**U.S. Department
of Transportation**

Federal **Aviation**
Administration

Airport Capacity
and Delay

REPRINT INCORPORATES
CHANGE 1 AND 2

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

Advisory Circular

**U.S. Department
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Subject: AIRPORT CAPACITY AND DELAY

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Initiated by: **AAS-100**

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1. **PURPOSE.** This advisory circular (AC) explains how to compute airport capacity and aircraft delay for airport planning and design.

2. CANCELLATIONS. This publication cancels the following Federal Aviation Administration (FAA) Advisory Circulars (ACs):

    a. AC 150/5060-1A, Airport Capacity Criteria Used in Preparing the National Airport Plan, dated July 8, 1968, and

    b. AC 150/5060-3A, Airport Capacity Criteria Used in Long Range Planning, dated December 24, 1969.

3. **BACKGROUND.** Changes in the composition of the nation's aircraft fleet together with improvements in air traffic control (ATC) practices have outdated capacity calculations contained the cancelled ACs. An FAA contractor reexamined the procedures for determining airport capacity and suggested improvements to update them. This AC implements these improvements. In addition, this AC refines definitions of capacity and delay. CAPACITY is the throughput rate, i.e. the maximum number of operations that can take place in an hour. DELAY is the difference in time between a constrained and an unconstrained aircraft operation. These definitions take into account that delays occur because of simultaneous demands on the facility. The acceptable level of delay will vary from airport to airport.

4. **APPLICATION TO AIRPORT DESIGN.** To apply these procedures, a reasonable understanding of the aeronautical activities being conducted at, or projected for, the airport is required. Care should be exercised in using available data so as to avoid data which represents a level of activity occurring sporadically during the year—unless it is intended to examine that specific condition. Since few airports operate at "peak demand" levels for more than two or three consecutive, hours in any one day and demand fluctuates throughout a period even as short as one hour, some delay will occur during a typical hours operations. It is suggested that airport design-be based on an hourly demand which can be expected to occur at least on a weekly basis.

6. <u>**REFERENCE**</u>. **Report No. FAA-RD-74-124,** Techniques for Determining Airport **Airside** Capacity and Delay, dated June 1976 is available **from** the National Technical Information Service **(NTIS),** 5285 **Port Royal** Road, Springfield, Virginia 22161, telephone (703) **557-4650. The NTIS reference** number is **AD-A032** 475.

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CONTENTS

CHAPTER I..   AIRPORT CAPACITY AND AIRCRAFT DELAY

1-1.   **GENERAL. Hourly** airport capacities and annual aircraft delay canputations are needed to design and evaluate airport **development** and **improvement** projects. The method for computing airport capacity and aircraft delay is the **throughput** method provided in this AC.

   a. Background.   The throughput **method** for calculating airport capacity and average delay per aircraft is derived from computer models used by the **Federal** Aviation Administration (FAA) to analyze airport capacity and reduce aircraft delay. Calculations of hourly capacity are needed to determine average delay. Since airport and airport component hourly capacities vary throughout the day due to variations in runway use, aircraft mix, ATC rules, **etc.,** a number of calculations **may** be **needed.**

   b. AC Organization.

      (1) Chapter 1 provides an overview of airport capacity and aircraft delay analyses.

      (2) Chapter 2 contains calculations for computing airport capacity, annual service volume **(ASV),** and aircraft delay for long range evaluations.

      (3) Chapter 3 contains more detailed computations suitable for a wide range of airport design and planning applications.

      (4) Chapter 4 contains special computations of capacity relating to:

         (i) Periods of poor visibility and ceiling conditions.

         (ii) Airports without radar coverage and/or an instrument landing system **(ILS).**

         (iii) Airports with parallel runways when one runway **is** limited to use by small aircraft.

      (5) Chapter 5 identifies **computer** models which may be used to further refine runway capacity and aircraft delay analyses.

      (6) The appendices contain examples applying chapter 2, 3, and 4 calculations.

   c. Units.   Since FM operational standards for spacing aircraft taking-off and **landing are in** customary units (feet, knots, etc.), it is expedient to perform capacity and delay computations in the same units.

1-2.   **AIRPORT COMPONENTS.**

   a. Runway.   The term runway includes the landing surface, plus those portions of the approach and departure paths used in common by all aircraft.

   b. **Taxiway**.   The term **taxiway** includes the parallel taxiways, **entrance-exit taxiways,** and crossing taxiways, recognizing that a capacity limiting condition may exist where an arriving or departing stream of aircraft must cross an active runway.

c. Gate **Group.** The term gate **group** identifies the number of gates located in the terminal **complex** which are used by an airline, or shared by two or **more airlines, or** other aircraft operating at the airport on a regularly scheduled basis. In most cases the terminal gates are not used by general aviation aircraft.

1-3. CAPACITY **TERMS.** The following subpargraphs **define** terms used herein. Symbols used in this AC are defined in Appendix **4,** Glossary of **Symbols/Terms.**

a. Aircraft **Mix.** Aircraft mix is the relative percentage of operations conducted by each of the **four** classes of aircraft (A, B, C, and **D).** Table **1-1** identifies physical aspects of the four aircraft classes and their relationship to **terms** used in the wake turbulence standards.

Table 1-1.   Aircraft **classifications**

Aircraft class	**Max.** Cert. **T.O.** might (lbs)	Number **Engines**	**Wake** Turbulence Classification
A	12,500 or less	Single	Small **(S)**
B		**Multi**	
C	**12,500 - 300,000**	**Multi**	**Large (L)**
D	over 300,000	**Multi**	**Heavy (H)**

b. Annual Service Volume **(ASV)**   **ASV** is a reasonable estimate of an airport's **annual capacity.** It accounts for differences in runway use, aircraft mix, weather conditions, etc., that **would** be **encountered** over a **year's time.**

c . **Capacity.** Capacity (throughput capacity) is a measure of the **maximum** number **of** aircraft operations which can be **accommodated** on the airport or airport **component** in an **hour. Since** the capacity of an airport component is independent of the capacity of other airport components, it can be calculated separately.

d. **Ceiling** and Visibility. For purposes of this AC, the terms **VFR, IFR,** and PVC **are used** as measures relating to the following ceilings and **visibilities.**

(1) Visual **flight** rule (VFR) conditions occur whenever the **cloud** ceiling is at least 1,000 feet above **ground** level and the visibility is at least three statute miles.

(2) **Instrument** flight rule **(IFR)** conditions **occur** whenever the reported **cloud** ceiling is at least 500 feet but less than 1,000 feet and/or Visibility is at least one statute mile but less than three statute miles.

(3) Poor visibility and ceiling (PVC) conditions exist whenever the **cloud** ceiling is less than 500 feet and/or the visibility is less than one statute **mile.**

e. **Delay.** Delay is the difference between constrained and unconstrained operating **time.**

   f. <u>Demand</u>. Demand is the magnitude of aircraft operations to be accammodated in a specified time period.

   g. <u>Gate.</u> A gate is an aircraft parking position used by a single aircraft loading **or unloading** passengers, mail, **cargo,** etc. A parking position which is regularly used by two aircraft at the **same time** is two gates for capacity calculations.

      (1) <u>Gate type</u> is the size of the gate. A **Type** 1 gate is capable of **accommodating** all aircraft, including **widebodies** such as the A-300, B-747, B-767, **DC-10,** L-1011. A **Type** 2 gate will **accommodate** only non-widebodied aircraft.

      (2) <u>Gate mix</u> is the percent of non-widebodied aircraft accommodated by the gate group.

      (3) <u>Gate **occupancy time is**</u> the length of time required to cycle an aircraft through the gate.

   h <u>Mix Index</u>. Mix index is a mathematical expression. It is the percent of Class C' aircraft plus **3 times** the percent of Class D aircraft, and is written: **%(C+3D).**

   i <u>Percent Arrivals (PA)</u>. The percent of arrivals is the ratio of arrivals to total operations and **is computed** as **follows:**

$$\text{Percent arrival8} = \frac{A+\frac{1}{2}(T\&G)}{A+DA+(T\&G)} \times 100, \text{ where}$$

   A = number of arriving aircraft in the hour
   DA = number of **departing** aircraft **in** the **hour**
   T&G = number of **touch** and **go's** in the hour

   j. <u>Percent Touch and **Go's.**</u> **The percent** touch and **go's** is the ratio of landings with an immediate takeoff to total operations and is cauputed as folluws:

$$\textbf{Percent} \text{ touch and go'8} = \frac{(T\&G)}{A+DA+(T\&G)} \times 100, \text{ where}$$

   A = number of arriving aircraft in the hour
   DA = number of departing aircraft in the hour
   T&G = number of touch and **go's** in the haur

Touch and go operations are normally associated with flight training. The number of these operations usually decreases as the number of air carrier operations increase, as demand for service approaches runway capacity, or as weather conditions deteriorate.

   k. <u>Runway-use Configuration</u>. **Runway-use** configuration is the number, **location,** and orientation of the active runway(s) , the type and direction of operations , and the flight rules in effect at a particular **time.**

1-4. <u>CAPACITY, **DEMAND,** DELAY RELATIONSHIPS</u>,   **As** demand approaches capacity, **indivi-** dual aircraft de&y is increased.   Successive hourly demands exceeding the **hourly** capacity result in unacceptable delays.   **When** the hourly demand is **less** than the hourly capacity, aircraft delays will still **occur** if the demand within a **portion** of the time interval exceeds the capacity during that interval, Because the magnitude and scheduling of user demand **is** relatively unconstrained, reductions in aircraft delay can best be achieved **through** airport improvements which increase capacity.

CHAPTER 2. CAPACITY AND DELAY CALCULATIONS FOR LONG RANGE PLANNING

2-1.   GENERAL. This chapter contains calculations for determining hourly airport capacity, ASV, and aircraft delay for long-range airport planning. Appendix 1 contains examples of these calculations. When more precise results are required, or if the conditions differ significantly from the assumptions described in the following paragraphs, apply the calculations found in subsequent chapters.

2-2.   CAPACITY ASSUMPTIONS. Hourly VFR and IFR values in figure 2-1 are based on runway utilizations which produce the highest sustainable capacity consistent with current ATC ties and practices. These values are representative of typical U.S. airports having similar runway-use configurations. VFR and IFR hourly airport capacities in figure 2-l are based on the following assumptions:

a.   Runway-use Configuration. Any runway layout can be approximated by one of the 19 depicted runway-use configurations. Multiple arrival streams are only to parallel runway configurations.

b.   Percent Arrivals. Arrivals equal departures.

c.   Percent Touch and Go's. The percent of touch and go's is within the ranges in table 2-1.

d.   Taxiways. a full-length parallel taxiway, ample runway entrance/exit taxiways, and no taxiway crossing problems.

e.   Airspace Limitations There are no airspace limitations which would adversely impact flight operations or otherwise restrict aircraft which could operate at the airport. Missed approach protection is assured for all converging operations in IFR weather conditions.

f.   Runway Instrumentation   The airport has at least one runway equipped with an ILS and has the necessary ATC facilities and services to carry but operations in a radar environment. For independent operations, 3,400 feet separation requires Precision Runway Monitor (PRM) equipment with high update radar. If PRM equipment is not available, independent operations will require 4,300 feet separation.

Table 2-1. Assumptions incorporated in figure 2-l

Mix Index %(C+3D)	Percent Arrivals	Percent Touch & Go	Demand Ratios	
			$\dfrac{\text{Annual Demand}}{\text{Av. Daily Demand*}}$	$\dfrac{\text{Av. Daily Demand*}}{\text{Av. Peak Hour Demand*}}$
0-20	50	0-50	290	9
2 1-50	"	0-40	300	10
5 1-80	"	0-20	310	11
81-120	"	0	320	12
121-180	"	0	350	14

* In the peak month

2-3.   ASV ASSUMPTIONS. The ASV values in figure 2-l are based on the assumptions of paragraph 2-2, table 2-1, and the following:

a.   Weather. VFR weather conditions occur roughly 10 percent of the time.

b.   **Runway-use Configuration** Roughly 80 percent of the time the airport is operated with the runway-use configuration which produces the greatest hourly capacity.

2-4.   AIRPORT CAPACITY AND ANNUAL SERVICE VOLUME. Calculate the approximate hourly capacities and the ASV as follows:

a.   Determine the percentage of aircraft classes C and D using, or expected to use, the airport.

b   Select the runway-use configuration from figure 2-1 that best represents the airport. Runway-use configurations 9 through 19 show by means of arrows the predominant direction of runway operations. When no direction is specified, the direction of operation is not critical. Runway-use configurations 14 through 19 indicate by dashed lines the limit of the range of runway orientation. For airports having three or more runway orientations (consider parallel runways as one runway orientation), identify the two-runway orientation that is operated most frequently. To adjust for staggered thresholds see paragraph 4-6.

c.   Calculate the mix index.

d.   Read the approximate VFR and IFR hourly capacities and the ASV directly from figure 2-1.

2-5.   AIRCRAFT DELAY. Calculate the aircraft delay as follows:

a.   Estimate annual demand using current or historical information or projections of future traffic.

b.   Calculate the ratio of annual demand to ASV.

c.   Obtain average delay per aircraft from figure 2-2. The upper portion of the band applies to airports where air carrier operations dominate. The full width of the band applies to airports where general aviation operations dominate. Delays 5 to 10 times average could be experienced by individual aircraft.

d.   **Calculate** total annual aircraft delay as the average delay multiplied by the annual demand.

2 6   AIRPORT DESIGN COMPUTER MODEL. The Airport Design Computer Model capacity and delay outputs are the 'same as those obtained from this chapter. The computer model covers the same runway-use configurations and traffic mixes as figure 2-1.

a.   **Entry Data** computer model requires the following:

(I)   The percentage of operations by aircraft weighing more than 12,500 pounds but less than 300,000 pounds with respect to the total number of aircraft operations.

(2)   The Percentage of operations by aircraft weighing more than 300,000 pounds with respect to the total number of aircraft operations.

(3)   The targeted level of annual operations (the demand).

(4)   The predominate operations (either air carrier or general aviation).

b.   **Output**. The Airport Design model lists the runway-use configurations in rank order of capacity and least delay. Other considerations (project costs and/or land availability) may preclude the selection and development of the highest ranking runway-use configuration (normally configuration No. 8). Table 2-2 illustrates a typical airport capacity and delay printout.   Figure A5-13 illustrates a printout of the runway-use configuration sketches.

Table 2-2. Typical airport capacity and delay printout

AIRPORT CAPACITY AND DELAY DATA

```
C =  Percent of airplanes over 12,500 lbs but not over 300,000 lbs .        55
D =  Percent of airplanes over 300,000 lbs . . . . . . . . . . . . . .        4
Mix Index (C+3D) . . . . . . . . . . . . . . . . . . . . . . . . .        67
Annual demand . . . . . . . . . . . . . . . . . . . . . . . . . . 220,000
Air carrier operations dominate
```

AIRPORT CAPACITY AND DELAY FOR LONG RANGE PLANNING

Runway-use Configuration (Sketch) No.	Capacity (Ops/Hour) VFR	IFR	ASV	Ratio of Annual Demand to Asv Ratio	Average Delay per Aircraft (Minutes) Low	High	Minutes of Annual Delay (000) Low	High
8	242	111	515,000	0.43	0.3	0.4	66	88
7	184	111	455,000	0.48	0.3	0.5	66	110
4	126	111	305,000	0.72	0.7	1.1	154	242
12	126	111	305,000	0.72	0.7	1.1	154	242
6	184	65	290,000	0.76	0.8	1.2	176	264
5	171	65	285,000	0.77	0.9	1.3	198	286
3	126	65	275,000	0.80	1.0	1.5	220	330
11	126	65	275,000	0.80	1.0	1.5	220	330
16	164	56	275,000	0.80	1.0	1.5	220	330
18	164	56	275,000	0.80	1.0	1.5	220	330
19	158	56	275,000	0.80	1.0	1.5	220	330
13	145	56	270,000	0.81	1.0	1.5	220	330
2	121	56	260,000	0.85	1.1	1.7	242	374
10	121	56	260,000	0.85	1.1	1.7	242	374
17	121	56	260,000	0.85	1.1	1.7	242	374
14	85	56	220,000	1.00	2.3	3.5	506	770
15	82	56	215,000	1.02	2.6	4.0	572	880
9	77	56	215,000	1.02	2.6	4.0	572	880
1	63	56	205,000	1.07	3.6	5.7	792	1254

2-7. COST OF AIRCRAFT DELAYS A major factor which influences a decision to proceed with a project is the benefit versus the cost of the improvement: The airport capacity and aircraft delay computations operate on the premise that individual aircraft within the broad aircraft classes A, B, C, and D (See table 1-1) have comparable service times. A cost computation however requires a more refined breakdown of aircraft types and usages.

a. Delay Costs. The per minute costs of figure A5-12 are conservative estimates and are based on the best data currently available. The costs represent a reasonable estimate of crew, fuel and maintenance costs for operators of air carrier and air taxi aircraft, and fuel and maintenance costs for operators of general aviation aircraft. Other data sources may be used in the calculation of savings. When other data sources are used, document the data source as well as the rationale used to allocate delay savings among the cost classes being identified.
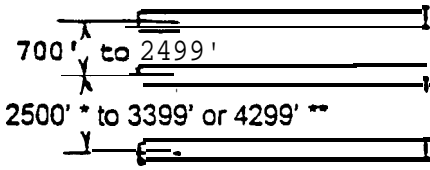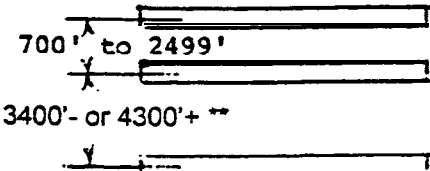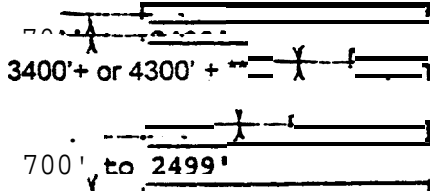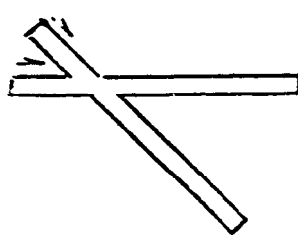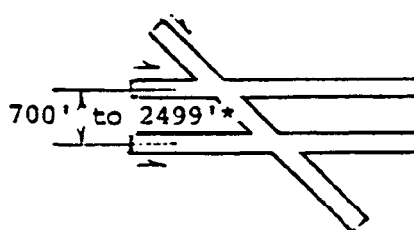
b. Estimating Savings. Appendix 1 contains an example for calculating the savings associated with the reduced aircraft delays based on the figure A5-12 aircraft groupings and estimates of delay costs. Figure A5-12 is the form used in this calculation.

NO.	Runway-use Configuration	Mix Index %(C+3D)	Hourly Capacity Ops/Hr VFR	Hourly Capacity Ops/Hr IFR	Annual Service Volume Ops/Yr
1.		0 to 20	98	59	230,000
		21 to 50	74	57	195,000
		51 to 80	63	56	205,000
		81 to 120	55	53	210,000
		121 to 180	51	50	240,000
2.	700' to 2499'*	0 to 20	197	59	355,000
		21 to 50	145	57	275,000
		51 to 80	121	56	260,000
		81 to 120	105	59	285,000
		121 to 180	94	60	340,000
3.	2500' * to 3399' or 4299' **	0 to 20	197	62	355,000
		21 to 50	149	63	285,000
		51 to 80	126	65	275,000
		81 to 120	111	70	300,000
		121 to 180	103	75	365,000
4.	3400'+ or 4300'+	0 to 20	197	119	370,000
		21 to 50	149	113	320,000
		51 to 80	126	111	305,000
		81 to 120	111	105	315,000
		121 to 180	103	99	370,000
5.	700' to 2499' 700' to 2499'	0 to 20	295	62	385,000
		21 to 50	213	63	305,000
		51 to 80	171	65	285,000
		81 to 120	149	70	310,000
		121 to 180	129	75	375,000

* **Staggered** threshold adjustments may apply, see paragraph 4-6.
** Refer to paragraph 2-2.f.
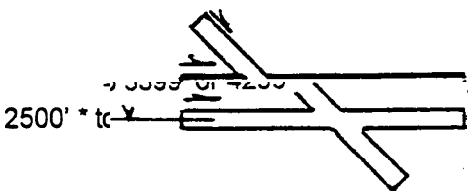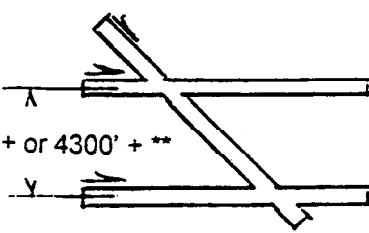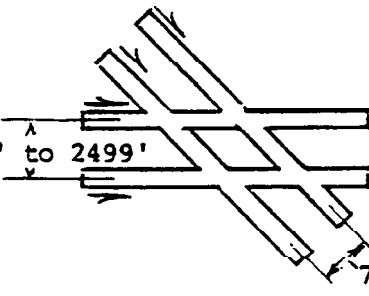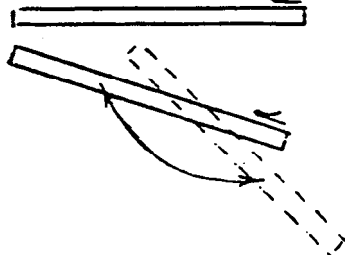
Figure 2-1. Capacity and ASV for long range planning

		Mix Index	Hourly Capacity Ops/Hr		Annual Service Volume
No.	Runway-use Configuration	%(C+3D)	VFR	IFR	Ops/Yr
6.	700' to 2499' 2500' * to 3399' or 4299' **	0 to 20	295	62	385,000
		21 to 50	219	63	310,000
		51 to 80	184	65	290,000
		81 to 120	161	70	315,000
		121 to 180	146	75	385,000
7.	700' to 2499' 3400'- or 4300'+ **	0 to 20	29s	119	625,000
		21 to 50	219	114	475,000
		51 to 80	184	111	455,000
		81 to 120	161	117	510,000
		121 to 180	146	120	645,000
8.	3400'+ or 4300' + ** 700' to 2499'	0 to 20	394	119	715,000
		21 51 to to 50	290	114	550,000
			242	111	515,000
		81 to 120	210	117	565,000
		121 to 180	189	120	675,000
9.		O to 20	98	59	230,000
		21 to 50	77	57	200,000
		51 to 80	77	56	215,000
		81 to 120	76	59	225,000
		121 to 180	72	60	265,000
10.	700' to 2499'*	0 to 20	197	59	355,000
		21 to so	14s	57	275,000
		51 to 80	121	56	260,000
		81 to 120	105	59	285,000
		121 to 180	94	60	340,000

* Staggered threshold adjustments may apply, see paragraph 4-6.

** Refer to paragraph 2-2.f.

Figure 2-1 .Capacity and ASV for long range planning (cont.)

No.	Runway-use Configuration	Mix Index %(C+3D)	Hourly Capacity Ops/Hr VFR	Hourly Capacity Ops/Hr IFR	Annual S&vice Volume Ops/Yr
11.		0 to 20	197	62	355,000
		21 to so	149	63	285,0C0
		51 to 80	126	65	275,000
			111	70	300,000
		121 81 to to 120 180	103	75	365,000
12.		0 to 20	197	119	370,000
		21 to so	149	114	320,000
		51 to 80	126	111	305,000
		81 to 120	111	105	315,000
		121 to 180	103	99	370,000
13.		0 to 2 0	197	59	355,000
		21 to 50	147	57	275,000
		51 to 80	145	56	270,000
		81 to 120	138	59	295,000
		121 to 180	125	60	350,000
14.		0 to 20	150	59	270,000
		21 to 50	108	57	225,000
		51 to 80	85	56	220,000
		81 to 120	·77	59	225,000
		121 to 180	73	60	265,000
15.		0 to 2 0	132	59	260,000
		21 to so	99	57	220,000
		51 to 80	82	56	215,000
		81 to 120	77	59	225,000
		121 to 180	73	60	265,000

2500' * tc

3400' + or 4300' + **

700' to 2499'

700' to 2499'

* Staggered threshold adjustments may apply, see paragraph 4-6.
** Refer to paragraph 2-2.f.

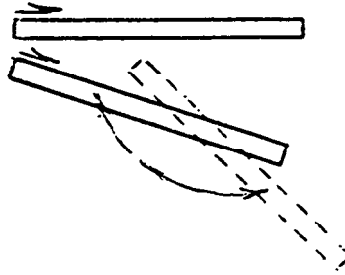Figure 2-I. Capacity and ASV for long range planning (cont.)

No.	Runway-use Configuration	Mix Index %(C+3D)		Hourly Capacity Ops/Hr VFR	IFR	Annual Service Volume Ops/Yr
16.	700' to 2499'	O to	20	295	59	**385,000**
		21 to	so	**210**	**57**	305,000
		51 **to**	80	164	**56**	275,000
		81 to	**120**	**146**	59	300,000
		121 to	180	129	60	**355,000**
17.	700' to 2499'	0 to	20	197	**59**	**355,000**
		21 to	so	14s	57	275,000
		51 to	80	**121**	**56**	260,000
		81 to	120	10s	**59**	285,000
		121 to	180	94	60	340,000
18.	**700' to 2499'**	**0 to**	**20**	301	59	385,000
		21 to	**50**	210	57	305,000
		51 to	**80**	164	56	275,000
		81 to	**120**	146	59	300,000
		121 to	**180**	**129**	60	**355,000**
	700' to 2499'					
19.	**700' to 2499'**	**0 to**	20	264	59	375,000
		21 to	so	193	57	295,000
		51 to	80	**158**	56	275,000
		81 to	120	146	**59**	300,000
		121	180	129	60	**355,000**
	700' to 2499'					

Figure **2-1.** Capacity and **ASV** for long range planning (cont.)

RATIO OF ANNUAL DEMAND TO ANNUAL SERVICE VOLUME
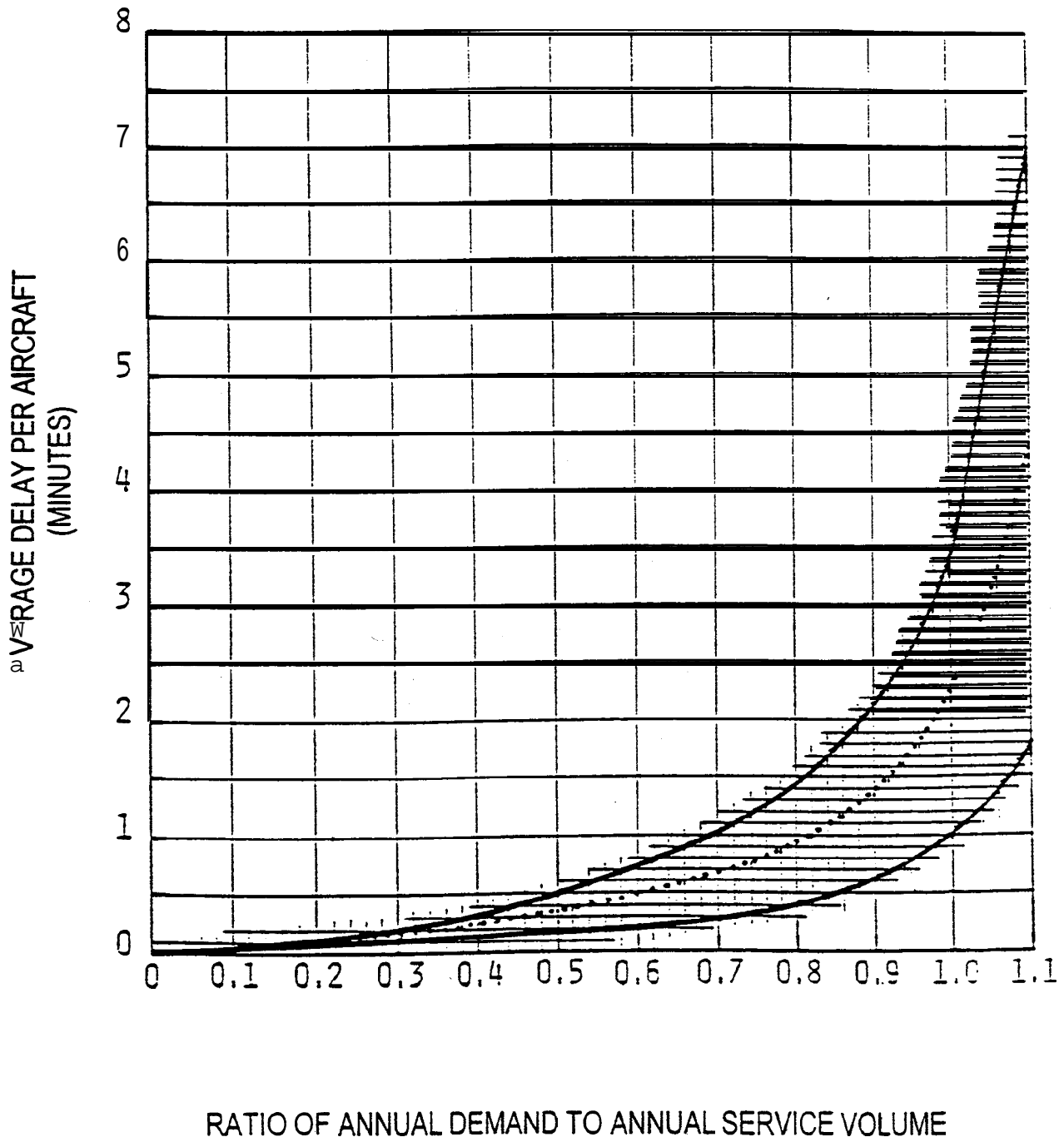
Figure 2-2. Average aircraft delay for long range planning

CHAPTER 3. AIRPORT CAPACITY AND AIRCRAFT DELAY CALCULATIONS

3-1. GENERAL. This chapter contains instructions for calculating hourly capacity, **ASV,** and aircraft delay for a wide range of runway-use configurations and operational alternatives.

    a. Capacity Calculations.

        (1) Hourly capacity of the runway component.
        (2) Hourly capacity of the **taxiway** canponent.
        (3) **Hourly** capacity of gate group **components.**
        (4) Airport hourly capacity.
        (5) ASV.

    b. Delay Calculations.

        (1) Hourly delay.
        (2) Daily delay.
        (3) Annual delay.

Figure 3-1 provides a checklist of the data required **for** these calculations. Appendix 2 contains examples of these calculations.

3-2. HOURLY CAPACITY OF THE RUNWAY COMPONENT. Except for situations involving PVC conditions, an absence of radar coverage or **ILS,** and airports with parallel runways when one runway is limited to use by **small** aircraft (all of which are covered in chapter **4),** calculate the runway component hourly capacity as follows:

    a. Select the runway-use configuration in figure 3-2 which best represents the use of the airport during the hour **of** interest. To adjust for staggered thresholds, see paragraph 4-6.

    b. Identify fraa figure 3-2 the figure number for capacity (for C^*, T, and E).

    c. Determine the percentage of Class C and D aircraft operating on the runway **component** and calculate the mix index.

    d. Determine percent arrivals (PA).

    e. Determine haurly capacity base **(C*).**

    f. **Determine** the percentage of **touch** and go operations during **VFR** operations and **determine** the touch and go factor **(T).** During IFR operations, **T** will be 1.00.

    g. Determine the location of exit **taxiways** (measured from the **threshold** at the **approach** end of the runway) and determine the exit factor **(E).**

    h. Calculate the hourly capacity of the runway **component** by the following equation:

$$\text{Hourly capacity of the runway component} = C^* \cdot T \cdot E$$

OUTPUT	INPUT NEEDED
1. **Hourly** capacity of runway **component** See: paragraph 3-2 appendix 2 (figure **A2-1**)	a. Ceiling and visibility (VFR, IFR, or **PVC**) b. **Runway-use** configuration c. Aircraft mix d. Percent arrivals e. Percent **touch** and go f. **Exit taxiway** locations
2. Hourly capacity of **taxiway** component See: paragraph 3-3 appendix 2 (figure **A2-2**)	a. Intersecting **taxiway location** b. **Runway** operations rate c. Aircraft mix on runway being crossed
3. Hourly capacity of gate group components See: paragraph 3-4 appendix 2 (figure **A2-3**)	a. Number and type of gates in each **gate group** b. Gate mix c. Gate occupancy times
4. Airport hourly capacity See: paragraph 3-5 appendix 2 (figure **A2-4**)	Capacity outputs from 1, 2, and **3** above
5. Annual service volume See: paragraph 3-6 appendix **2** (figure **A2-5**)	a. **Hourly** capacities of runway **component** b. **Occurence** of operating conditions
6. Hourly delay to aircraft on rummy component See: paragraph 3-7 appendix 2 (figure A2-6)	a. **Hourly** demand b. **Hourly** capacity of the runway **component** c. **Demand** profile factor
7. Daily delay to aircraft on rummy **component** See: paragraphs 3-8 and 3-9 appendix **2** (figure8 **A2-7,** and **A2-8)**	a. **Hourly** delay b. **Hourly** demand c. Hourly capacity
8. Annual delay to aircraft **on runway component** See: paragraph 3-10 appendix 2 (figure **A2-9)**	a. Annual demand b. **Daily** delay c. Hourly demand d. Hourly capacities e. **Percent VFR/IFR** conditions f. **Runway-use** configuration

Data Sources:
National Climatic **Center, Asheville, North** Carolina
Air Traffic **Control Tower records**
Offical Airline Guides
Airport Management
Observations

Figure **3-1.** Information **required for capacity** and **delay calculations**

3-3. HOURLY CAPACITY OF THE TAXIWAY COMPONENT. Calculate the hourly capacity of a taxiway component as follows:

    a. Determine the distance **from** the runway end (start of takeoff roll) **to the taxiway crossing.**

    b. Determine the runway operations **rate, i.e.,** the demand being accommodated on the runway being crossed.

    c. Calculate the mix index **of the** runway being crossed.

    d. Determine the hourly capacity of the **taxiway** crossing.

       (1) **Use** figure 3-66 when the crossed runway accommodates arrivals or mixed operations.

       (2) Use figure 3-67 when the crossed runway accommodates only departures and touch and **go's.**

3-4. HOURLY CAPACITY OF GATE GROUP COMPONENTS. Calculate the hourly gate group capacities as follows:

    a. Determine the number of gate groups and the number of gates in each gate **group.**

    b Determine the gate mix, **i.e.,** the percent of non-widebadied aircraft using each gate group.

    c. Determine the percentage of gates in each gate group that can accommodate widebodied aircraft.

    d. Determine for each gate group the average gate occupancy time for **wide**bodied **and** non-widebodied aircraft.

    e. When widebodied aircraft are served, calculate the gate occupancy ratio **(R)** by the following equation:

$$R = \frac{\text{Average gate occupancy time for widebodied aircraft}}{\text{Average gate occupancy time for non-widebodied aircraft}}$$

When widebodied aircraft are not served, **R** equals 1.00.

    f. Calculate the hourly capacity of each gate group by use of figure 3-68.

3-5. AIRPORT HOURLY CAPACITY. Calculate the airport hourly capacity as follows:

    a. Calculate the hourly capacities of the runway, **taxiway,** and gate **groups** components and determine the hourly demands on each.

    b. Calculate the demand ratio for each cauponent by dividing the component demand **by** the runway component demand.

c.   Calculate the component quotients by dividing each **components** capacity by its demand ratio.

d   Identify the airport hourly capacity, **i.e.,** the lowest quotient calculated in c above.

3-6.   ANNUAL SERVICE VOLUME (ASV).   Calculate the ASV as follows:

a.   Calculate the. weighted hourly capacity **(C_w)** for the runway **component** as follows:

(1)   Identify the different runway-use configurations used over the course of a year.

(2) Determine the percent of **time** each runway-use configuration is in **use (P_1** through **P_n).**   Include those times when the hourly capacity is zero, i.e., the weather conditions are below airport minimums or the airport is closed for other reasons.   If a runway-use configuration is used less than 2 percent of the time, that time **may** be credited to another runway-use configuration.

(3) Calculate the hourly capacity for each runway-use configuration **(C_1** through **C_n).**

(4)   Identify the runway-use configuration that provides the maximum capacity.   Generally, this configuration is also the configuration most frequently used.

(5) Divide the hourly capacity of each runway-use configuration by the hourly capacity of the runway-use configuration that provides the **maximum** capacity.

(6) Determine the **ASV** weighting factor **(W_1 through** Wn) for each **runway-**use configuration from Table 3-1.

Table 3-1.   ASV **Weighting** Factors

Percent of **Maximum** capacity	**Weighting** Factors			
	VFR	**IFR**		
		Mix Index (0—20)	**Mix Index (21—50)**	**Mix Index (51—180)**
91+	**1**	**1**	**1**	**1**
E1-90	**5**	1	3	**5**
66—80	15	2	8	15
51—65	**20**	**3**	**12**	**20**
0-50	25	**4**	16	25

(7) Calculate the weighted hourly capacity (C_w) of the runway component by the following equation:

$$C_w = \frac{(P_1 \cdot C_1 \cdot W_1) + (P_2 \cdot C_2 \cdot W_2) + \ldots + (P_n \cdot C_n \cdot W_n)}{(P_1 \cdot W_1) + (P_2 \cdot W_2) + \ldots + (P_n \cdot W_n)}$$

b. Calculate the ratio of annual demand to average daily demand during the peak month (D). Typical annual demand to average daily demand ratios are provided in table 3-2.

c. Calculate the ratio of average daily demand to average peak hour demand during the peak month (H). Typical average daily to average peak hour demand ratios are provided in table 3-2.

Table 3-2. Typical Demand Ratios

Mix Index	Daily (D)	Hourly (H)
0-20	280-310	7-11
21-50	300-320	10-13
51-180	310-350	11-15

d. Calculate ASV by the following equation:

$$ASV = C_w \cdot D \cdot H$$

3-7. **HOURLY DELAY TO AIRCRAFT ON THE RUNWAY COMPONENT.** Hourly delay calculations described in this paragraph apply to those hours when the hourly demand does not exceed the hourly capacity of the runway component. For those hours when the hourly demand exceeds the hourly capacity of the runway component, paragraph 3-9 calculations apply. Calculate hourly delay as follows:

a. Calculate the hourly capacity of the runway component for the specific hour of interest.

b. Identify from figure 3-2 the figure number for delay (for the arrival delay index (ADI) and the departure delay index (DDI)).

c. Identify the hourly demand (HD) and the peak 15 minute demand (Q) on the runway component.

d. Calculate the ratio of hourly demand to hourly capacity (D/C).

e. Determine the arrival delay index (ADI) and departure delay index (DDI).

    f   Calculate the arrival delay factor (ADF) and departure delay factor (DDF) by the f&owing equations:

$$ADF = ADI \cdot (D/C)$$

$$DDF = DDI \cdot (D/C)$$

    g. Calculate the demand profile factor (DPF) by the **following** equation:

$$DPF = \frac{100 \; Q}{HD}$$

NOTE: **Airports with a high** percentage **of air carrier activity** normally **have** a **DPF of 50 percent.** Airports with a high percentage **of general** aviation activity normally **have a DPF in** the **30** to 35 percent range.

    h **Calculate the average delay for arriving aircraft (DAHA) and** departing aircraft. **(DAHD)** figure 3-69.

    i. **Calculate hourly delay** (DTH) **by the following equation:**

$$DTH = HD(PA \cdot DAHA + (100-PA) \cdot DAHD)/100$$

3-8. <u>DAILY DELAY TO **AIRCRAFT** ON THE **RUNWAY** COMPONENT WHEN **THE** D/C RATIO IS **1.0** OR LESS **FOR EACH HOUR.**</u> Calculate the daily delay as **follows:**

    a. **For each hour, calculate the hourly delay to aircraft on the runway** component.

    b. **Calculate the delay for the time period in question by summing the delay for each of the hours.**

3-9. <u>DAILY DELAY **TO** AIRCRAET ON THE **RUNWAY** COMPONENT WHEN **THE** D/C RATIO IS **GREATER** THAN 1.0 FOR ONE OR **MORE** HOURS.</u> **Calculate the daily delay as follows:**

    a. **Identify the saturated time** periods. **A saturated period consists of** the consecutive hours when demand exceeds capacity (termed the overload phase) plus the subsequent hour(s) **required to** accommodate **the residual demand (termed the recovery phase).**

    b. **For each saturated period** (overload plus recovery phase) , calculate the delay to **aircraft as follows:**

        (1) **Determine the duration of the overload phase.**

        (2) **Calculate the hourly AD/C ratio during the overload** phase, **i.e., the** sum of the hourly **demands during the overload** phase **divided by the sum of the hourly capacities during the overload phase.**

        (3) Determine the percent of arrivals (PAS) for the saturated (overload plus **recovery) period.**

        (4) Determine **the ADI and the DDI** for **the saturated** (overload plus **recovery)** period.

(5) Calculate the arrival delay factor **(ADF)** and departure delay factor **(DDF)** using the following equations:

$$\text{ADF} = \text{ADI} \cdot (\text{AD/C})$$

$$\text{DDF} = \text{DDI} \cdot (\text{AD/C})$$

(6) Determine the average delay per arrival (DASA) and per departure (DASD) during the saturated (overload plus recovery) period from figure 3-70.

(7) Calculate the delay in the saturated period **(DTS)** by the **following** equation:

$$\text{DTS} = (\text{HD}_1 + \text{HD}_2 + \ldots + \text{HD}_n) \cdot (\text{PAS} \cdot \text{DASA} + (100 - \text{PAS}) \text{DASD})/100, \text{ where}$$

HD_1 through HD_n = Hourly demand during hours 1 through n of the saturated period.

c. Determine for each unsaturated hour the delay in accordance with the procedures in paragraph **3-8.**

d   Calculate the total daily delay by summing the saturated and unsaturated delay;.

3-10.   ANNUAL DELAY TO AIRCRAFT ON THE RUNWAY COMPONENT. The following procedure uses 24 representative days, one VFR and one IFR for each **calander** month.   Other increments of time may be selected.   If the airport has considerable fluctuation in **operations** during the week, or if a more precise delay determination is needed, one representative VFR and one representative **IFR** day should be used for each day of the week.   Variation in seasonal traffic will require repetition of these computations for each season.   Airports which have consistent patterns of **operations** throughout the week and year require fewer computations.

a.   Convert annual demand to average day demand for each month.

(1) Distribute the annual demand to the 12 calendar months to account for seasonal variations in traffic.

(2) **Develop** average day demand by dividing the monthly demands by the number of days in the respective month.

b   Adjust the average day demand to account for differences in VFR and **IFR** demand..

(1) Determine from **weather** records the percent of the time that **IFR** and PVC operating conditions prevail **(%IFR).**

(2) Determine **from** traffic records the percent IFR (and PVC) demand to VFR demand **(%IFR** demand).

(3) Calculate the representative VFR day demand (VFR demand) and representative IFR day demand (IFR demand) by the following equations:

$$\text{VFR demand} = \frac{\text{(Average day demand)}}{1-\%\text{IFR}(1-\%\text{IFR demand}/100)/100}$$

$$\text{IFR demand} = \text{VFR demand} \cdot \%\text{IFR demand}/100$$

    c. From historical data, develop a breakdown of hourly demand for the representative day(s).

    d. Calculate the representative daily delays.

    e. Determine monthly delay by multiplying the representative daily delays by the number of days it represents and summing these quotients.

    f. Sum the monthly delays.

3-11. **HOURLY DEMAND CORRESPONDING TO A SPECIFIED LEVEL OF AVERAGE HOURLY DELAY.**
Determine the hourly demand which corresponds to a stipulated average level of delay by trial and error, i.e., using a graphical plotting of delay versus demand.

Figure 3-2. Runway-use diagrams

LEGEND

⊬▭ IDENTIFIES THAT THE RUNWAY IS USED FOR ARRIVALS

▭⊦ IDENTIFIES THAT THE RUNWAY IS USED FOR DEPARTURES

S   IDENTIFIES A VARIABLE RUNWAY SPACING

C   IDENTIFIES A RUNWAY SPACING OF 700 TO 2499 FEET

X,Y IDENTIFIES INTERSECTION DISTANCES

θ   IDENTIFIES THE ANGLE BETWEEN NONPARALLEL RUNWAYS

N.A. MEANS NOT APPLICABLE

<   INDICATES "LESS THAN"

≥   INDICATES "GREATER THAN OR EQUAL TO"

*   SEE NOTES ITEM NO. 3

SEE CHAPTER 4 FOR CASES WHEN AIRCRAFT ARE RESTRICTED FROM USING ONE, OR MORE, OF THE RUNWAYS.

HOURLY CAPACITY BASE C*

HOURLY CAPACITY BASE (C*) (OPERATIONS PER HOUR)

PERCENT ARRIVALS — 40, 50, 60

MX INDEX -- PERCENT (C+3D)

TOUCH & GO FACTOR T

Percent Touch & Go	Mix Index--Percent (C+3D)	TOUCH & GO FACTOR T
0	0 to 180	1.00
1 to 10	o to 70	1.04
11 to 20	o to 70	1.10
21 to 30	o to 40	1.20
31 to 40	o to 10	1.31
41 to 50	o to 10	1.40

$$C^* \times T \times E = \text{Hourly Capacity}$$

EXIT FACTOR E

To determine Exit Factor E:

1. Determine exit range for appropriate mix index from table below
2. For arrival runways, determine the average number of exits(N) which are: (a) within appropriate exit range, and (b) separated by at least 750 feet
3. If N is 4 or more, Exit Factor = 1.00
4. If N is less than 4, determine Exit Factor from table below for appropriate mix index and percent arrivals

Mix Index--Percent (C+3D)	Exit Range (Feet from threshold)	40% Arrivals			50% Arrivals			60% Arrivals		
		N-O	N=1	N-2 or 3	N-O	N=1	N-2	N-O	N=1	N-2 or 3
0 to 20	2000 to 4000	0.72	0.87	0.94	0.70	0.86	0.94	0.67	0.84	0.92
21 to 50	3000 to 5500	0.79	0.86	0.94	0.76	0.84	0.93	0.72	0.81	0.90
51 to 80	3500 to 6500	0.79	0.86	0.92	0.76	0.83	0.91	0.73	0.81	0.90
81 to 120	5000 to 7000	0.82	0.89	0.93	0.80	0.88	0.94	C.77	0.86	0.93
121 to 180	5500 to 7500	0.86	0.94	0.98	0.82	0.91	0.96	0.79	0.91	0.97

FIGURE 3-3. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NOS.: 1,54 FOR VFR CONDITIONS.

HOURLY CAPACITY BASE C*

HOURLY CAPACITY BASE (C*) (OPERATIONS PER HOUR)

PERCENT ARRIVALS — 40, 50, 60

MX INDEX -- PERCENT (C+3D)

TOUCH & GO FACTOR T

$$T = 1.00$$

$$C^* \times T \times E = \text{Hourly Capacity}$$

EXIT FACTOR E

To determine Exit Factor E:

1. Determine exit range for appropriate mix index from table below
2. For arrival runways, determine the average number Of exits(N) which are: (a) within appropriate exit range, and (b) separated by at least 750 feet
3. If N is 4 or more, Exit Factor = 1.00
4. If N is less than 4, determine Exit Factor from table below for appropriate mix index and percent arrivals

Mix Index--Percent (C+3D)	Exit Range (Feet from threshold)	40% Arrivals			50% Arrivals			60% Arrivals		
		N=0	N=1	N=2 or 3	N=0	N=1	N=2 or 3	N=0	N=1	N=2 or 3
0 to 20	2000 to 4000	0.62	0.79	0.90	0.62	0.79	0.90	0.62	0.79	0.90
21 to 50	3000 to 5500	0.72	0.83	0.93	0.72	0.83	0.93	0.72	0.83	0.90
51 to 80	3500 to 6500	0.75	0.84	C.92	3.75	0.84	0.92	0.75	0.84	0.92
81 to 120	5000 to 1000	0.80	0.87	0.94	0.80	0.87	0.94	0.80	0.87	0.34
121 to 180	5500 to 7500	0.94	1.00	1.00	0.83	0.93	0.97	0.83	0.93	0.97

FIGURE 3-4. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NOS.: 2,72,73,87,88 FOR VFR CONDITIONS.

chap 3

HOURLY CAPACITY BASE C*

HOURLY CAPACITY BASE (C*) (OPERATIONS PER HOUR)

PERCENT ARRIVALS

40
50
60

MIX INDEX -- PERCENT (C+3D)

TOUCH & GO FACTOR T

Percent Touch & Go	Mix Index-- Percent (C+3D)	TOUCH & GO FACTOR T
0	0 to 180	1.00
1 to 10	0 to 70	1.03
11 to 20	0 to 70	1.05
21 to 30	0 to 40	1.09
31 to 40	0 to 10	1.15
41 to 50	0 to 10	1.20

C* x T x E = Hourly Capacity

EXIT FACTOR E

To determine Exit Factor E:

1. Determine exit range for appropriate mix Index from table below
2. For arrival runways, determine the average number of exits(N) which are: (a) within appropriate exit range, and (b) separated by at least 750 feet.
3. If N is 4 or more, Exit Factor = 1.00
4. If N is less than 4, determine Exit Factor from table below for appropriate nix index and percent arrivals

Mix Index-- Percent (C+3D)	Exit Range (Feet from threshold)	EXIT FACTOR E								
		40% Arrivals			50% Arrivals			60% Arrivals		
		N=0	N=1	N=2 or 3	N=0	N=1	N=2 or 3	N=0	N=1	N=2 or 3
0 to 20	2000 to 4000	0.62	0.79	0.90	0.62	0.79	0.90	0.62	0.79	0.90
21 to 50	3000 to 5500	0.72	0.83	0.93	0.72	0.83	0.93	0.72	0.83	0.93
51 to 80	3500 to 6500	0.75	0.84	0.92	0.75	0.84	0.92	0.75	0.84	0.92
81 to 120	5000 to 7000	0.80	0.87	0.94	0.80	0.87	0.94	0.80	0.87	0.94
121 to 180	5500 to 7500	0.85	0.96	0.98	0.83	0.93	0.97	0.83	0.93	0.97

FIGURE 3-5. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NO. 3 FOR VFR CONDITIONS.

'HOURLY CAPACITY BASE C*

HOURLY CAPACITY BASE (C*) (OPERATIONS PER HOUR)

PERCENT ARRIVALS

40
50
60

MIX INDEX -- PERCENT (C+3D)

TOUCH & GO FACTOR T

Percent Touch & Go	Mix Index-- Percent (C+3D)	TOUCH & GO FACTOR T
0	0 to 180	1.00
1 to 10	0 to 70	1.02
11 to 20	0 to 70	1.04
21 to 30	0 to 40	1.08
31 to 40	0 to 10	1.13
41 to 50	0 to 10	1.17

C* x T x E = Hourly Capacity

EXIT FACTOR E

To determine Exit Factor E:

1. Determine exit range for appropriate mix index from table below
2. For arrival runways, determine the average number of exits(N) which are: (a) within appropriate exit range, and (b) separated by at least 750 feet
3. If N is 4 or more, Exit Factor = 1.00
4. If N is less than 4, determine Exit Factor from table below for appropriate nix index and percent arrivals

Mix Index-- Percent (C+3D)	Exit Range (Feet from threshold)	EXIT FACTOR E								
		40% Arrivals			50% Arrivals			60% Arrivals		
		N=0	N=1	N=2 or 3	N=0	N=1	N=2 or 3	N=0	N=1	N=2 or 3
0 to 20	2000 to 4000	0.62	0.79	0.90	0.62	0.79	0.90	0.62	0.79	0.90
21 to 50	3000 to 5500	0.72	0.83	0.93	0.72	0.83	0.93	0.72	0.83	0.93
51 to 80	3500 to 6500	0.75	0.84	0.92	0.75	0.84	0.92	0.75	0.84	0.92
81 to 120	5000 to 7000	0.80	0.87	0.94	0.80	0.87	0.94	0.80	0.87	0.94
121 to 180	5500 to 7500	0.83	0.93	0.97	0.83	0.93	0.97	0.83	0.93	0.97

FIGURE 3-6. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NOS.: 4,57,74,75,89,90 FOR VFR CONDITIONS.
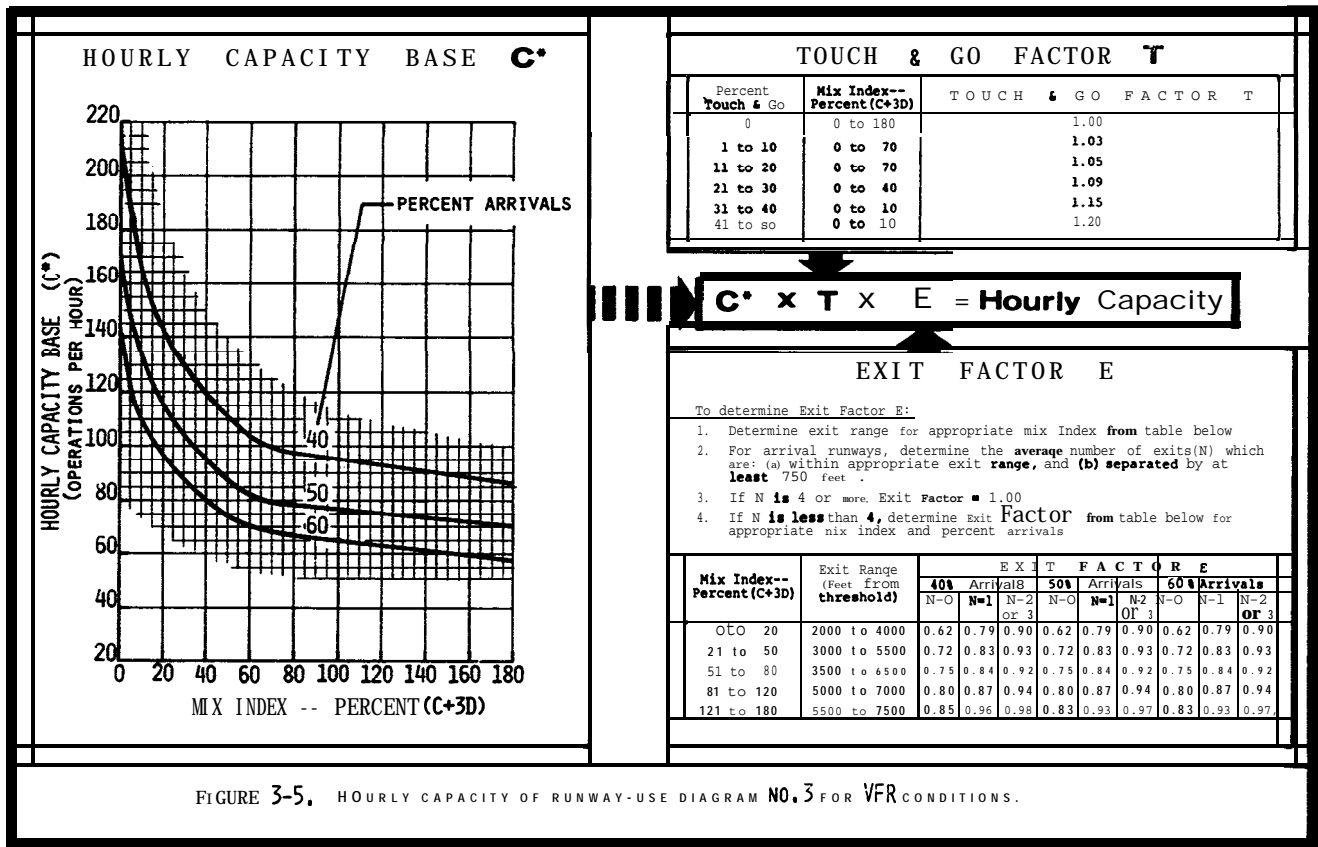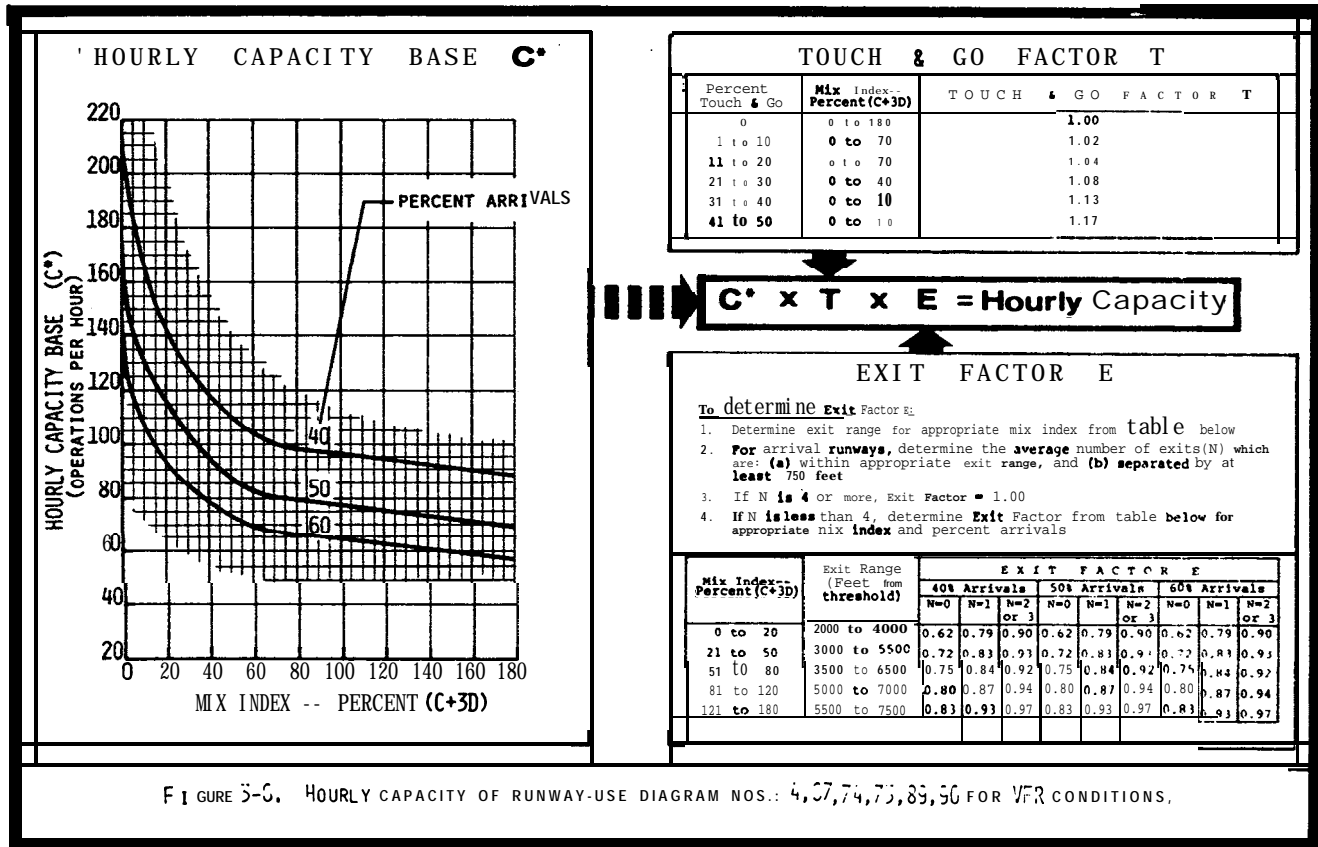
FIGURE 3-7. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NO. 5 FOR VFR CONDITIONS.

FIGURE 3-8. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NOS. 7, 8, 76, 91 FOR VFR CONDITIONS.