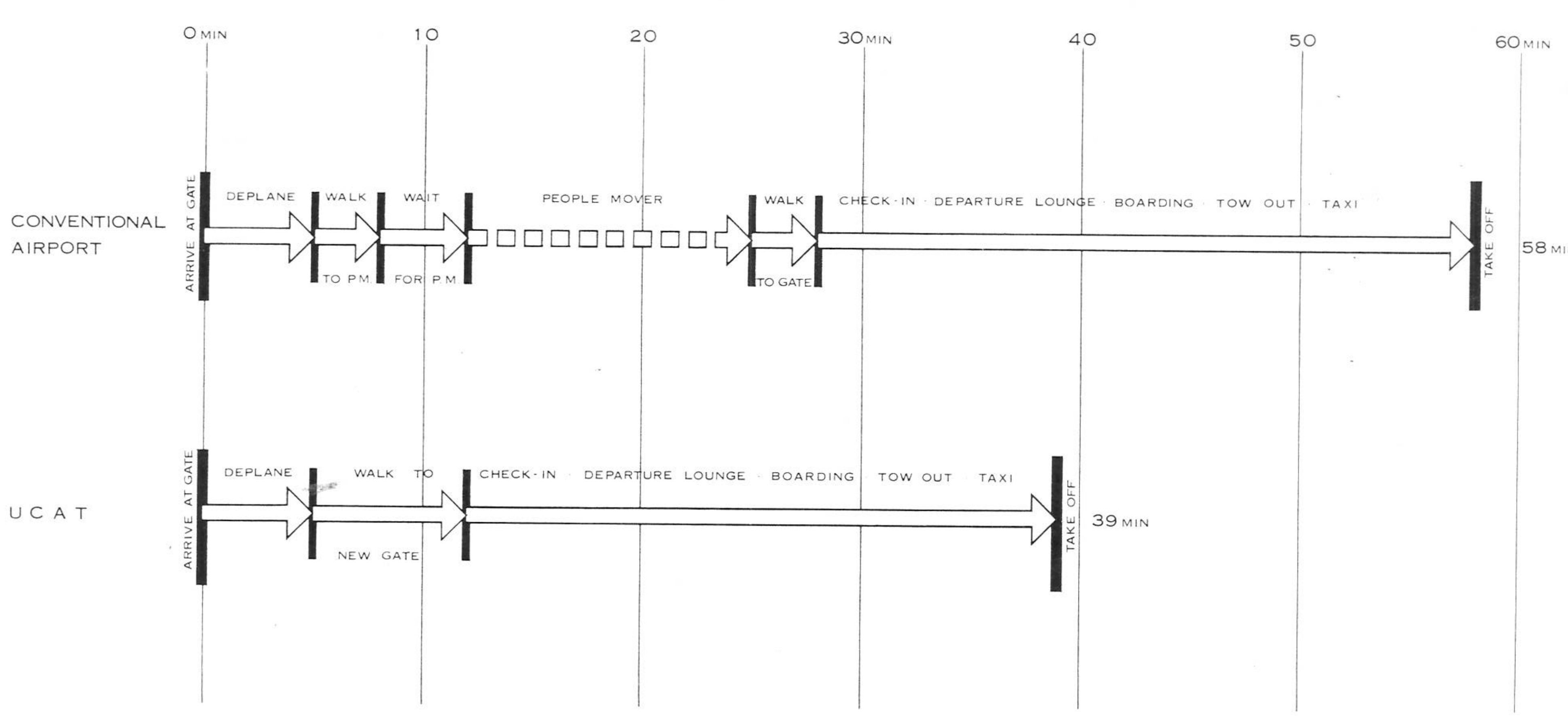
DEPARTURE AND ARRIVAL TIME VECTORS illustrate time pattern within the airport. Conventional designs and UCAT are compared. The juxtaposition makes obvious that the departure time difference of 12 minutes is the sum of several reductions:



GROUND ACCESS TIME VECTORS



DEPARTURE AND ARRIVAL TIME VECTORS



TRANSFER TIME VECTORS

the absence of curb-side baggage check-in, absence of walk to gate and reduction of taxi distance. At arrival, the difference of 13 minutes is the sum of shorter taxi, short walk to baggage and shorter wait for baggage, all due to reduction of overall size.

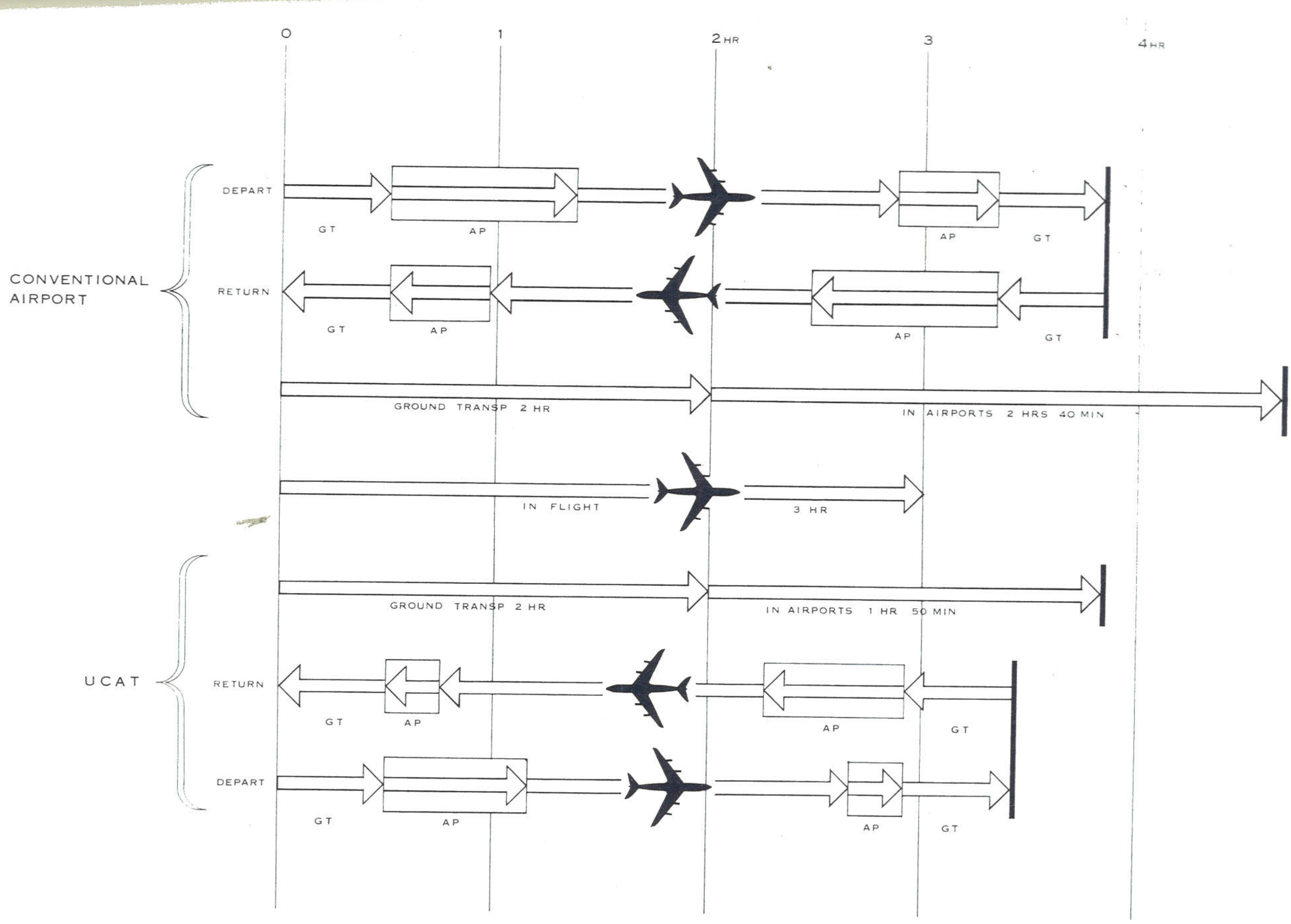
The DEPARTURE AND ARRIVAL TIME VECTOR analysis shows that the combined time savings of a departing and returning traveler, within the UCAT over conventional systems is 25 minutes, or a reduction from 80 to 55 minutes time spent at the airport. At a daily passenger figure of 67,600 (24.6 million/year), this represents a time savings of 28,166 hours. In terms of money, at $10.00 per hour, this amounts to over 1/4 million dollars per day!

Matters become much worse when the passenger must transfer en-route. The time vectors compare a conventional system where transfer points are 6000 feet apart (e.g. Kansas City, DFW, LAX), with UCAT. The UCAT with its 7-3/4 minute maximum walking distance has a transfer time reduction of 19 minutes. (TRANSFER TIME VECTORS)

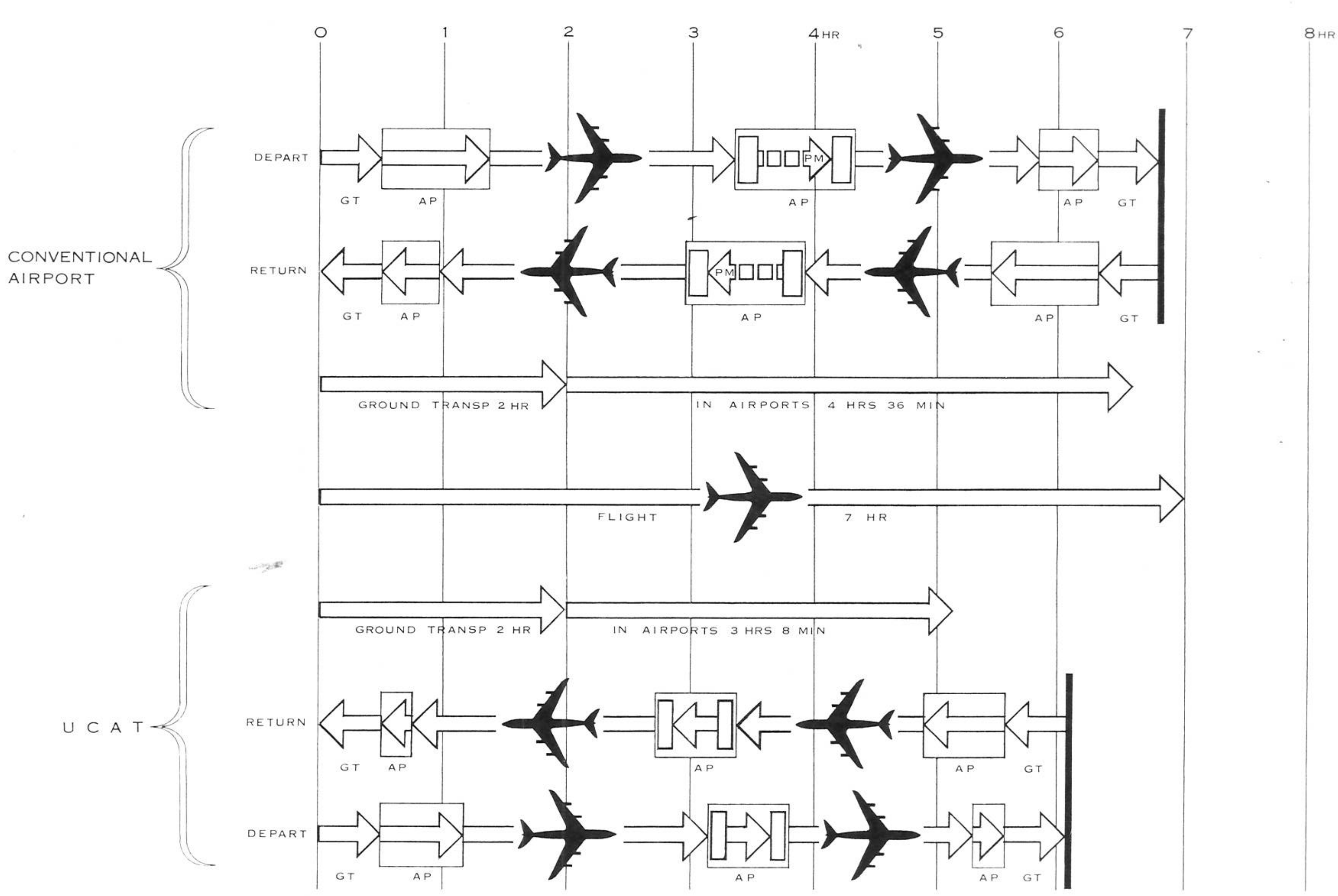
Assemblying the time vectors for ground access, airport process-through and flight, the paradox of present plans and procedures in relation to the basic axiom - the essence of flying is speed - becomes glaringly evident.

The vector analysis is based on a constant ground transport time of 30 minutes, and departure, arrival and transfer times as shown in the respective diagrams. Again, both cases illustrated (NON-STOP RETURN and EN-ROUTE TRANSFERS AND RETURN TIME VECTORS) are comparing conventional systems to UCAT. Based on the figures of the individual vectors, spectacular time reductions are achieved through the geometry of the UCAT. Let it be assumed that 25% is transit; the comparable UCAT shows a per passenger time savings of 23.5 minutes or 31.5%.

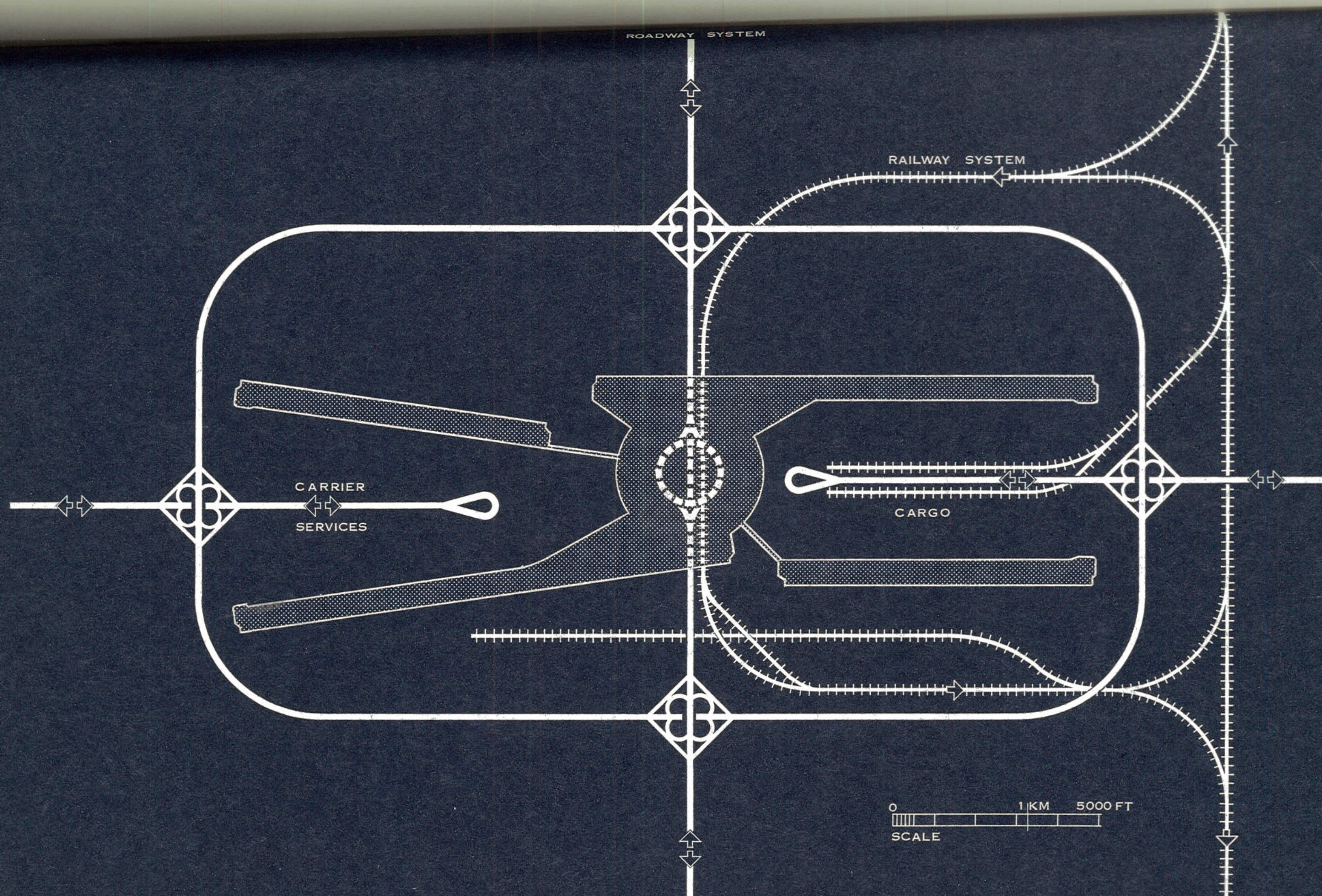
In general terms of buildings this means that a traveler who occupies a given space for 60 minutes in the conventional systems, will occupy the identical space in the UCAT for only 41 minutes. Either the building can be smaller by a corresponding amount, or the passenger capacity be increased. In terms of cost, a conventional terminal of $32,000,000 has its UCAT counterpart costing $22,000,000, or a $10,000,000 savings in initial building cost alone.



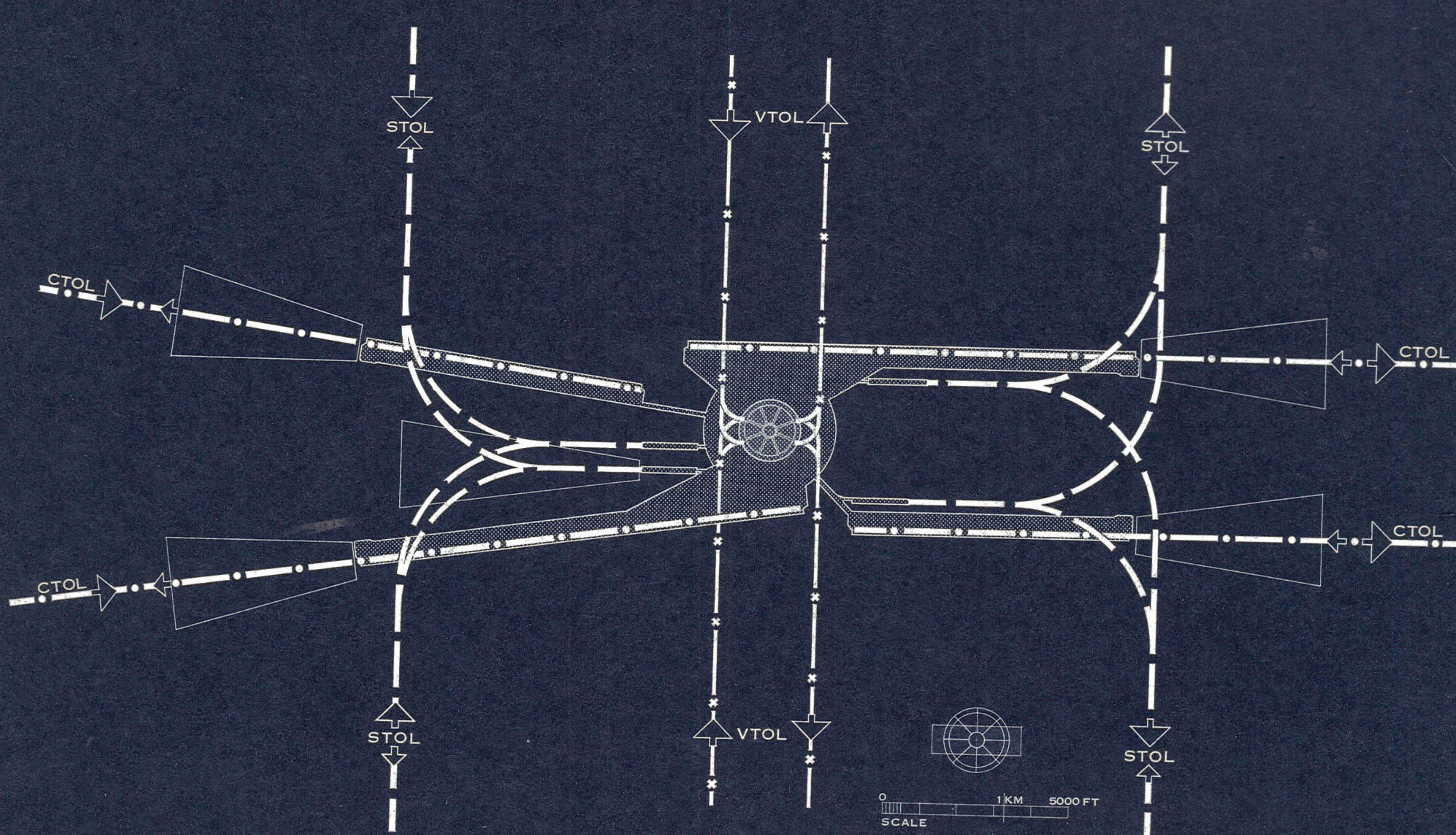
NON-STOP RETURN TIME VECTORS



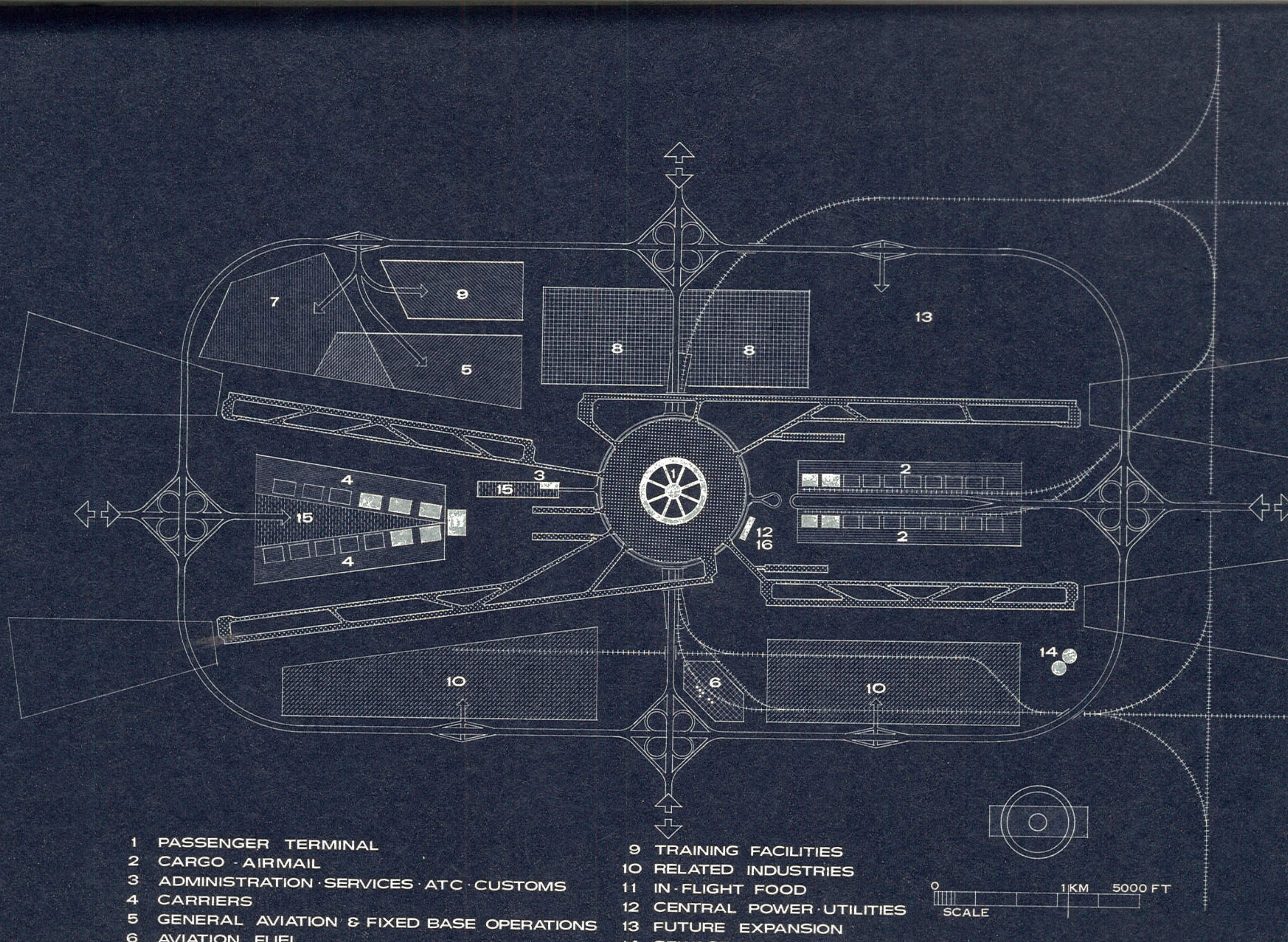
EN ROUTE TRANSFERS AND RETURN TIME VECTORS



BASIC GROUND ACCESS SYSTEM



AIR TRAFFIC PATTERN DIAGRAM



1 PASSENGER TERMINAL
2 CARGO · AIRMAIL
3 ADMINISTRATION · SERVICES · ATC · CUSTOMS
4 CARRIERS
5 GENERAL AVIATION & FIXED BASE OPERATIONS
6 AVIATION FUEL
7 ACCOMODATIONS
8 FUTURE TERMINAL / PARKING
9 TRAINING FACILITIES
10 RELATED INDUSTRIES
11 IN · FLIGHT FOOD
12 CENTRAL POWER · UTILITIES
13 FUTURE EXPANSION
14 SEWAGE & GARBAGE DISPOSAL
15 PARKING
16 FIREFIGHTING

AIRPORT FUNCTION AND LAND USE PLAN

such, that adequate altitude separation from scheduled traffic occurs automatically at points of route intersection. VTOL traffic, of course, follows closely along the cross coordinate. Lateral separation from STOL traffic is furthered by layout of STOL strips.

Runway configuration has most significant effects on rapid ground maneuvering of airplanes. The preferred arrangement (based on adequate land) would provide for four independent (if required ILS) runways, converging near the center. Thus simultaneous operation on each pair may take place. No runway crossing is necessary.

Taxi distances are as short as possible, avoiding all delays (as yet typical of most parallel runway systems).

The AIRPORT FUNCTION AND LAND-USE PLAN illustrates basic relationships of all major components.