Airport Landside Analysis and Modeling (2)

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CEE 4674 - Airport Planning and Design

Material Presented in this Section

Sizing Other Spaces at the Terminal

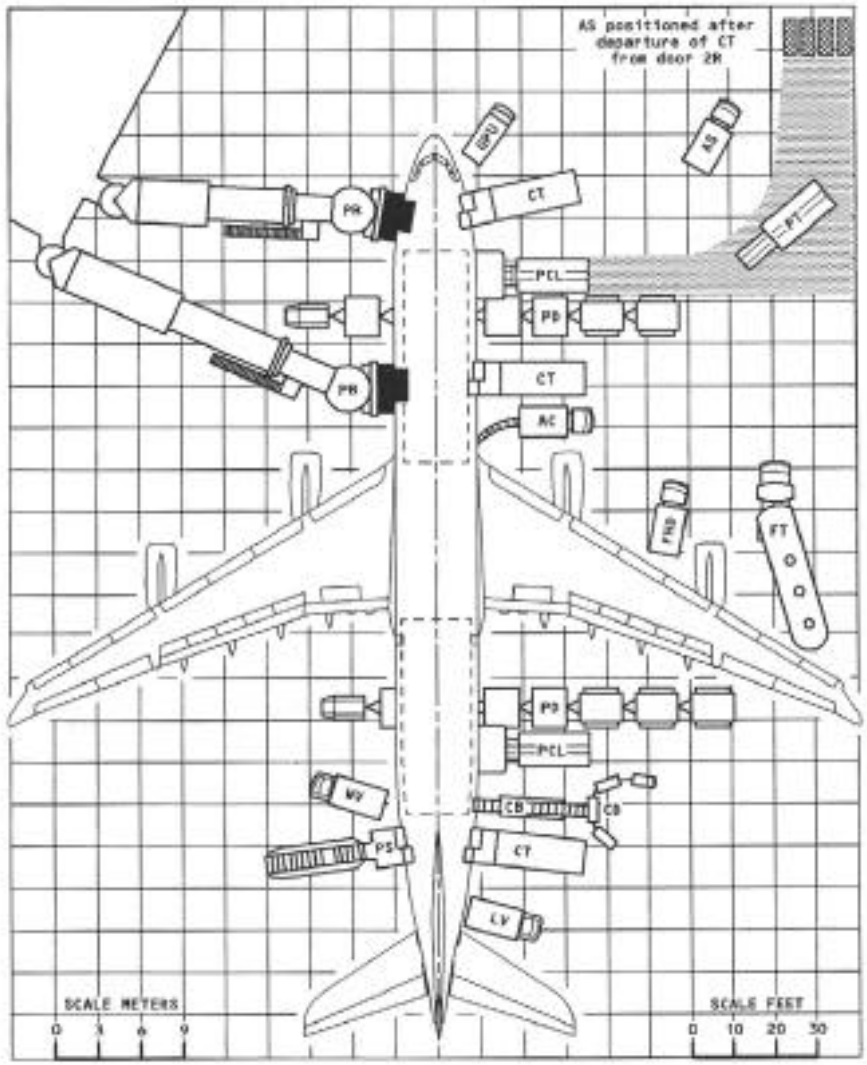
- Apron Areas
- Departure lounges
- Parking facilities
- Cargo terminals

Apron Areas

- Apron areas provide space to service aircraft
- Also serve to park them overnight and during flight layovers

Commuter traffic at DFW (2 Saab 340s)

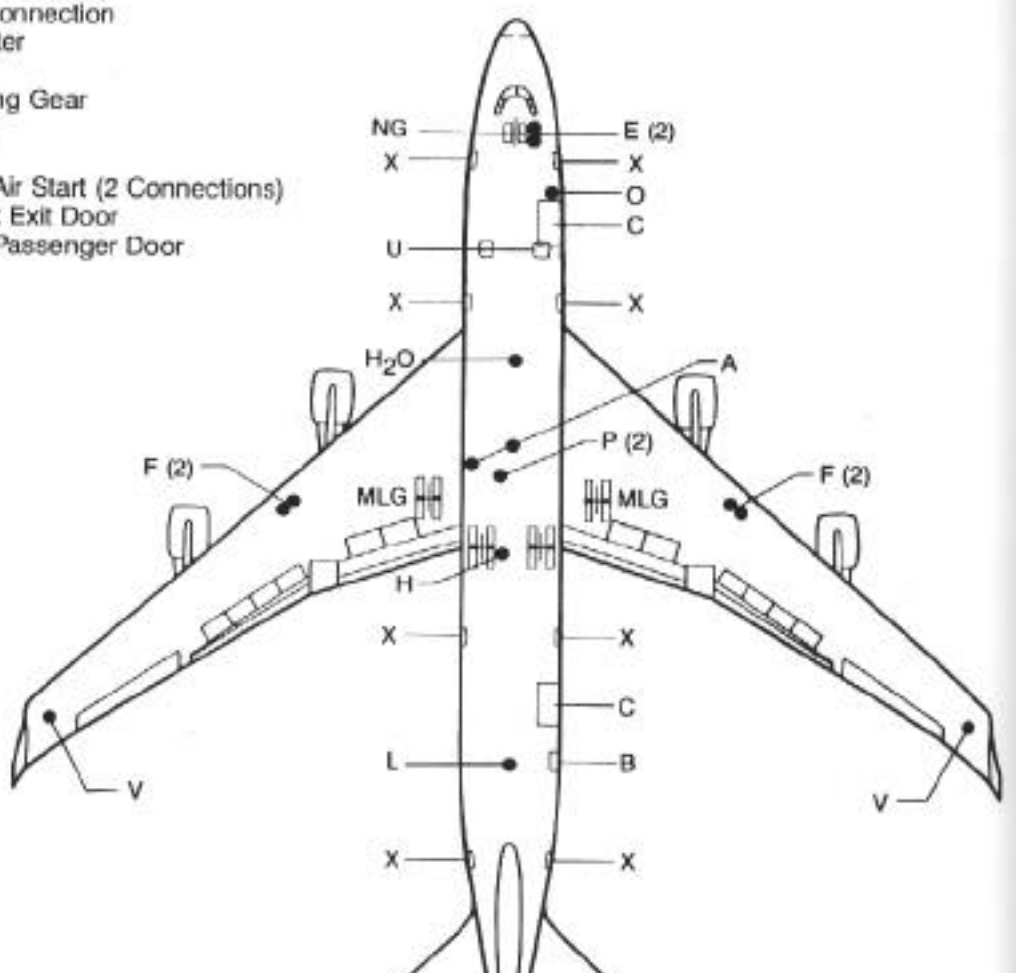
Apron Service Diagram (Airbus A340)



Used to determine apron and boarding gate configurations

Aircraft Service Port Diagram

A	Air Conditioning
B	Bulk Cargo Door
C	Cargo Container Door
E(2)	Electrical (2 Connections)
F(2)	Fuel (2 Connections)
H	Hydraulic Connection
H_20	Potable Water
L	Lavatory
MLG	Main Landing Gear
NG	Nose Gear
O	Oxygen
P(2)	Pneumatic Air Start (2 Connections)
U	Upper Deck Exit Door
X	Main Deck Passenger Door
V	Fuel Vent



Apron Equipment Table (IATA)

TABLE OF AIRCRAFT GROUND HANDLING EQUIPMENT

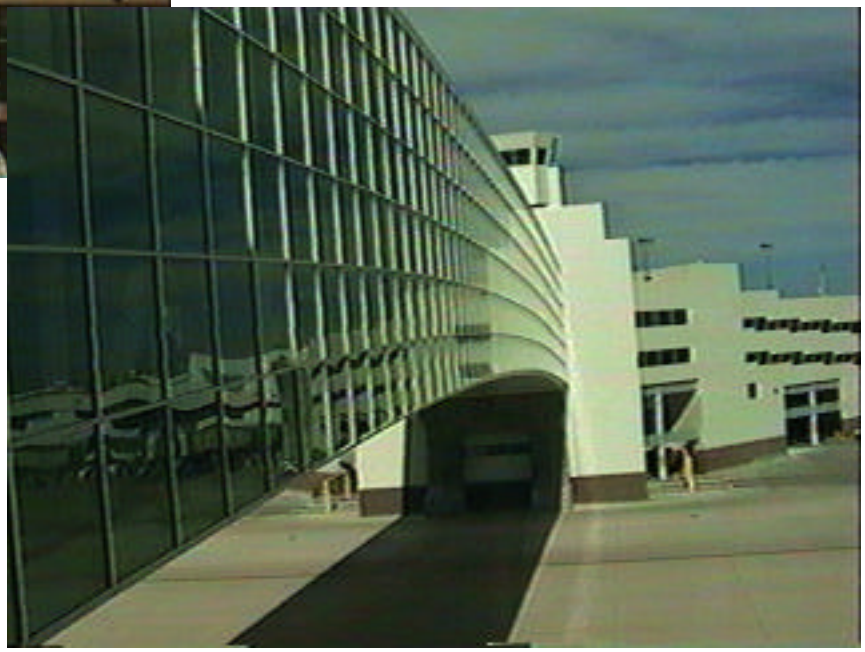
TYPE OF EQUIPMENT	IATA AHM NUMBER	LENGTH (m)	WIDTH (m)	AREA (m)	HEIGHT (m)	TURNING RADIUS (m)
MAIN DECK LOADER	932	12.0	4.5	54.0	3.0	20.0
LOWER DECK LOADER	931	8.5	3.5	29.7	2.9	12.0
TRANSPORTER	969	6.5	3.5	22.8	1.5	5.5
AIRCRAFT TOW TRACTOR (WIDE BODY)		9.0	2.8	25.2	2.0	7.5
AIRCRAFT TOW TRACTOR (NARROW BODY)		5.5	2.5	13.7	2.3	5.5
PALLET DOLLEY - SIDE LOADING (END TOWING)	966	4.5	2.6	11.7	3.0	5.5
PALLET DOLLEY - END LOADING (SIDE TOWING)	966	3.8	3.4	14.4	3.0	5.5
6m ULD DOLLY	967	8.0	2.6	20.8	3.5	8.0
CONTAINER DOLLY	965	4.0	1.8	7.2	2.2	4.5
BAGGAGE CART	963	3.5	1.5	5.3	2.0	6.0
BELT CONVEYOR	925	7.5	2.0	15.0	1.0	7.6
PASSENGER STAIRS (WIDE BODY)	920	10.0	2.5	25.0	4.0	12.2
CATERING TRUCK (WIDE BODY)	927	9.0	2.5	22.5	4.0	12.2
AIR CONDITIONING UNIT		6.5	2.5	16.3	2.5	6.5
LAVATORY VEHICLE	971	6.5	2.5	16.3	2.2	6.5
POTABLE WATER VEHICLE	970	6.5	2.5	16.3	2.2	8.0
ULD TRANSPORT SEMI-TRAILER (4 PALLET)	960	16.0	2.5	40.0	4.0	9.0
TUGS (RAMP TRACTORS)	968	2.5	1.3	6.5	1.7	2.5

The IATA Ramp Services and Equipment Group has developed the above table of dimensions for typical aircraft ground handling equipment for use in producing the layout of airport terminal aprons. Numerous models of each type of ground handling equipment are produced by many manufacturers in at least a dozen countries. The dimensions provided should be considered as typical of each type of equipment and should be used as a "rule of thumb" for general airport planning purposes.

Sample Apron Area Service Equipment

Ramp Services are VeryLabor Intensive

Unusual Terminal Areas



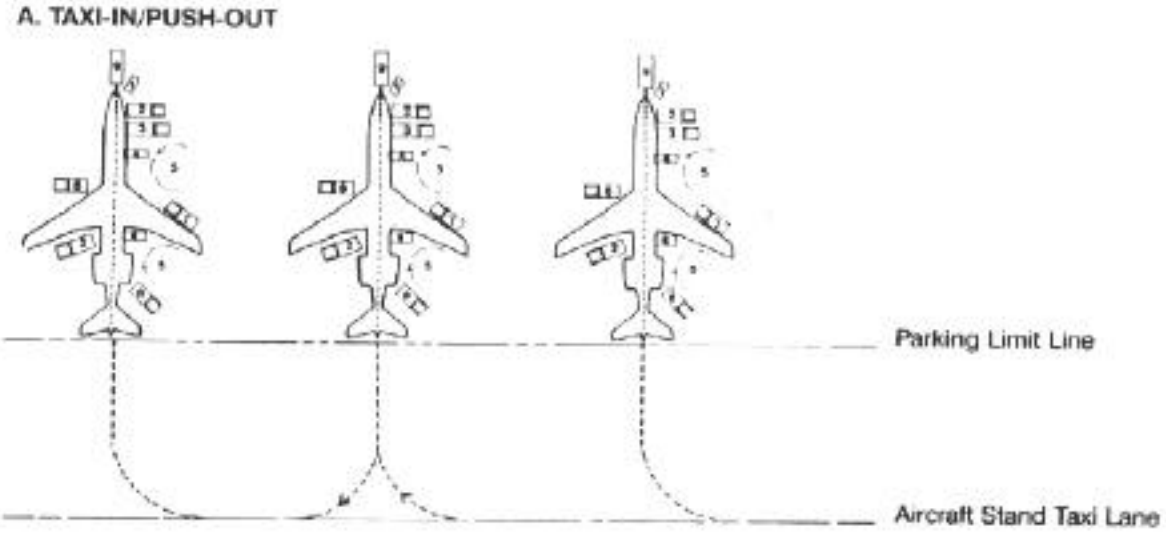
Aircraft Parking Configurations

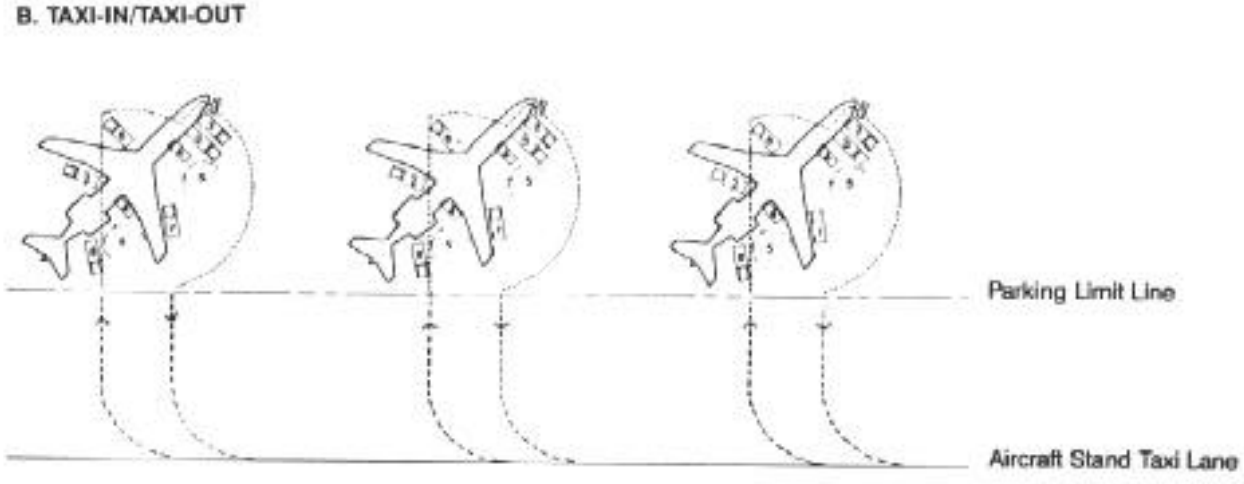
Three types of parking configurations have been used at most airports:

- Taxi-in and Push-out
- Taxi-in and Taxi-out (front)
- Taxi-in and Taxi-out (back)

The configuration depends largely on the terminal design system employed

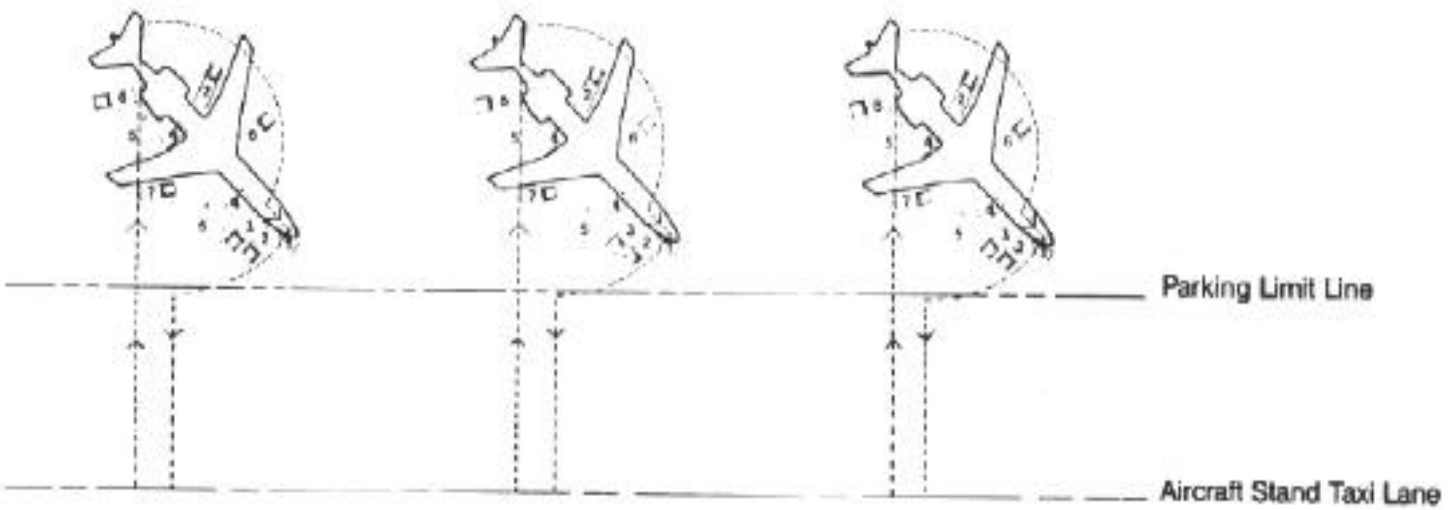
Parking Configurations (IATA)



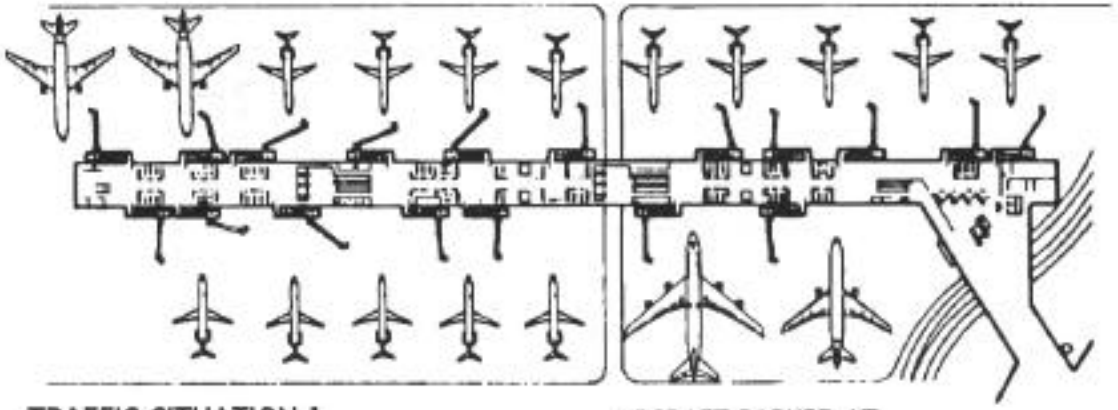


Parking Configurations (IATA)

C. TAXI-IN/TAXI-OUT

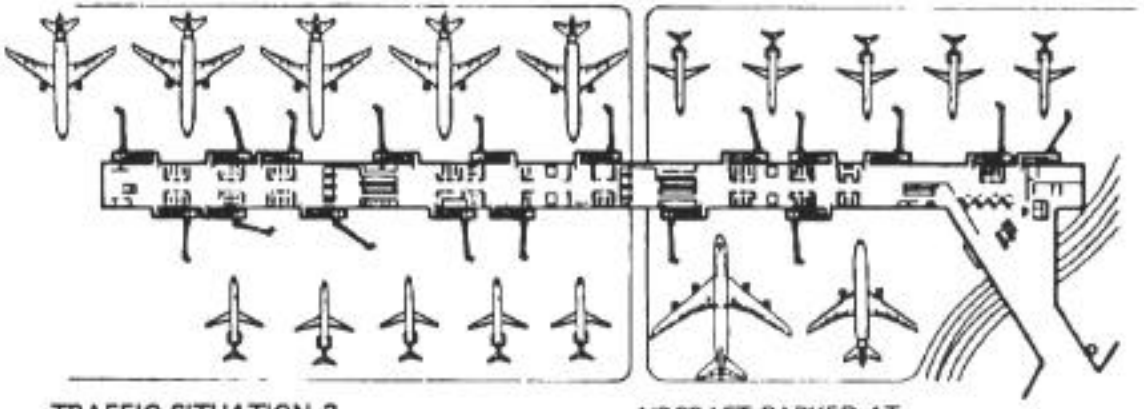


Apron-Terminal Flexible Design



TRAFFIC SITUATION 1
DURING MORNING PEAK HOURS
PREDOMINANCE OF SMALL AIRCRAFT

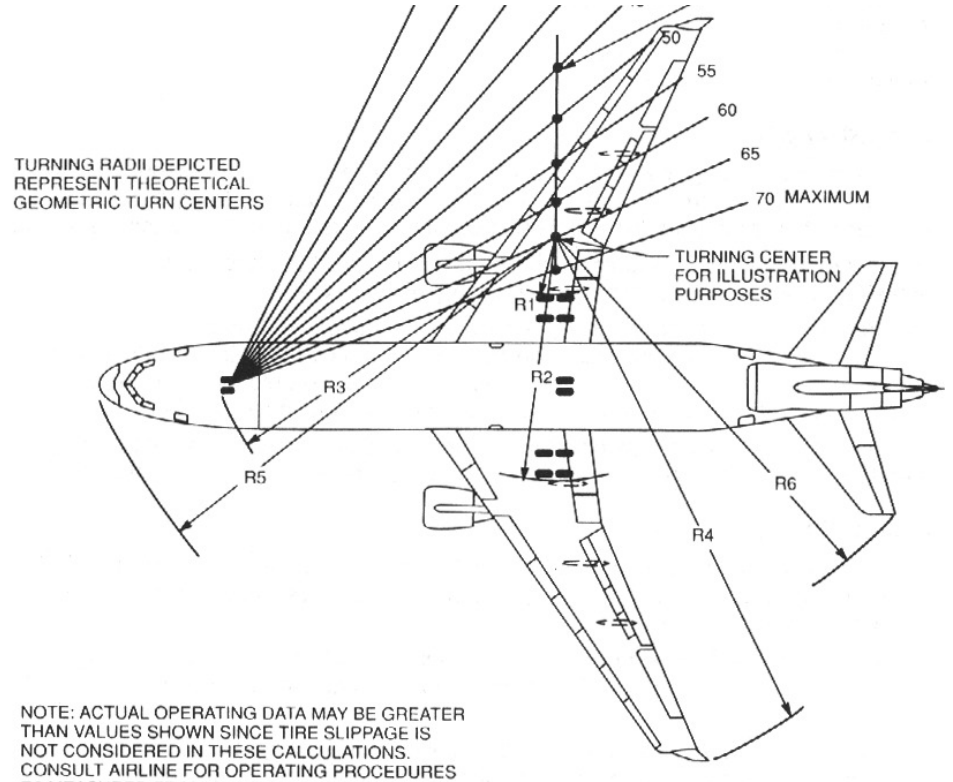
AIRCRAFT PARKED AT
TERMINAL BUILDING: 18
14 DC-9 / 3 DC-10 / 1 B747-400



TRAFFIC SITUATION 2
DURING INTERMEDIARY PHASE
MIX OF SMALL AND WIDE-BODY AIRCRAFT

AIRCRAFT PARKED AT
TERMINAL BUILDING: 17
10 DC-9 / 6 DC-10 / 1 B747-400

Aircraft Turning Capabilities



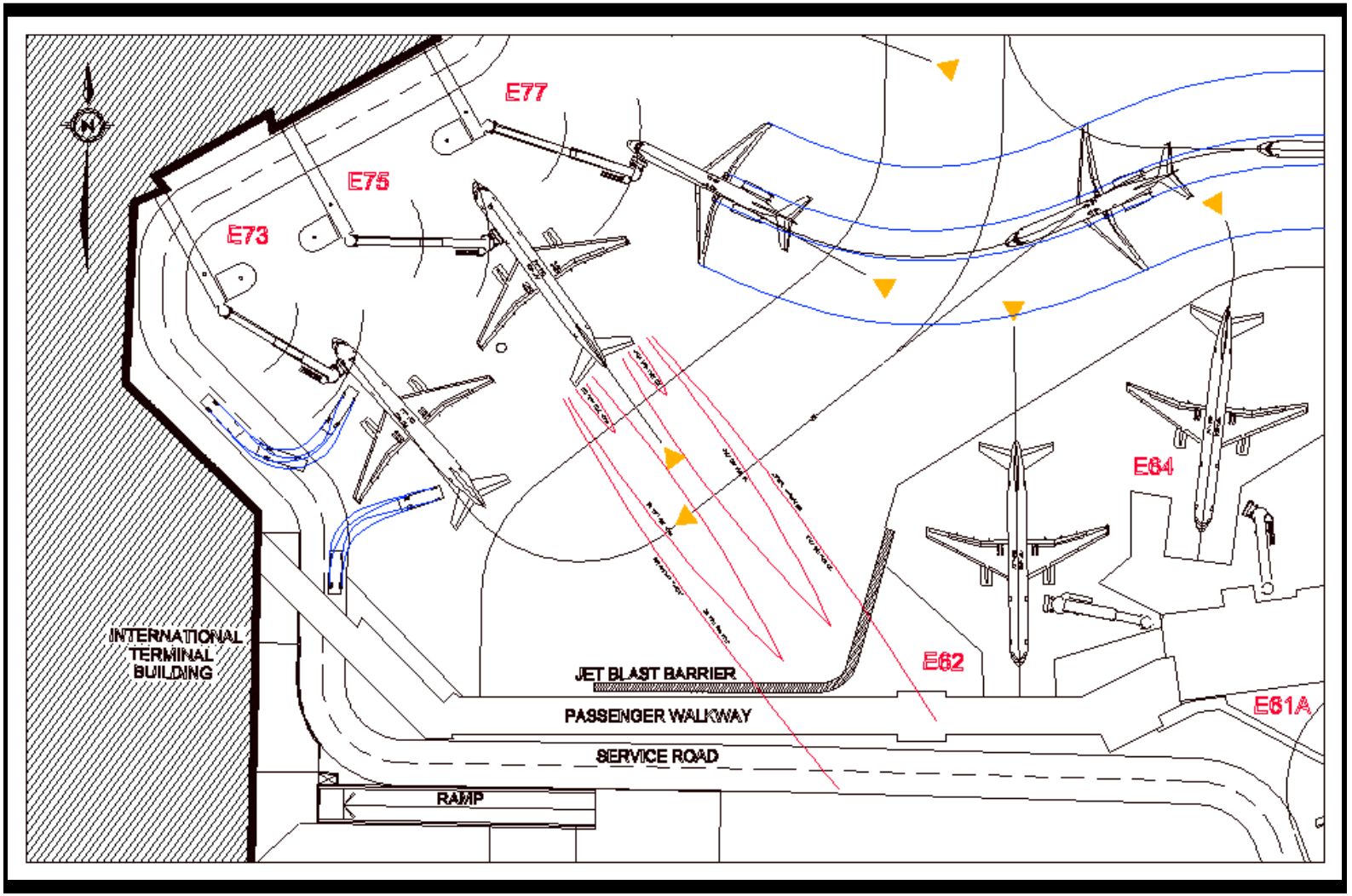
NOTE: ACTUAL OPERATING DATA MAY BE GREATER THAN VALUES SHOWN SINCE TIRE SLIPPAGE IS NOT CONSIDERED IN THESE CALCULATIONS. CONSULT AIRLINE FOR OPERATING PROCEDURES R3 MEASURED FROM OUTSIDE FACE OF TIRE.

STEERING ANGLE (DEG)	R–1		R–2		R–3		R–4		R–5		R–6	
	FT	m	FT	m	FT	m	FT	m	FT	m	FT	m
25	153.7	46.8	194.9	59.4	194.0	59.1	262.6	80.0	205.7	62.7	220.2	67.1
30	120.2	36.6	161.4	49.2	164.3	50.1	229.5	69.9	178.2	54.3	189.5	57.8
35	95.5	29.1	136.7	41.7	143.5	43.7	205.2	62.5	159.4	48.6	167.7	51.2
40	76.3	23.2	117.5	35.8	128.2	39.1	186.4	56.8	145.9	44.5	151.3	46.1
45	60.7	18.5	101.9	31.1	116.6	35.6	171.2	52.2	136.1	41.5	138.5	42.2
50	47.6	14.5	88.8	27.1	107.8	32.9	158.5	48.3	128.7	39.2	128.3	39.1
55	36.3	11.1	77.5	23.6	100.9	30.8	147.6	45.0	123.1	37.5	119.9	36.6
60	26.3	8.0	67.6	20.6	95.6	29.1	138.0	42.0	118.8	36.2	112.9	34.4
65	17.3	5.3	58.5	17.8	91.4	27.9	129.4	39.4	115.6	35.2	107.0	32.6

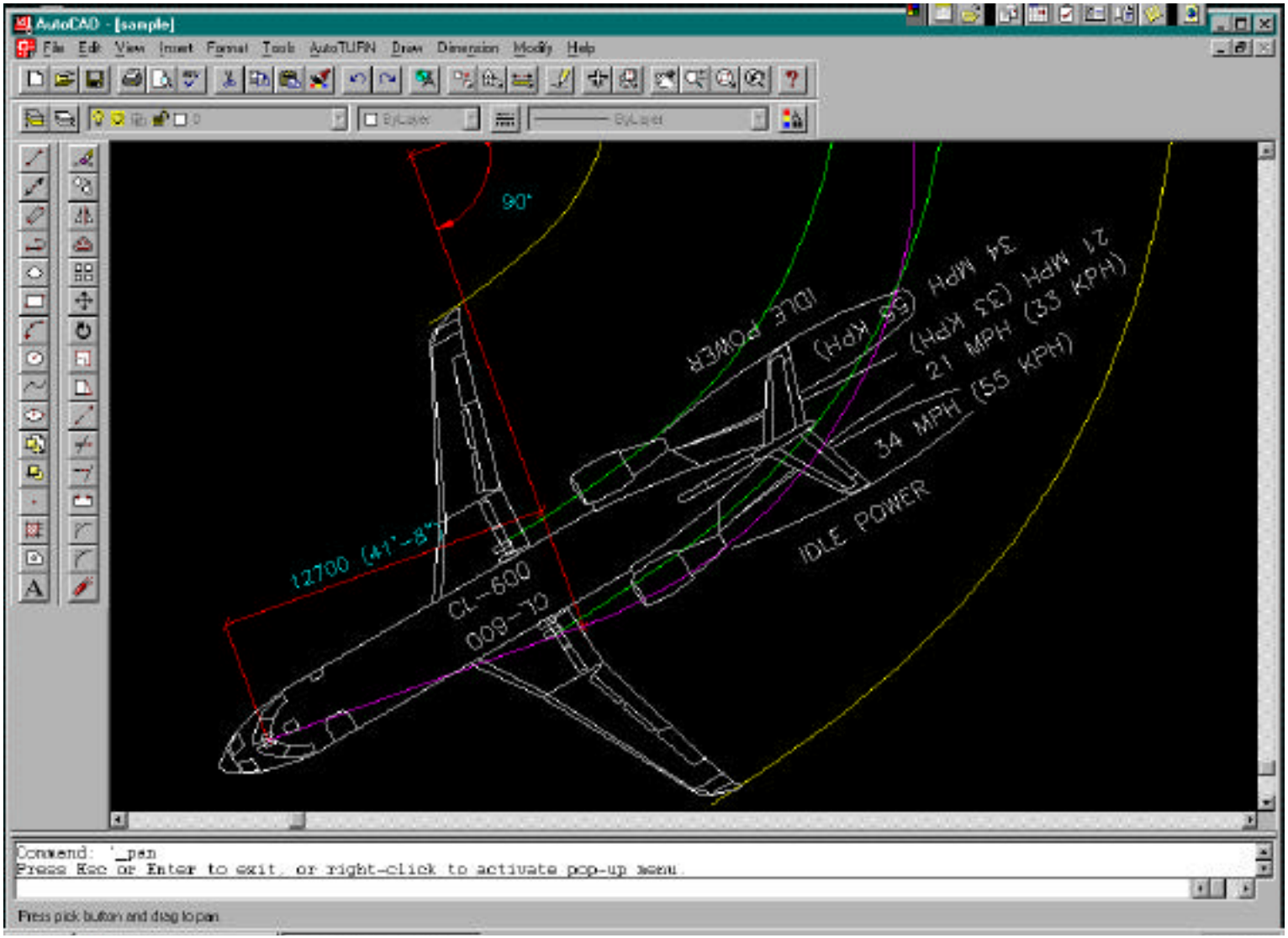
Apron Area Dynamic Analysis

- Several computer programs exist to study aircraft movements in the apron areas
- **Autoturn** from Transoft is one example of such program
  - Dynamic turn analysis
  - Aircraft exhaust plume analysis

Sample Autoturn Analysis



Autotun Aircraft Analysis



Determining Gate Capacity at the Airport

- Gates can be a critical asset at many airports
- The number of gates is usually determined using simple demand and supply analysis formulas
- Gates can be “owned” by airlines (leased from the airport authority)

Gate Analysis (Ashford's Method)

- Aircraft Parking and Gate Analysis
  - Can be executed using ramp (sort of Gantt) charts where flights are plotted against time over a 24 hr. period.
  - Gantt charts show activities over time

Gate Analysis (Ashford's Method)

A simple formula to estimate the number of gates proposed by Norman Ashford is:

$$U = \frac{F}{G(S)}$$

U = Utilization factor (0-1)

F = No. of flights

G = No. of gates available

S = Slots per day

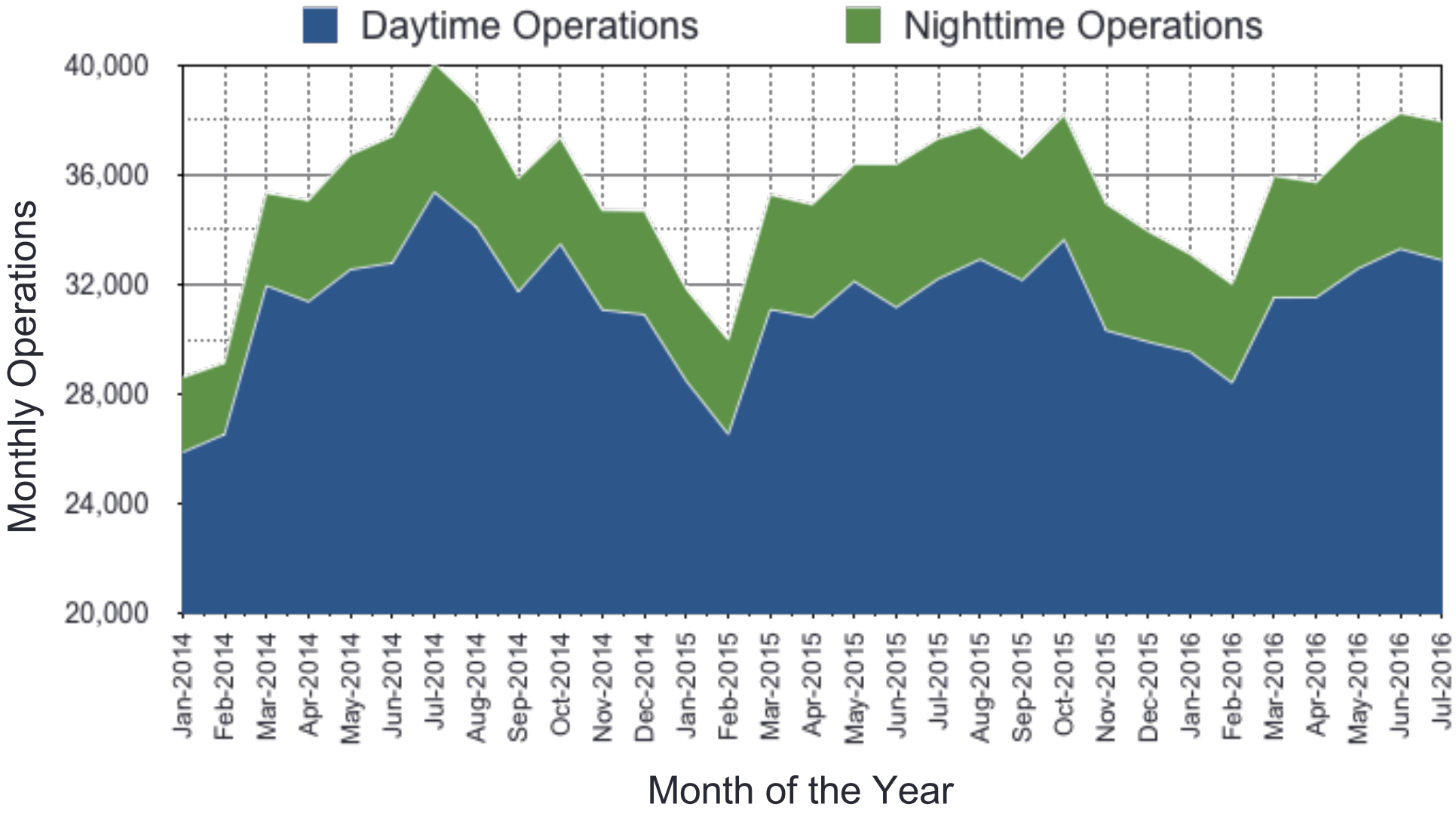
Usually S = 20-30 per day (24 hour period)

Demand vs Capacity Ratios

- Through experience, we know airports cannot operate at maximum saturation capacity rates for a full day
- Busy airports in the US typically average daily demand to peak hour ratios between 13 and 14 (see examples provided)
- Some international airports like Istanbul and London Heathrow average average daily demand to peak hour **ratios close to 15**
- Annual demand / average daily demand = 320
- Typically busy airports are operated for 14 hours at high demand rates during the day with 2 shoulder periods in the morning and the night (where demand is increasing or decreasing)

Aviation Demand Varies by Month (Season)
ORD Airport

source: Chicago Department of Aviation



Annual Service Volume Calculations

Typically 320

Typically 14

$$ASV = \left(\frac{D_{annual}}{D_{daily}}\right)\left(\frac{D_{daily}}{D_{hourly}}\right)\sum_{i=1}^{n} C_i f_i$$

where:

ASV = annual service volume (operations)

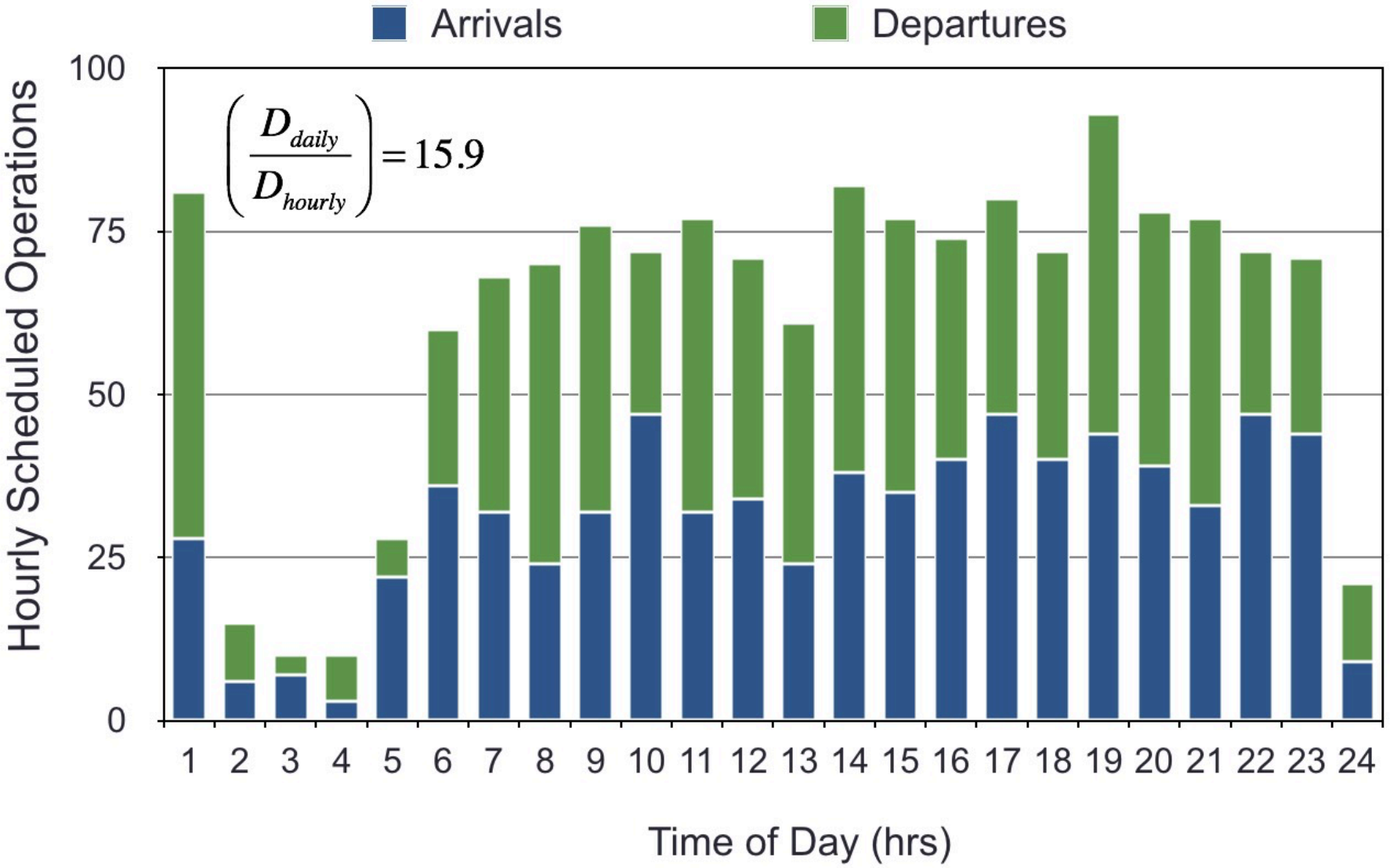
$\left(\frac{D_{annual}}{D_{daily}}\right)$ = annual demand to daily demand ratio (dim)

$\left(\frac{D_{daily}}{D_{hourly}}\right)$ = ratio of daily demand to peak hour demand (dim)

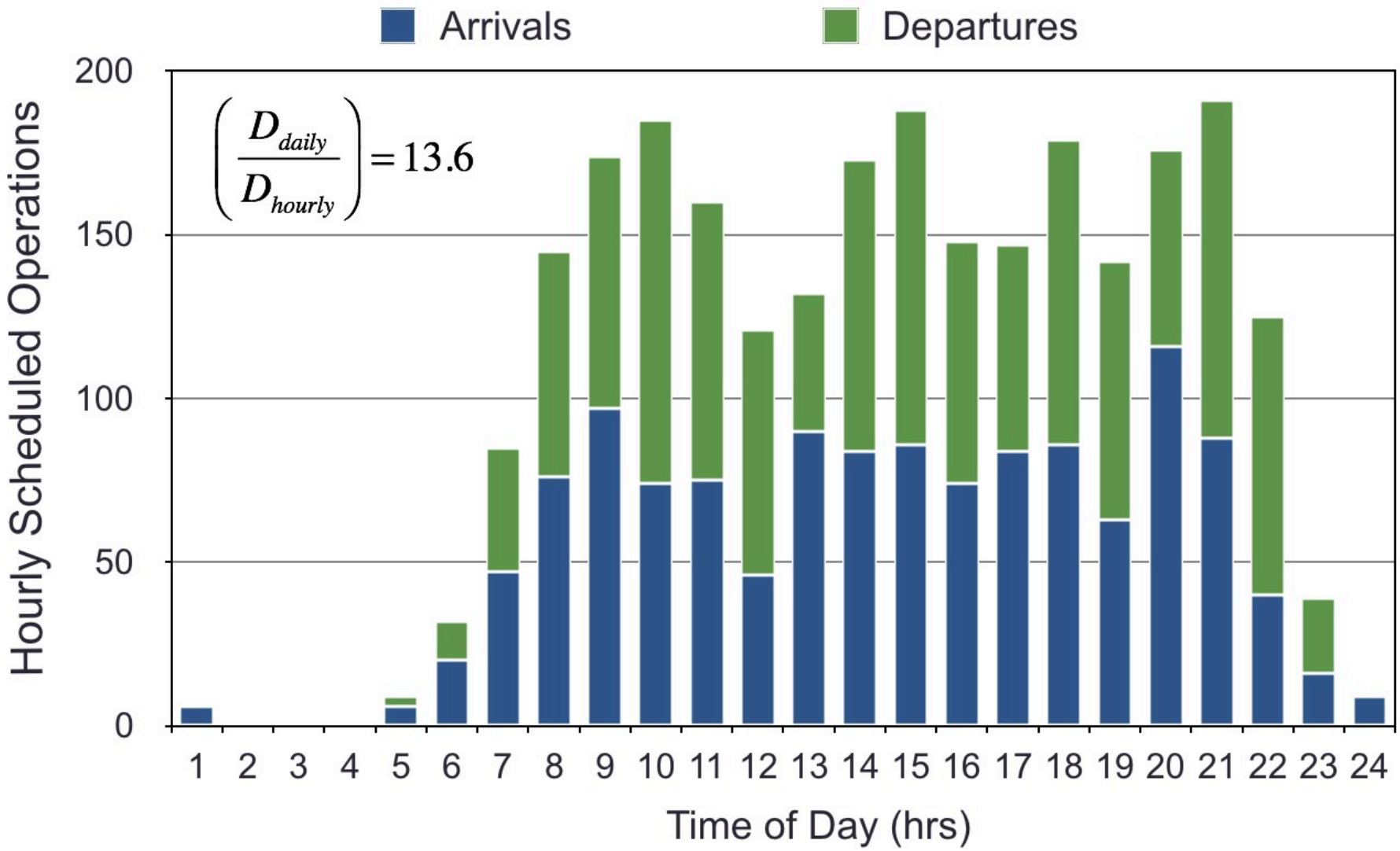
C_i = hourly saturation capacity for runway configuration i

f_i = fraction of time the airport operates using runway configuration i

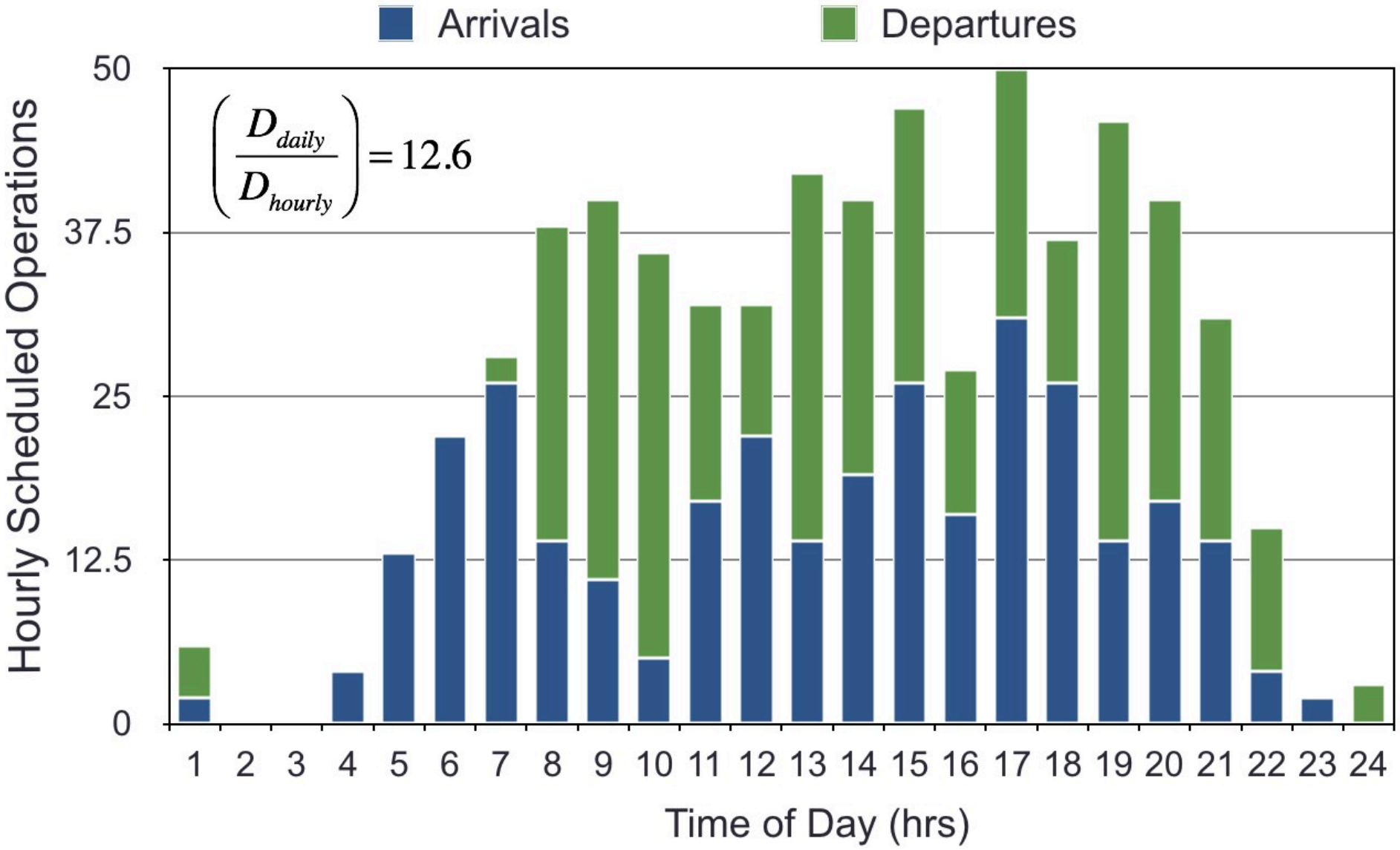
Istanbul Airport Scheduled Commercial Flights



Atlanta Airport Scheduled Commercial Flights



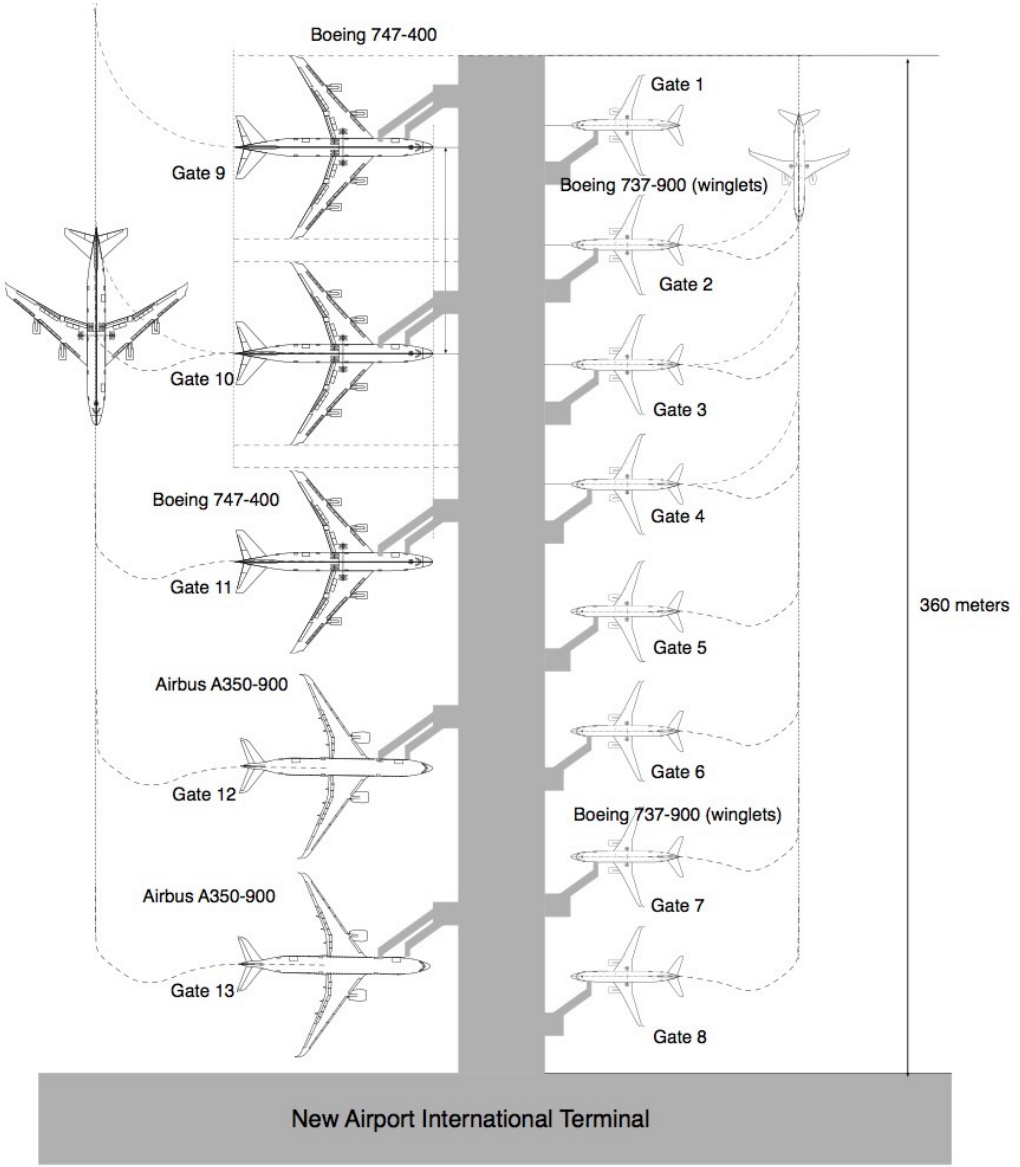
Incheon Airport Scheduled Commercial Flights



Planning Gates Starts with a Sketch of the Concept

Finger Pier
360 meters long

360 meters allows
~ 5 Code E aircraft or
~ 8 Code C aircraft
per finger pier



Gate Capacity Planning Method (FAA)

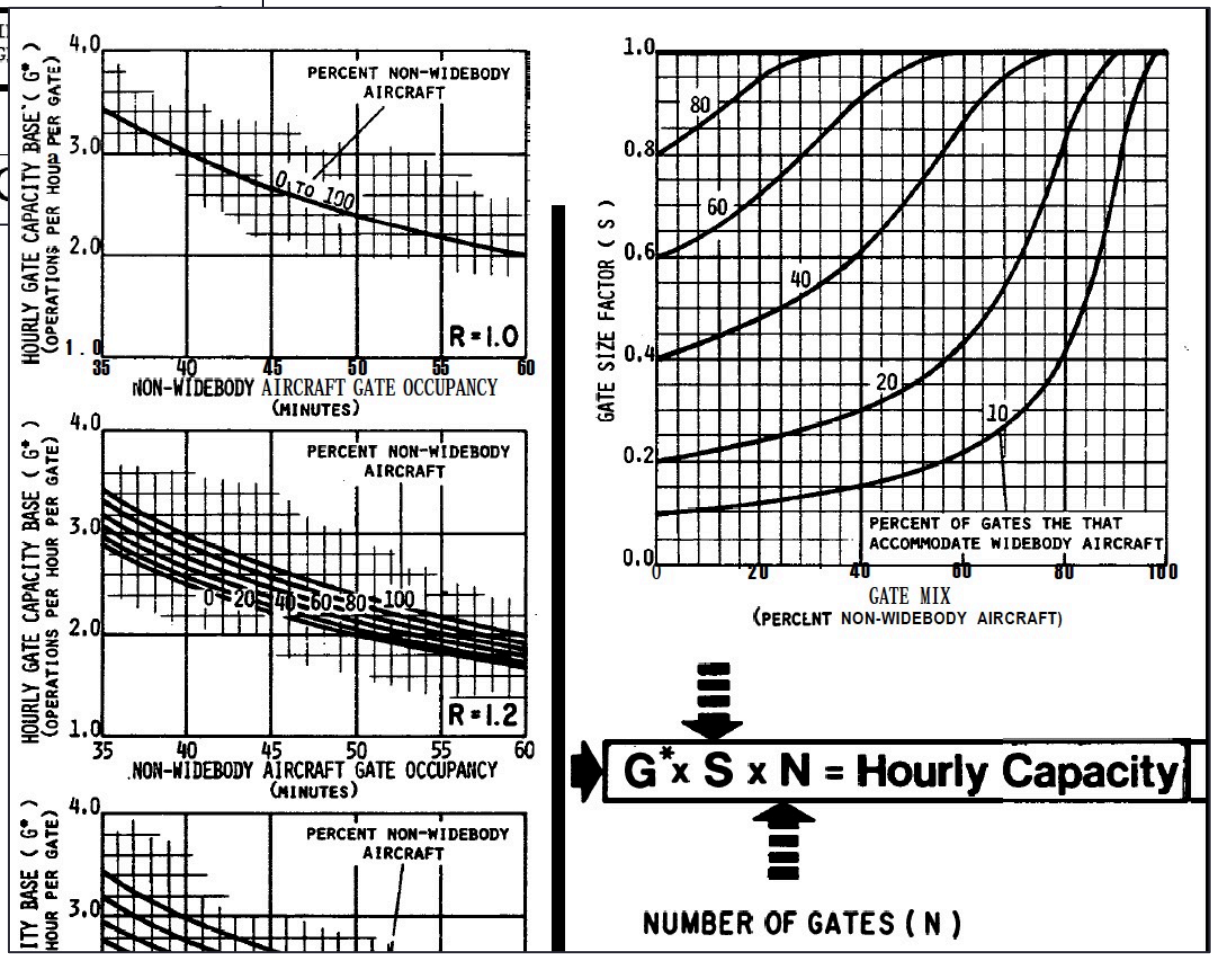
U.S. Department of Transportation
Federal Aviation Administration

Airport Capacity and Delay

REPRI
CHANG

AC: 150/5060-5
Date: 9-23-83

Advisory C



FAA Advisory Circular 150/5060-5 Airport Capacity and Delay

A Graphical planning Method to estimate airport gate capacity

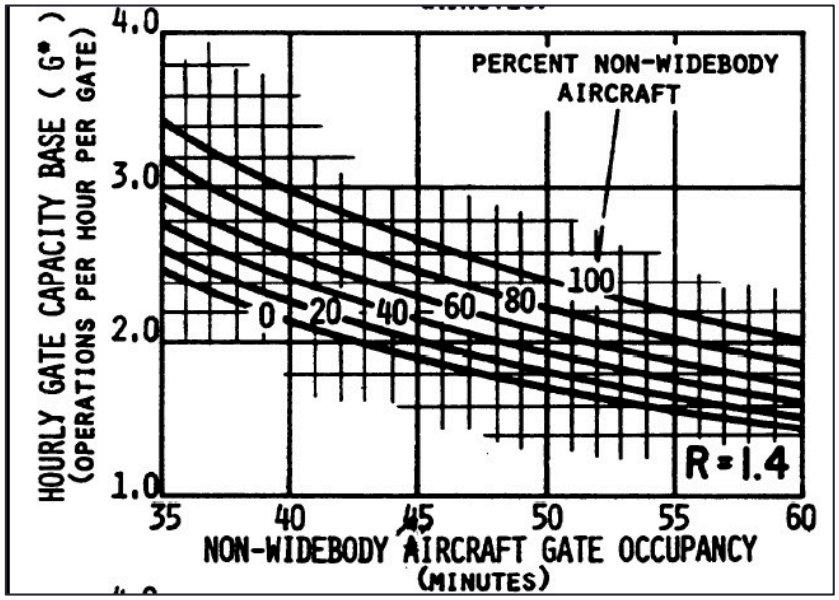
Planning Equations for Gate Capacity

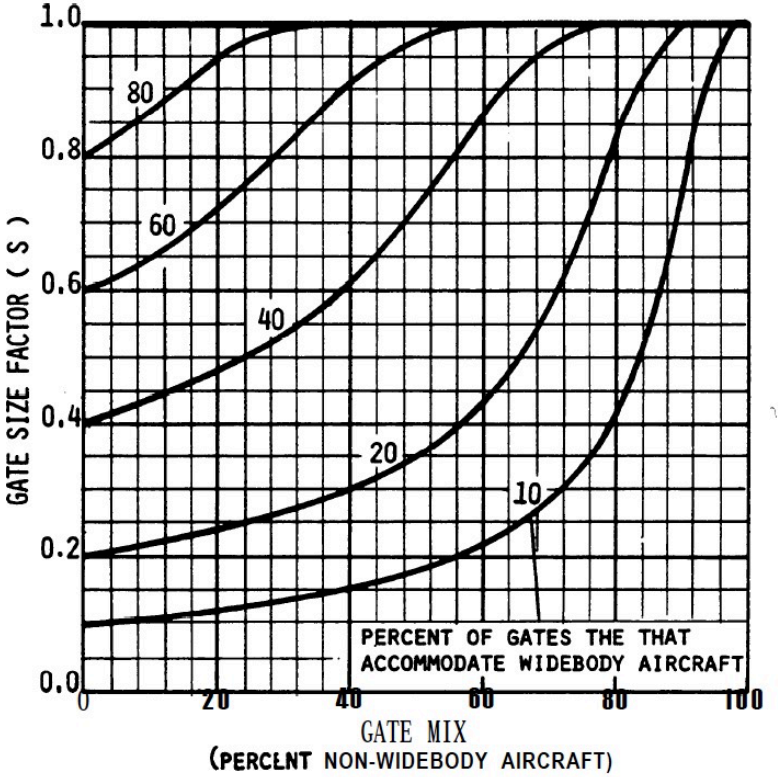
$$Capacity = G * N * S$$

$G =$ Baseline gate capacity (operations/hr)

$N =$ Number of gates available

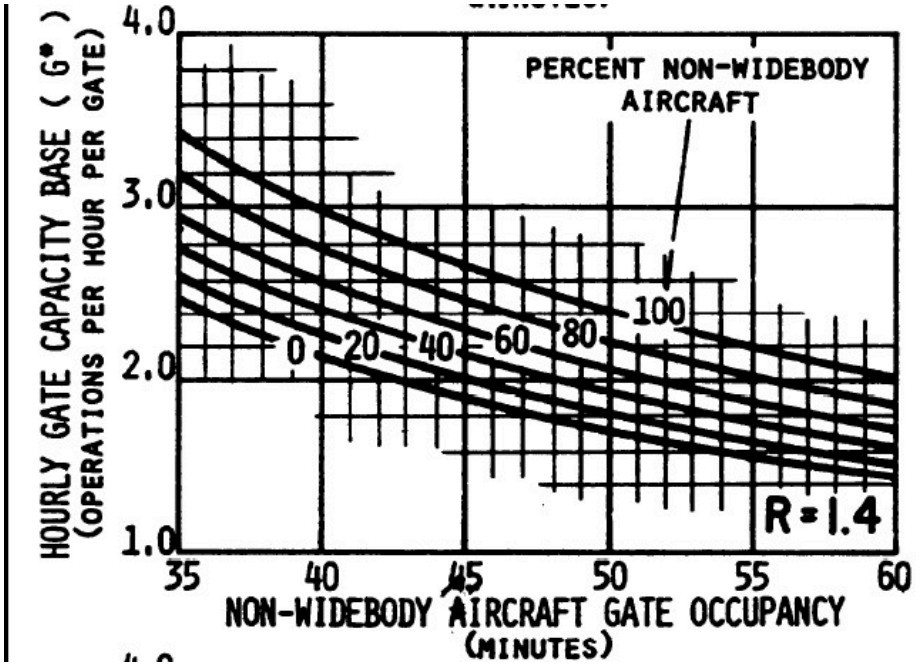
$S =$ Gate size factor (dim)





Planning Equations for Gate Capacity

- Gate planning method to estimate gate capacity
- Inputs required:
  - **Number of planned gates**
  - **Aircraft fleet mix or composition of wide-body and non-wide-body**
- Gate occupancy time



Source: FAA Advisory Circular 150/5060

$$Capacity = G * N * S$$

$G =$ Baseline gate capacity (operations/hr)

$N =$ Number of gates available

$S =$ Gate size factor (dim)

Example 1: Gate Capacity

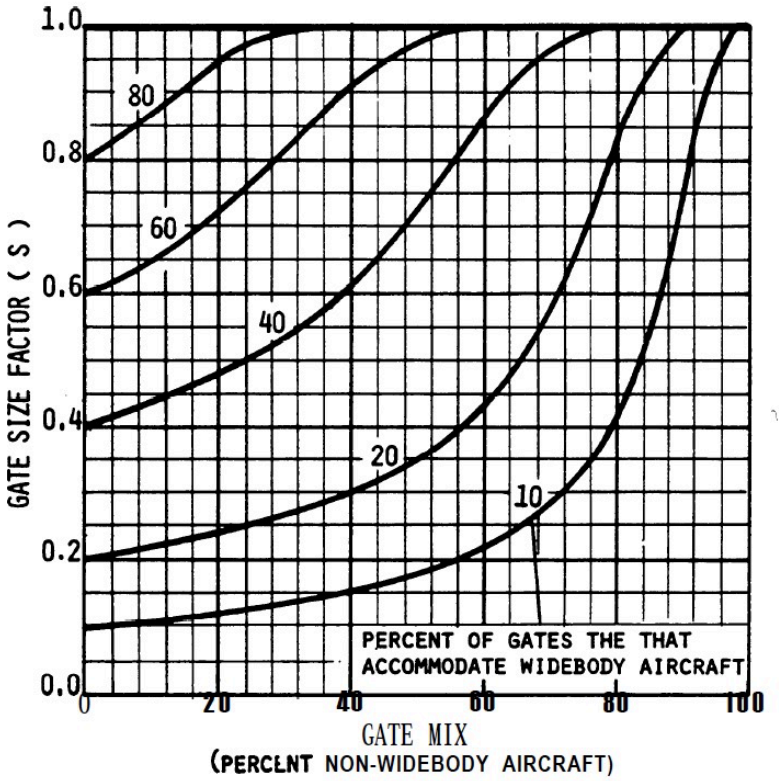
- New terminal with planned 37 gates
- 29 narrow body and wide body
- Gate occupancy (narrow body) = 60 min
- Gate occupancy (wide body) = 90 min
- R = ratio of wide body and narrow body occupancy = 1.5 (use 1.4 per FAA)
- Gate mix = 0.80
- Percent of gates for wide body = 0.22
- Gate size factor = 0.82

$Capacity = G * N * S$

$G =$ Baseline gate capacity (operations/hr)

$N =$ Number of gates available

$S =$ Gate size factor (dim)



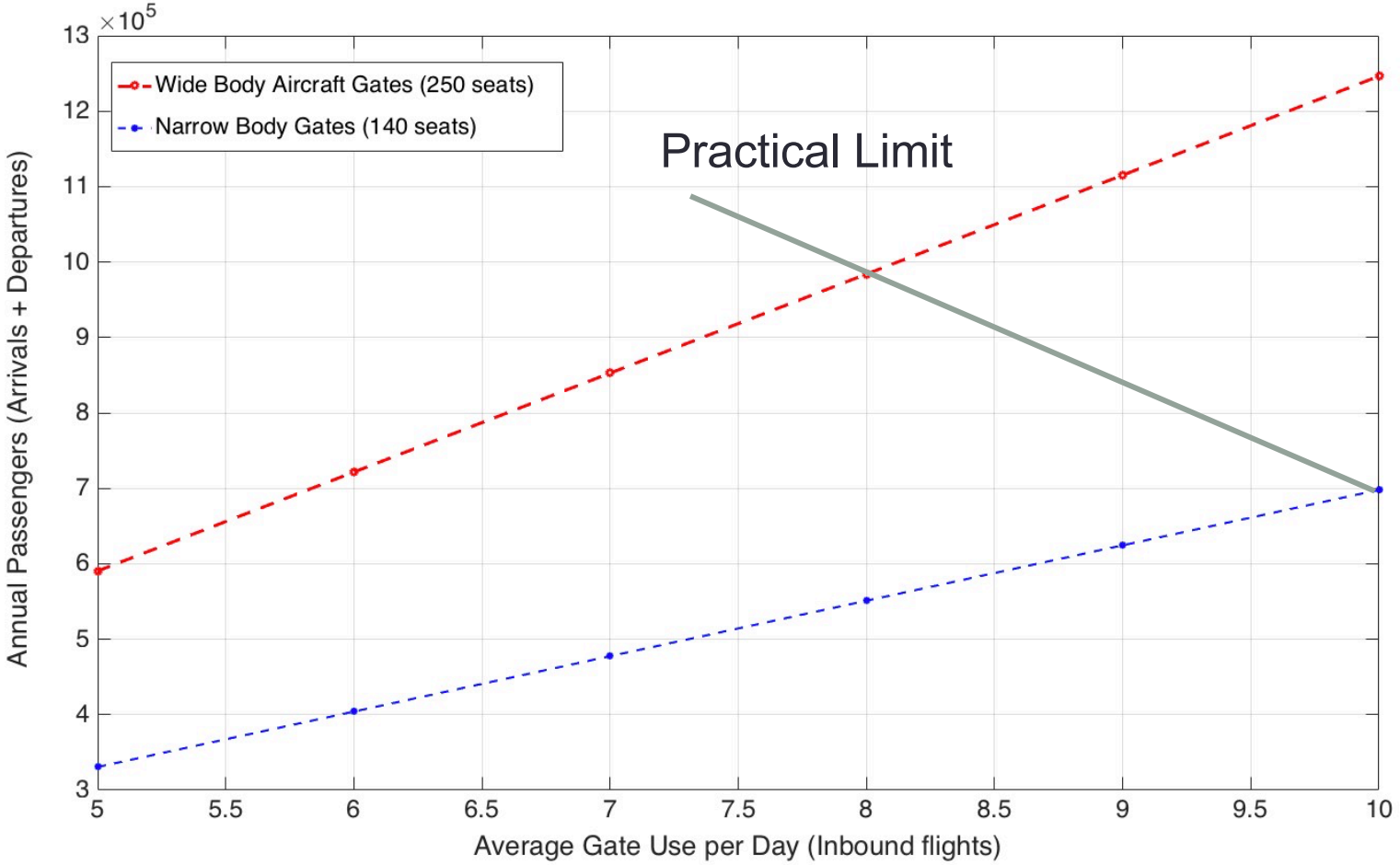
Capacity (operations per hour)= 0.82 * 37 * 1.8 = 54 per hour

Typical Gate Handling Capacities at Selected World Airports

Airport Name	Gates/Stands	Annual Passengers (Arriving + Departing)	Passengers/gate or stand	ICAO Code	Seats/flight
Punta Cana	24	5,800,000	241,667	MDPC	179
Dublin	50	25,049,000	500,980	EIDW	165
Malaga	48	14,404,000	300,083	LEMG	169
Jeju	27	26,237,000	971,741	RKPC	183
Washington National	35	23,039,000	658,257	KDCA	100
Gatwick	78	40,279,000	516,397	EGKK	180
Washington Dulles	119	21,650,000	181,933	KIAD	119
Palma de Mallorca	88	22,768,082	258,728	LESG	174
Mexico City	107	38,433,000	359,187	MMMX	131
Seoul Incheon	76	49,291,000	648,566	RKSI	228
Miami	97	44,350,000	457,216	KMIA	159
New York Kennedy	135	56,827,000	420,941	KJFK	168
Heathrow	212	74,985,000	353,703	LHR	205
Atlanta	214	101,491,000	474,257	ATL	136
San Diego	51	20,081,000	393,745	SAN	146
Istanbul	79	61,322,000	776,228	IST	181

Gate Planning Chart Analysis

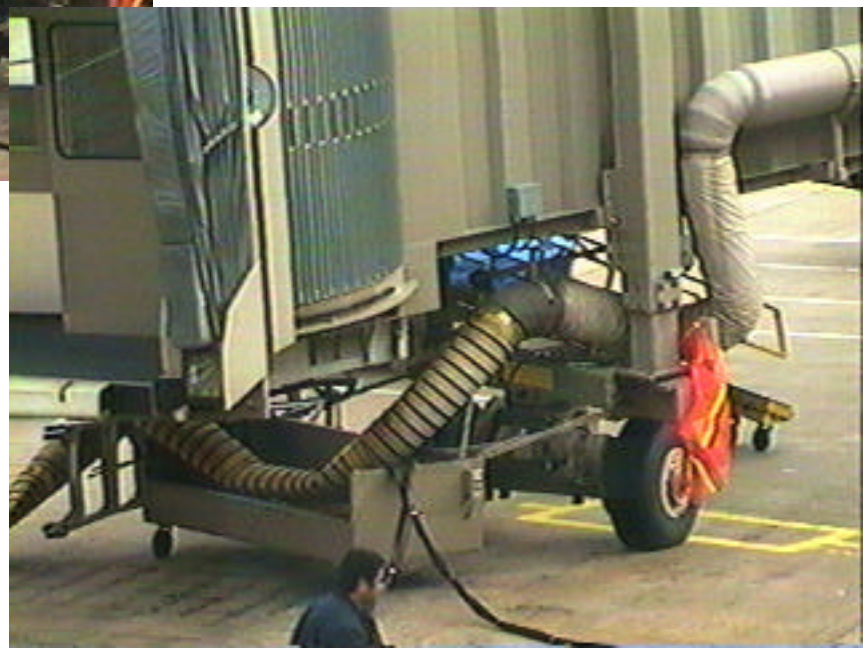
Use the average seating capacity of aircraft (wide-body vs narrow body)
Average load factor (0.82)
Average gate utilization per day (inbound flights)
Number of days in the year for analysis (320 days assumed in this chart)



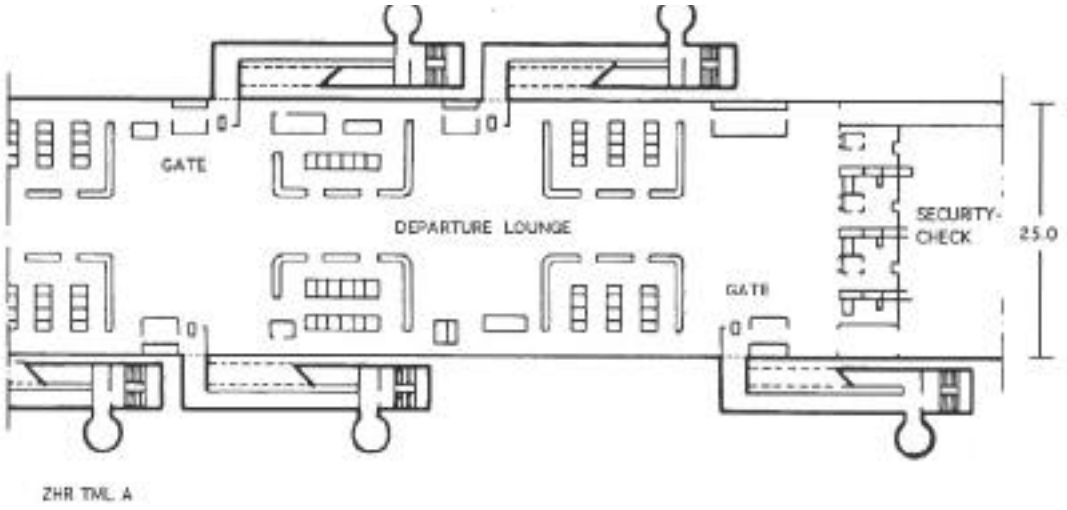
Loading Gates

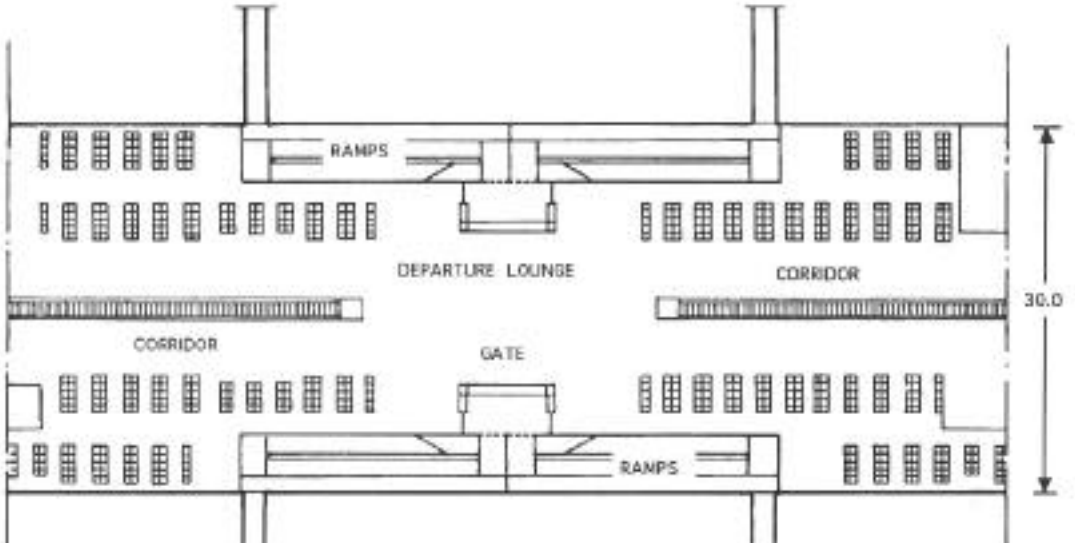
- Come in many flavors and sizes
  - Large articulated units able to serve Wide-body aircraft
  - Small units serving regional jets

Loading Gates



Waiting Lounges





Waiting Lounges

- Dimensionally departure lounges has been sized using static measures of effectiveness (IATA standard)
- ITA Standard for Departure Lounges 8.5 ft^2/acft. seat.
- IATA Waiting and circulation areas >10.8 ft^2/person more than 15 min.
- Architectural standard with baggage 15 ft^2/person
- Many airlines use 15 ft^2/Pax @ 87%* load factor

* 87% of passengers are at the waiting lounge 15 min. before departure.

Waiting Lounges (Examples)

DFW Airport

Waiting Lounge Sizing

Let n = 150 Passengers (medium-size transport)

S = 15 ft/Passenger standard

L = 0.87 (87% Load Factor)

A = 2600 ft^2 Area of Dept. lounge

Find max. service volume. (S_V)

$$S_V = \frac{A}{(L)(S)} = 199 Pax \quad @ \quad 15\ ft^2/Pax.$$

Parking Facilities at Airports

Charlotte-Douglas Intl. Airport (North Carolina)

The Curbside at the Airport

Control Towers at Airports

ASDE Radars

Washington Dulles

DFW Airport

Control Towers

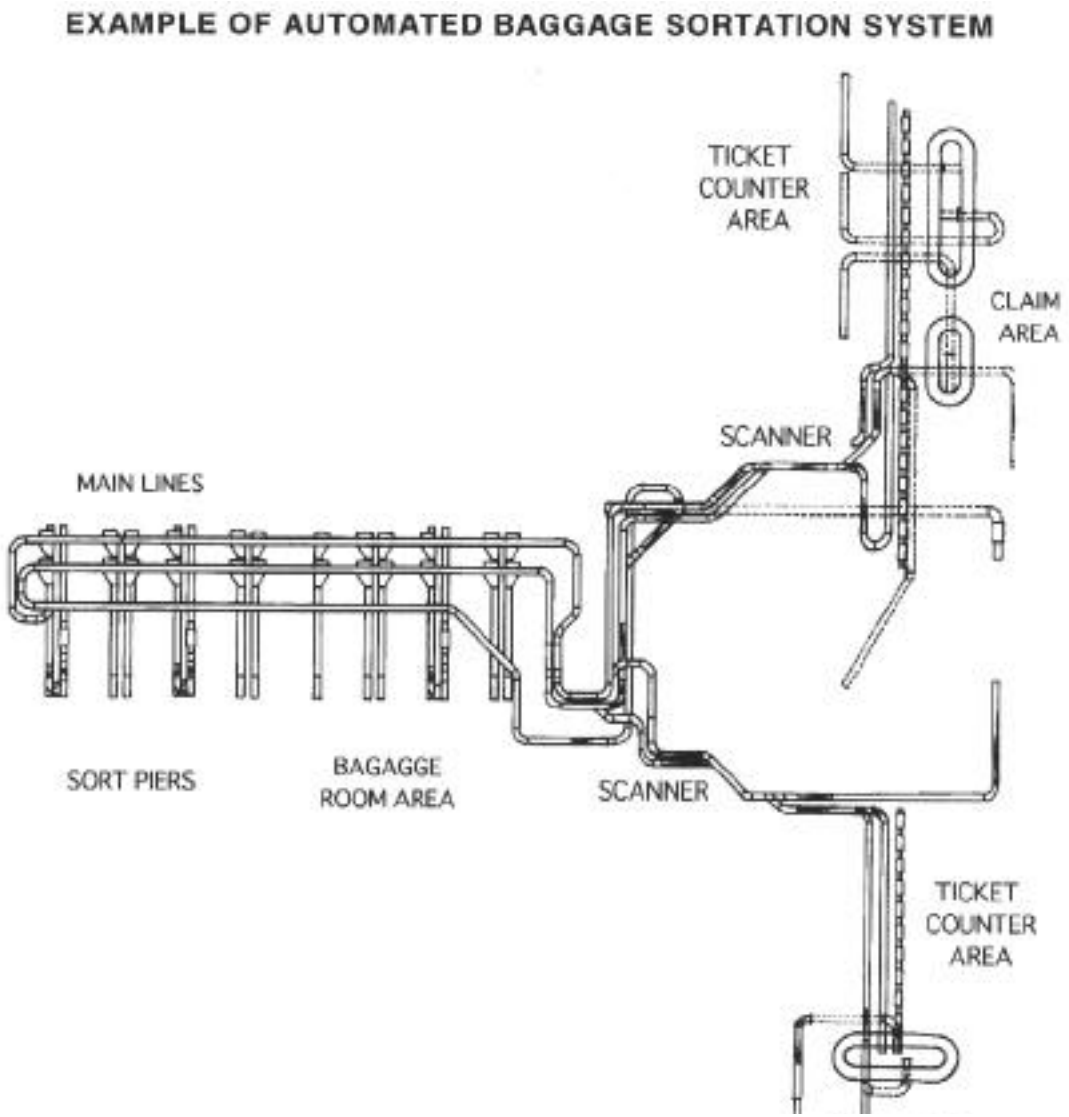
Denver Intl. Airport

Oklahoma City

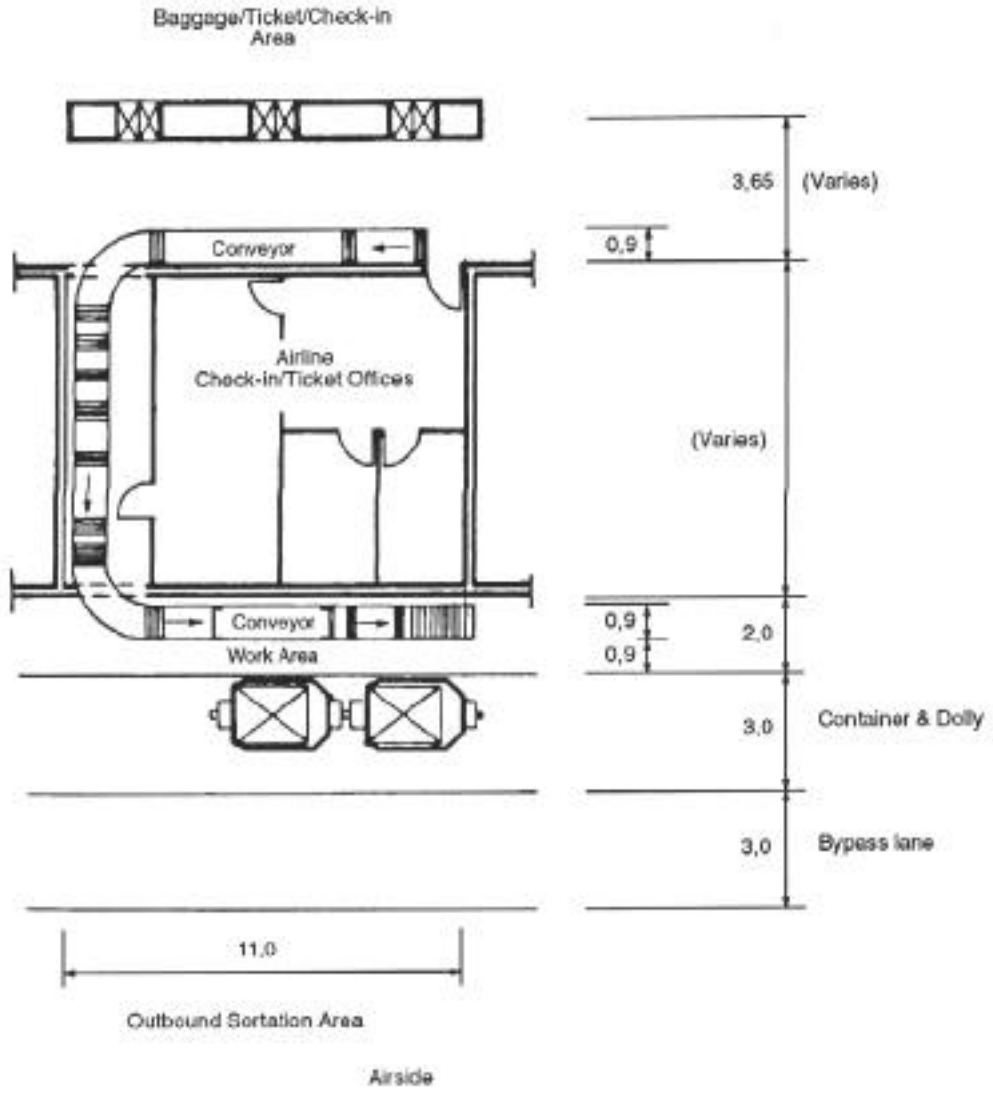
Baggage Systems

- Not to be understimated
- Some systems are very complex
- Direct feed systems
- Remote feed systems
- Plenty of automation these days
- Some system scarry 15,000 bags per hour

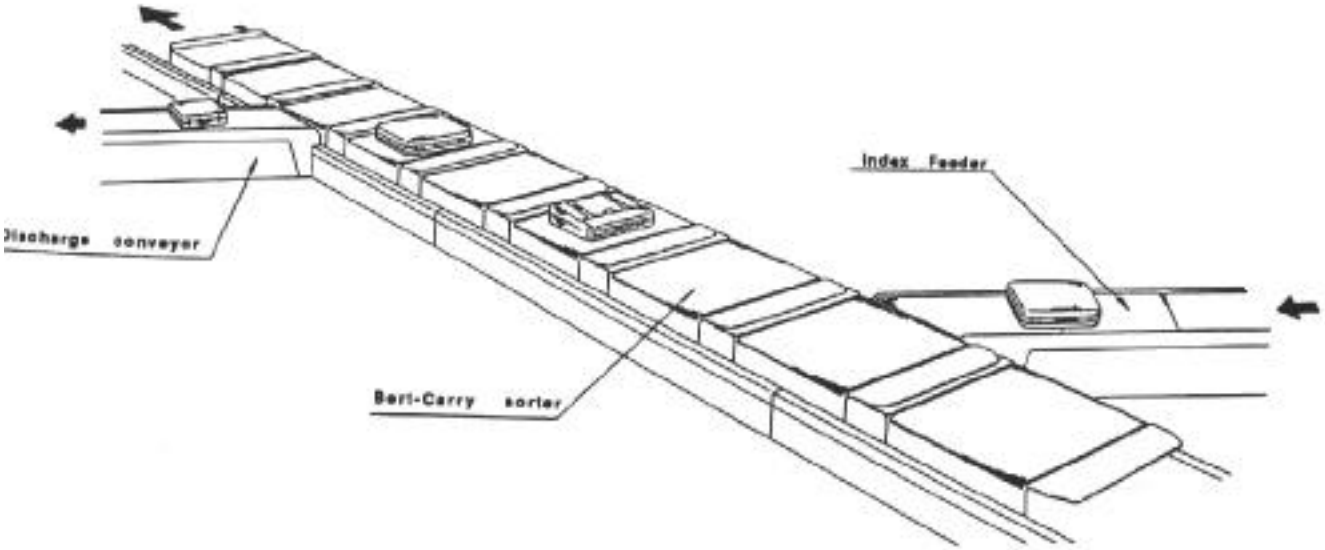
Baggage Systems (Remote Feed System)



Baggage Systems (Departure)

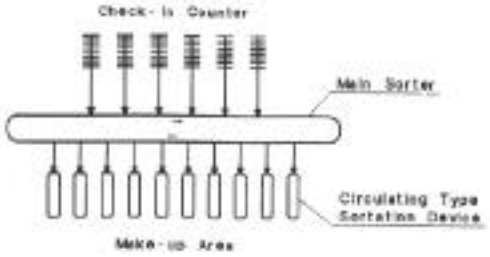


Baggage Systems (Automated Sorting)

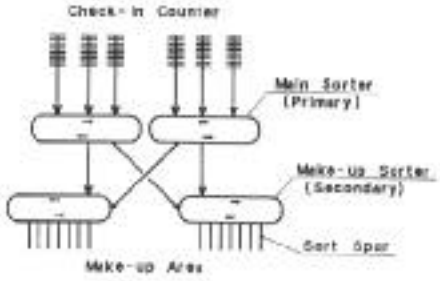


APPLICATION LAYOUT OF BELT-CARRY SORTER

APPLICATION 1



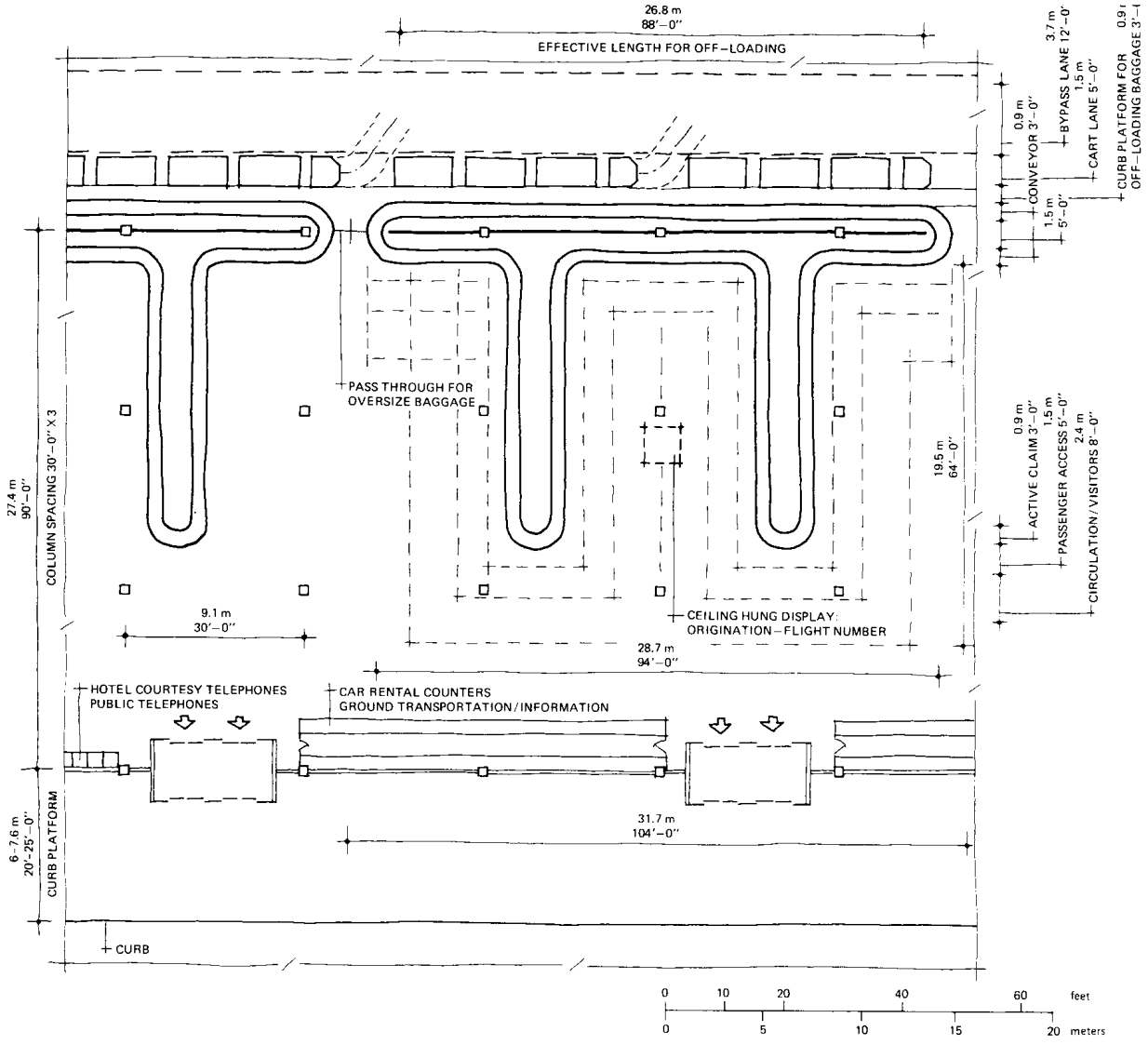
APPLICATION 3



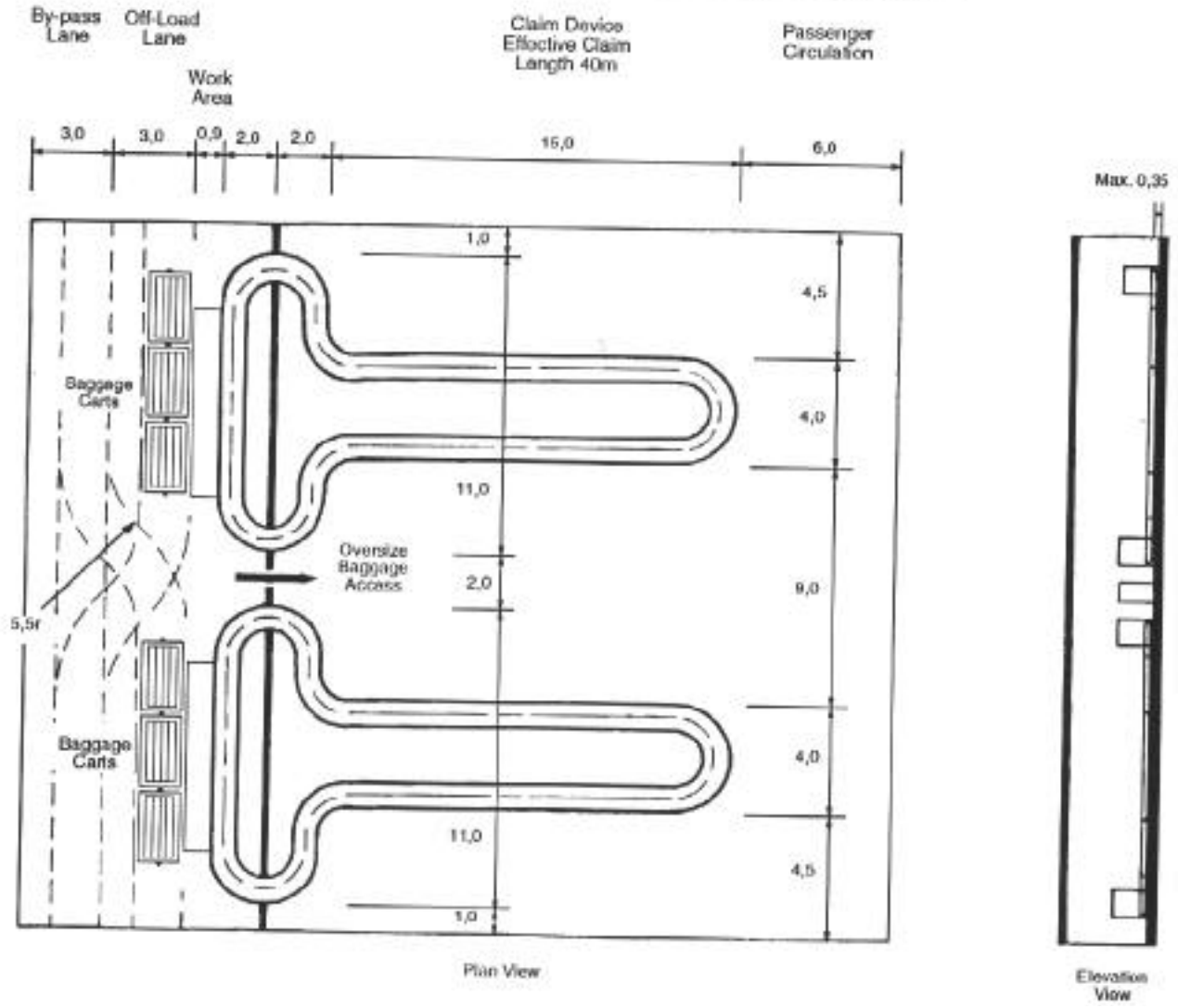
APPLICATION 2

APPLICATION 4

Direct Feed System (Hart)



Direct Feed System (IATA)



Baggage Claim Systems

Remote Feed System

Direct Feed System

References

1) IATA. *Airport Development Reference Manual: 8th Edition.* International Airline Transport Association, Montreal, 1995.