AIRPORT CAPACITY CRITERIA USED IN LONG-RANGE PLANNING

December 24, 1969

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

AC NO: 150/5060-3A
DATE: 12/24/69

ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

SUBJECT: AIRPORT CAPACITY CRITERIA USED IN LONG-RANGE PLANNING

1. PURPOSE. This circular makes available to the public the method used by the Federal Aviation Administration for determining the approximate practical hourly and practical annual capacities of various airport runway configurations. This information is used in long-range (ten years or more) planning for expansion of existing airports and construction of new airports to accommodate forecast demand.

2. CANCELLATION. This circular cancels AC 150/5060-3, Airport Capacity Criteria Used in Long-Range Planning, dated 7 April 1969.

3. REFERENCES. See Bibliography, Appendix 3.

4. BACKGROUND. Advisory Circular 150/5060-3 was issued on 7 April 1969 This revised edition, AC 150/5060-3A, is essentially the same in content as the original publication but the referencing of certain figures has been clarified and certain minor corrections have been made to the text.

   AC 150/5060-1A is the basic source document for this long-range approach, but the extended time period has caused a need for extension of certain assumptions and anticipation of some improvements in the post-1975 time period. Since demand forecasts are normally in five-year increments (i.e., 1970, 1975, 1980, etc.) and become less precise beyond the first five-year figures, a more simplified method for determining capacity in long-range studies is established herein. The accepted time frame for "long range" by planners is usually 15 or 20 years, but to remain consistent with standard forecast periods and logically carry beyond AC 150/5060-1A coverage, ten or more years is considered long range in this circular.

4. SCOPE. Airfield capacity in terms of aircraft operations may be determined from use of the material contained in this publication. Other implications of the term "capacity" as applied to airports such as the "capacity" of the terminal building, the automobile parking lot, the access road, etc., are not covered in this circular, but obviously will need to be analyzed in an overall airport planning study. The operational figures contained in this publication should be used in long-range airport planning analyses.

5. HOW TO GET THIS PUBLICATION. Additional copies of this circular may be obtained from Department of Transportation, Distribution Unit, TAD-484.3, Washington, D. C. 20590.

Clyde W. Pace, Jr.
Acting Director
Airports Service

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

1. INTRODUCTION. A simplified approach developed by the Federal Aviation Administration for determining the practical annual and hourly IFR (Instrument Flight Rule) and VFR (Visual Flight Rule) airfield capacities for airports is presented in this circular. As the demand forecasts for long-range planning (ten years or more) are less precise, the simplified technique outlined herein is acceptable for these forecast periods. A more detailed approach is already established in AC 150/5060-1A, Airport Capacity Criteria Used in Preparing the National Airport Plan, for use in short-range planning. The material contained in this circular was developed and simplified from the procedure and methods established in AC 150/5060-1A, but calculations have been modified where appropriate to account for system improvements anticipated in the post-1975 time period.

In this simplified approach there are 22 different configurations of runways pictorially displayed on Table 1. Four different aircraft groupings or "mixes" are listed for each configuration and the VFR and IFR practical hourly and practical annual capacities (PANCAP) are shown for each mix. The main assumptions used in arriving at these capacity calculations are shown in paragraph 2. By changing the assumptions (making wind percentage adjustments, changing percent of IFR and VFR weather, etc.), combining configurations and interpolating between mixes, Table 1 is adaptable to almost any individual airport situation. Likewise, many airports within a certain geographic area may be readily reviewed with Table 1 and long-range plans made to satisfy airfield capacity demands. To achieve the objective of airport planning, which is to ensure that adequate facilities are provided in a timely manner, construction must precede demand. Table 2 presents activity demand levels for advance planning purposes.

It is important to keep in mind that the calculations of "practical" capacities are based upon a reasonable or acceptable average delay level. An airport's runways may generally be considered to have reached capacity when delays to departures average four minutes during the normal two peak adjacent hours of the week. At specific runways used by small aircraft only, this departure delay level is two minutes for the peak hour of the week. Practical hourly capacities can be exceeded (during some saturated peak periods by as much as 25 percent) but the average delays during these periods will be increased beyond acceptable levels.

2. ASSUMPTIONS. The set of parameters established in developing Table 1 is listed below. While these assumptions may need to be adjusted for application to individual situations, they are reasonable for long-range planning.

a. Weather. An annual weather condition of 90 percent VFR and 10 percent IFR was assumed in calculating the weighted hourly capacity and PANCAP.

No reduction has been made to the capacity of any configuration in Table 1 to account for crosswinds in excess of 15 knots. That is, each configuration is considered to accommodate all winds. Examples 3 and 4 of paragraph 3 show how to account for wind variations. Operations are conducted in both directions unless otherwise shown.

The weighted hourly capacity was adjusted for IFR demand as a percentage of VFR demand on all configurations where mixes 3 or 4 showed a substantial difference between IFR and VFR practical hourly capacities. A format of the weighting procedure used is shown on Figure 5.

Note from Figure 5, column (D), that the demand during instrument weather, D_I, is reduced considerably when a large amount of small aircraft is involved. However, for this long-range analysis the reduction is not as great as presently occurs, since it is presumed many more of these small aircraft will be flying in instrument weather in the future.

b. Mix. The following mixes relate to the four numbers shown in the Mix column for each configuration in Table 1:

NO.	%A	%B	%C	%D + E
1	0	0	10 (11-9)	90
2	0	30 (27-33)	30	40
3	20 (18-22)	40	20	20
4	60 (54-66)	20	20	0

Categories of aircraft for capacity purposes are generally as follows:

Type A - 4-engine jet and larger

Type B - 2 and 3-engine jet, 4-engine piston, and turbo prop

Type C - executive jet and transport type twin-engine piston

Type D and E - light twin-engine piston and single-engine piston

A specific list of these aircraft is contained in Appendix 2 of AC 150/5060-1A.

The figures in parentheses show the spread or tolerance of ± 10 percent for the critical portion of the forecast mix in determining direct use of Table 1. If forecast mix is within ± 10 percent of one of the above 4 mixes, the listed mix may be used without additional interpolation. In determining this ± 10 percent the large aircraft in the mix is critical. For example, a mix of 22 percent A, 15 percent B, 30 percent C, and 29 percent D + E is forecast for a location. The 22 percent A is within ± 10 percent of 20 percent A and mix 3 may be used directly. If the mix had been 25 percent A and 19 percent B, then Figure 1 should be used and percent A for interpolation would be 16 percent. An example of interpolation is presented later in the examples of paragraph 3.

Some representative airports expected to correspond to the 4 mixes by 1980 are:

Mix 1 - Opa Locka, Miami, Florida; Wiley Post, Oklahoma City, Oklahoma; Van Nuys Municipal, Los Angeles, California; Republic Airport, Farmingdale, New York.

Mix 2 - Wichita Municipal, Wichita, Kansas; Santa Fe Municipal, Santa Fe, New Mexico.

Mix 3 - Greater Cincinnati, Covington, Kentucky; Kansas City International, Kansas City, Missouri; Greater Pittsburgh, Pittsburgh, Pennsylvania.

Mix 4 - John F. Kennedy International, New York, New York; Chicago O'Hare International, Chicago, Illinois; Los Angeles International, Los Angeles, California.

c. Peaking Factors and Training. The percent of daily activity during the peak hour of the day (averaged for the consecutive two busy hours) is defined as the "peaking factor." This factor greatly influences annual capacity and varies with the type of aircraft mix in operation at a particular airport.

Although a 20 percent peaking factor for a mix of 90 percent D + E is shown on Figure 3, it is assumed in the post-1975 time period that this will flatten somewhat at the primary general aviation airports. The selection of a 15 percent peaking factor for mix 1 also tends to make the selection of the four mixes more representative. Therefore, for mix 1, a 15 percent peaking factor is used. From Figure 3 a multiplying factor of 1,800 is obtained (e.g., a weighted hourly capacity of 100 gives a PANCAP of 180,000 for a daily peaking factor of 15 percent) and applied to the weighted hourly capacities of mix 1. Sixty percent touch-and-go activity is assumed. This percent touch-and-go results in increasing the PANCAP by 25 percent (multiply by 1.25).

For mix 2 the peaking factor is 12.5 percent, multiplier 2,350, and 30 percent touch-and-go (multiply by 1.115).

For mix 3 the peaking factor is 9.5 percent, multiplier 3,250, and 10 percent touch-and-go (multiply by 1.04).

For mix 4 the peaking factor is 8 percent, multiplier 3,750, and zero touch-and-go (multiply by 1.00).

Application of the assumptions on peaking factors and training in calculating PANCAP is shown on Figure 5. No adjustments for training or peaking are made to the hourly capacity figures.

d. Terminal. A central location of the terminal was generally assumed. However, in a few cases some reduction to full use was made due to aircraft crossing an active runway. These reductions were minor and occurred on configurations (B), (E), (J), (K_1), and (K_2) of Table 1.

e. Navigational Equipment. In computing IFR capacities, full airport instrumentation was assumed, including control towers, ILS, ALS, and other associated equipment. For example, Layout D of Table 1 assumes two completely instrumented parallel runways separated by 5,000 feet or more would be in operation to obtain the IFR capacity shown. Naturally, if these runways have instrumentation for only one direction, then operations in the other direction would be greatly reduced from the IFR capacity shown. Thus, for the period of time that winds might require use of a nonprecision runway, IFR capacity is much less than shown and it may be desirable to consider this in evaluation of PANCAP. For mixes 3 and 4, airports were assumed to have ASR located on or close to the airport or were assumed to be served by a common IFR room. Additional IFR capacity was included on mix 3 and 4 calculations assuming computer-aided approach spacing (CAAS) will be implemented in the post-1975 time period. The increase for CAAS was only that now included on Figures 7 and 8 of Appendix 2, AC 150/5060-1A. No future air traffic procedural changes have been assumed.

f. Taxiways. Because taxiways are inexpensive when compared with other solutions for improving airfield capacity, it was assumed for long-range planning that a taxiway exit rating of 1 exists for all runway configurations. This means that all taxiways needed for expediting traffic on and off the runway system are assumed to exist for each configuration.

g. Runway Use. It was also assumed that at least 50 percent of the aircraft mix could use each runway. Should present length or strength restrictions dictate a reduction in the number of aircraft that can use one of the runways, runway improvements normally should be assumed and included in any evaluation of airport expansion. However, for exceptions to the 50 percent use and no improvement contemplated, use the adjustment shown in paragraph 2e, Appendix 2, AC 150/5060-1A.

h. Airspace. Unrestricted airspace was also assumed in the computations. If noise abatement procedures or nearby airports cause restrictions to airport operations, they should be evaluated on an individual basis. No future regulatory restrictions are included in the assumptions contained herein.

TABLE 1

AIRPORT CAPACITIES FOR LONG - RANGE PLANNING PURPOSE

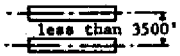
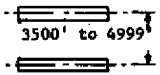
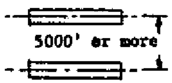
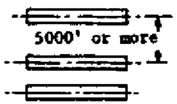
Runway Configuration		Mix	PANCAP	Practical Hourly Cap.		Remarks
Layout	Description			IFR	VFR	
(A) 	Single Runway (arrivals = departures)	1	215,000	53	99	
		2	195,000	52	76	
		3	180,000	44	54	
		4	170,000	42	45	
(B) 	Close parallels (IFR dependent)	1	385,000	64	198	
		2	330,000	63	152	
		3	295,000	55	108	
		4	280,000	54	90	
(C) 	Independent IFR approach/departure parallels	1	425,000	79	198	See AT P 7110.8 for offset threshold criteria on 3500' spacing.
		2	390,000	79	152	
		3	355,000	79	108	
		4	330,000	74	90	
(D) 	Independent IFR arrivals and departures	1	430,000	106	198	2 X (A) = (D)
		2	390,000	104	152	
		3	360,000	88	108	
		4	340,000	84	90	
(E) 	Independent plus one close parallel	1	600,000	117	297	(A) + (B) = (E)
		2	525,000	115	228	
		3	475,000	99	162	
		4	450,000	96	135	

TABLE 1 (Cont'd)

AIRPORT CAPACITIES FOR LONG - RANGE PLANNING PURPOSE

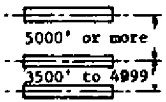
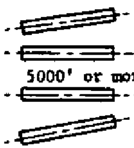
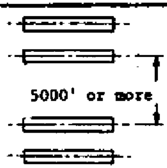
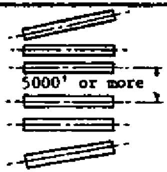
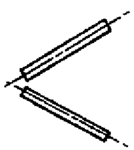
Runway Configuration		Mix	PANCAP	Practical Hourly Cap.		Remarks
Layout	Description			IFR	VFR	
(F)  5000' or more; 3500' to 4999'	Independent plus simultaneous departure runway	1	665,000	156	307	(A)+(C)+(F) since improved flexibility permits trade off on arrival/departure ratio and full departure runway.
		2	595,000	153	236	
		3	540,000	146	162	
		4	525,000	133	139	
(G)  5000' or more	Independent parallels plus divergent runways	1	665,000	156	307	Same as (F.)
		2	595,000	153	236	
		3	540,000	146	162	
		4	525,000	133	139	
(H)  5000' or more	Independent parallels plus two close parallels	1	770,000	128	396	2 X (B)-(H) IFR is departure-limited. These high theoretical figures may be limited by other system considerations.
		2	660,000	126	304	
		3	590,000	110	216	
		4	560,000	108	180	
(I)  5000' or more	Independent parallels, close parallels, plus divergent runways	1	1,050,000	177	505	These high theoretical figures may be limited by other system considerations.
		2	930,000	174	392	
		3	790,000	155	269	
		4	770,000	153	229	
(J) 	Widely Spaced Open V with independent operations	1	425,000	79	198*	*Crossing problem reduces capacity.
		2	340,000	79	136	
		3	310,000	76	94	
		4	310,000	74	84	

TABLE 1 (Cont'd)

AIRPORT CAPACITIES FOR LONG - RANGE PLANNING PURPOSE

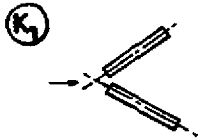
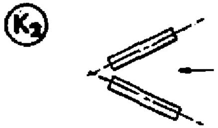
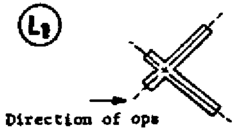
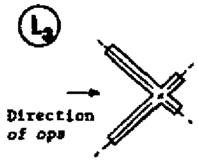
Runway Configuration		Mix	PANCAP	Practical Hourly Cap.		Remarks
Layout	Description			IFR	VFR	
	Open V, dependent, operations away from intersection	1	420,000	71	198	
		2	335,000	70	136	
		3	300,000	63	94	
		4	295,000	60	84	
	Open V, dependent, operations toward intersection	1	235,000	57	108	
		2	220,000	56	86	
		3	215,000	50	66	
		4	200,000	50	53	
	Two intersecting at near threshold	1	375,000	71	175	
		2	310,000	70	125	
		3	275,000	63	83	
		4	255,000	60	69	
	Two intersecting in middle	1	220,000	61	99*	*Indicates single runway capacity controls.
		2	195,000	60	76*	
		3	195,000	53	58	
		4	190,000	47	52	
	Two intersecting at far threshold	1	220,000	55	99*	*Same as (L2)
		2	195,000	54	76*	
		3	180,000	46	54	
		4	175,000	42*	57	

TABLE 1 (Cont'd)

AIRPORT CAPACITIES FOR LONG - RANGE PLANNING PURPOSE

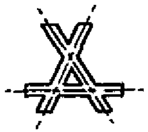
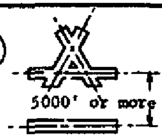
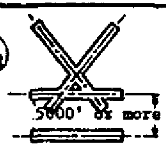
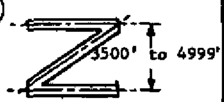
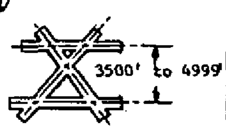
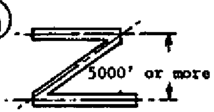
Runway Configuration: Layout	Runway Configuration: Description	Mix	PANCAP	Practical Hourly Cap.: IFR	Practical Hourly Cap.: VFR	Remarks
(M) 	Three intersecting	1	375,000	71	175	For long-range planning purposes, capacity of two intersecting runways should be used (L1). This assumes that intersections are reasonably favorable (i.e., intersections near the thresholds). For poor intersections use (L2) + 30% for PANCAP.
		2	310,000	70	125	
		3	275,000	63	83	
		4	255,000	60	69	
(N1) 	Parallel and intersecting intersection points at ends	1	590,000	124	274	(L1)+(A)=(N1)
		2	505,000	122	201	
		3	455,000	107	137	
		4	425,000	102	114	
(N2) 	Parallel and intersecting	1	460,000	114	198	(L2)+(A)+(N2), since trade off usage possible and flexibility improves capacity.
		2	405,000	112	152	
		3	380,000	97	112	
		4	365,000	89	97	
(O1) 	"Z" configuration and parallel with both intersecting	1	465,000	87	217	For estimating purposes, this calculation is (C) + 10 percent.
		2	430,000	87	167	
		3	390,000	87	118	
		4	365,000	81	99	
(O2) 	"Z" configuration and parallel with both intersecting	1	465,000	87	217	For estimating purposes, this calculation is (C) + 10 percent.
		2	430,000	87	167	
		3	390,000	87	118	
		4	365,000	81	99	

TABLE 1 (Cont'd)

AIRPORT CAPACITIES FOR LONG-RANGE PLANNING PURPOSE

Runway Configuration		Mix	PANCAP	Practical Hourly Cap		Remarks
Layout	Description			IFR	VFR	
P1 	"Z" configuration and parallel with both intersecting	1	475,000	116	217	For estimating purposes, this calculation is (D) + 10 percent.
		2	430,000	114	167	
		3	395,000	96	118	
		4	375,000	92	99	
P2 	"Z" configuration and parallel with both intersecting	1	475,000	116	217	For estimating purposes, this calculation is (D) + 10 percent.
		2	430,000	114	167	
		3	395,000	96	118	
		4	375,000	92	99	

3. PROCEDURE FOR DETERMINING AIRFIELD CAPACITY. The basic procedure for use of this publication in determining capacity is as follows:

   a. Analyze the operations forecast for the location, establish the anticipated aircraft mix, and select the nearest mix type from paragraph 2b.

   b. Select the layout from Table 1 which most closely represents the future operational configuration of the airport.

   c. If no adjustments are necessary to the assumptions of paragraph 2, PANCAP, IFR, and VFR hourly capacities are obtained directly from Table 1 for the selected layout and mix.

In general, the three steps above will be satisfactory to determine airfield capacity for long-range planning purposes. However, if there is a major disparity from the assumptions of paragraph 2 at the particular location under study, and a close capacity determination is needed, it may be necessary to adjust the assumptions. These adjustments to obtain a more refined answer will occur primarily on four of the basic assumptions:

(1) variation in forecast mix;

(2) variation in layout combinations and use of runways due to strong winds;

(3) variation in amount of training activity conducted at the airport; and

(4) variation in percent of IFR/VFR weather.

In the four sample calculations that follow, examples of these four variations are given.

Example 1, Straightforward Use of Table 1.

Given: Single runway configuration. Time period - 1980. All assumptions set forth in paragraph 2 appear reasonable. Aircraft mix forecasts: 0% A, 2% B, 11% C, and 87% D + E.

To find: Practical annual and practical hourly IFR and VFR capacities.

Solution: The aircraft mix forecast is within ± 10 percent of mix 1. Use layout (A) and mix 1 directly from Table 1. Therefore, the PANCAP = 215,000 operations, practical hourly IFR = 53 operations, and practical hourly VFR = 99 operations.

Example 2, Adjustment for Variation in Aircraft Mix.

Given: Three intersecting runway configurations. Time period - 1978. All assumptions in paragraph 2 appear reasonable. One runway is short and can only be used by aircraft of C size or smaller. Aircraft mix forecast: 15% A, 28% B, 25% C, and 32% D + E.

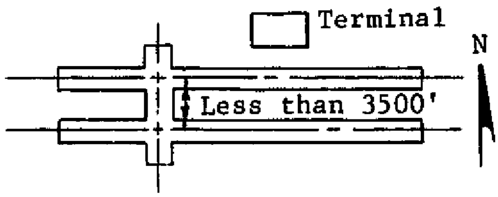
To find: Practical annual and practical hourly IFR and VFR capacities.

Solution: The runway restriction to the short runway does not affect Table 1 since more than 50 percent of the aircraft population is still able to use each runway. No assumptions on increased runway length need to be made. The mix forecast is somewhat between mix 2 and mix 3. From Figure 1 (Figure 10 of AC 150/5060-1A), the percent Class A for interpolation is 7 percent. Interpolating between mix 2 and mix 3 results in reducing the calculations of Table 1 for mix 2, configuration (M,) by 7/20 of the difference between mix 2 and mix 3 (or conversely, increasing mix 3, configuration (M,) by 13/20 of the difference between mix 2 and mix 3). Therefore, the PANCAP = 310,000 - [7/20 (310,000 - 275,000)] = 298,000 operations.

VFR hourly = 125 - [7/20 (125 - 83)] = 110 operations
IFR hourly = 70 - [7/20 (70 - 63)] = 68 operations

Example 3, Adjustments for a Combination of Variations in Configuration, Runway Use, and Training Activity.

Given: Configuration of one set of close parallel runways plus one intersecting runway (see sketch).



Time period - 1980. Wind coverage, based upon a 15 knot component, is approximately 80 percent E/W (including calm winds), 18 percent N/S, and 2 percent NE/SW. No training activity is conducted at the airport. Aircraft mix forecast is 20 % A, 40% B, 20% C, and 20% D + E. All other assumptions of paragraph 2 appear reasonable.

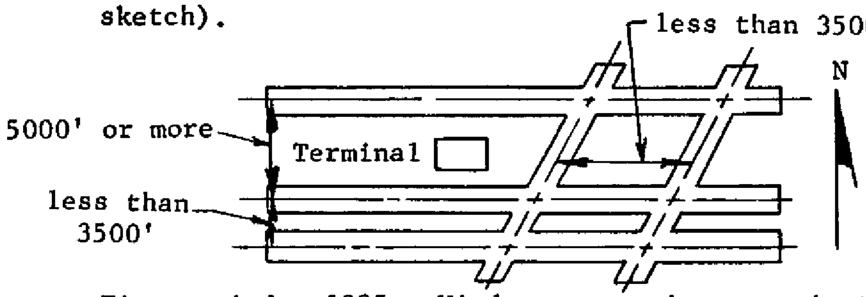
To find: Practical annual and practical hourly IFR and VFR capacities.

Solution: Mix 3 is used in this analysis. For simple calculations, the N/S wind coverage is presumed to reduce the N/S operation to a single runway. Therefore, 18 percent of configuration (A), mix 3, plus 80 percent of configuration (B), mix 3 = PANCAP; or PANCAP = 18% X 180,000 + 80% X 295,000 = 268,000 operations. Notice this includes a reduction of 2 percent due to strong crosswind components. Since no training activity is conducted at the field the 10 percent touch-and-go correction increase applied to mix 3 must be deducted from the PANCAP. For a touch-and-go of 10 percent (assumed for mix 3 in Table 1 calculations), the PANCAP is increased by 4 percent. Therefore, 268,000 - (4% X 268,000) = 257,000 operations.

Maximum VFR hourly = 108 operations
Minimum VFR hourly = 54 operations
Maximum IFR hourly = 55 operations
Minimum IFR hourly = 44 operations
Average VFR hourly = 18% X 54 + 80% X 108 = 96 operations
Average IFR hourly = 18% X 44 + 80% X 55 = 52 operations

Example 4, Adjustments for a Combination of Variations in Configuration, Runway Use, Aircraft Mix, and Percentage of IFR/VFR Weather.

Given: Three parallels in one direction (independent plus one close parallel) and two close parallels in another direction (see sketch).



Time period - 1985. Wind coverage is approximately 78 percent east or west (including calms), 10 percent to the east/northeast and 15 percent to the southwest. No training activity is conducted from the airport. The forecast aircraft mix is 40% A, 30% B, 25% C, and 5% D + E. VFR weather occurs 95 percent of the time and IFR 5 percent. Other assumptions of paragraph 2 appear reasonable.

To find: Practical annual and practical hourly IFR and VFR capacities.

Solution: There are three sets of configurations, depending upon wind conditions. To the east or west (75%) configuration (E) is used. For operations to the northeast (15%) configuration (B) is used. For operations to the west/southwest (10%), there is no runway directly aligned to accommodate the winds; however, assuming that strong crosswinds at a small angle (less than 20°) can be handled by post-1980 aircraft, all runways may be used when winds are to the east/northeast. Obviously all runways cannot be used simultaneously, even under VFR conditions. Therefore, for west/southwest operations configuration E plus 10 percent in VFR is used. The 10 percent is an estimated adjustment for some additional capacity from the close parallel crosswind runways but should not be applied during IFR conditions since both sets of close parallels cannot be used simultaneously during IFR weather. This estimated adjustment is an example of a judgment factor which may be used based upon knowledge of the airport, discussions with controllers, etc.

The forecast mix is exactly halfway between mixes 3 and 4. Therefore, all calculations will be based upon mix 3 less one-half the difference between mixes 3 and 4.

Hourly VFR and IFR capacities must first be obtained.

Operations to E or W:

75% X [(E) mix 3 - ½ ((E) mix 3 - (E) mix 4)]

VFR = .75 X [162 - .5 (162 - 135)] = 111

IFR = .75 X [99 - .5 (99 - 96)] = 73

Operations to NE:

15% X [(B) mix 3 - ½ ((B) mix 3 - (B) mix 4)]

VFR = .15 X [108 - .5 (108 - 90)] = 15

IFR = .15 X [55 - .5 (55 - 54)] = 8

Operations to W/SW:

VFR = 10% X [(E) mix 3 + 10% - ½ ((E) mix 3 + 10% - (E) mix 4 + 10%)]

VFR = .10 X [178 - .5 (178 - 148)] = 16

IFR = 10% X [(E) mix 3 - ½ ((E) mix 3 - E mix 4)]

IFR - .10 X [99 - .5 (99 - 96)] = 10

The practical hourly capacity considering percentage use of the various configurations due to winds is then:

Average hourly VFR = 111 + 15 + 16 = <u>142</u>

Average hourly IFR = 73 + 8 + 10 = <u>91</u>

Note that maximum practical hourly capacities occur 10 percent of the time and are 178 VFR and 99 IFR while minimum practical hourly capacities occur 15 percent of the time and are 108 VFR and 55 IFR.

The weighted hourly capacity may then be obtained, but Figure 5 procedures must be slightly altered for VFR - IFR assumption and training activity. In Figure 5, 90 percent VFR and 10 percent IFR was used, and for mix 3 a training activity assumption results in a 4 percent increase to the PANCAP. The factors "given" in this example state a 95 percent VFR and 5 percent IFR with no training activity. Thus the columns from Figure 5 would be:

(A)	(B)	(C)	(D)	(E)	(F)	(G)	
halfway between 3 and 4	91	142	.9	102	71%	I 4	V 1

The weighted hourly capacity is then:

WH = 102 X 4 X 5% + 142 X 1 X 95% ÷ 4 X 5% + 1 X 95%

WH = <u>135</u>

The PANCAP is then obtained by: PANCAP = WH X [3250 + ½ (3750 - 3250)] X 1 = 135 X 3500 X 1 = <u>472,000</u> operations. Note that since there is no training activity conducted at the airport, a multiplier of one is used -- no increase for touch-and-go. Rather than going through the calculations above for this fairly complex example, an estimate could be made by looking at the configuration, comparing it with the nearest configuration and mix in Table 1, making a rough adjustment for weather and then selecting a "spread" of capacity. Depending on the accuracy needed, an answer of 450,000 to 500,000 annual operations might be satisfactory with a rough VFR hourly capacity of 140 to 160 and an IFR hourly capacity of 80 to 95.

4. <u>DEMAND LEVELS FOR PLANNING ADDITIONAL DEVELOPMENT</u>. For the configurations and mixes in Table 1, Table 2 lists levels of annual demand at which additional facilities should be planned to improve capacity. For mixes 1 and 2 costs are usually relatively inexpensive and additional facilities (i.e., new airports, new parallel runways, etc.) should be completed at these demand levels. For mixes 3 and 4 all planning should be completed when the demand level is reached and actual construction of facilities should be in place when demand equals capacity. Land acquisition should precede construction by approximately 5 years.

As an example of using Table 2, take an existing air carrier airport with a PANCAP of 560,000, configuration (H), mix 4 of Table 1. Assume that the airport capacity cannot be significantly improved over 560,000 and that general aviation activity relief will have no major effect. Forecast air carrier demand for the area served is:

Current	- 250,000
1970	- 300,000
1975	- 400,000
1980	- 560,000
1985	- 750,000

From Table 2, mix 4 - 335,000 operations is the demand level at which all planning should be completed for a new air carrier airport. This demand is forecast to occur in 1972. By 1980 a new air carrier airport will be needed and land acquisition should begin by 1975.

Of course, this approach is purely from a capacity/demand standpoint and many additional local factors must be analyzed in order to confirm timing and construction of new airport facilities. Appendix 1 gives a method for applying capacity techniques to an airport system and generally discusses some of the other areas of consideration needed in a comprehensive study.

TABLE 2

ADVANCE PLANNING DEMAND LEVELS

Configuration (From Table I)	MIX	Demand Level of Activity for Planning Additional Improvements (60% of fig. on Table I)
A	1	130,000
	2	115,000
	3	110,000
	4	100,000
B	1	230,000
	2	200,000
	3	175,000
	4	170,000
C	1	255,000
	2	235,000
	3	215,000
	4	200,000
D	1	260,000
	2	235,000
	3	215,000
	4	200,000
E	1	360,000
	2	315,000
	3	285,000
	4	270,000
F	1	400,000
	2	355,000
	3	325,000
	4	315,000
G	1	400,000
	2	355,000
	3	325,000
	4	315,000
H	1	460,000
	2	395,000
	3	355,000
	4	335,000
I	1	630,000
	2	560,000
	3	475,000
	4	460,000
J	1	255,000
	2	205,000
	3	185,000
	4	185,000

NOTE: AVERAGE COSTS ARE ASSUMED FOR LONG-RANGE PLANNING

TABLE 2 (Cont'd)

ADVANCE PLANNING DEMAND LEVELS

Configuration (From Table I)	Mix	Demand Level of Activity for Planning Additional Improvements (60% of fig. on Table I)
K_1	1	255,000
	2	205,000
	3	185,000
	4	185,000
K_2	1	140,000
	2	135,000
	3	130,000
	4	120,000
L_1	1	225,000
	2	185,000
	3	165,000
	4	155,000
L_2	1	130,000
	2	115,000
	3	115,000
	4	110,000
L_3	1	130,000
	2	115,000
	3	110,000
	4	105,000
M	1	225,000
	2	185,000
	3	165,000
	4	155,000
N_1	1	355,000
	2	305,000
	3	275,000
	4	250,000
N_2	1	275,000
	2	245,000
	3	230,000
	4	220,000
O_1 & O_2	1	280,000
	2	260,000
	3	235,000
	4	220,000
P_1 & P_2	1	285,000
	2	260,000
	3	235,000
	4	225,000

NOTE: AVERAGE COSTS ARE ASSUMED FOR LONG-RANGE PLANNING

VFR
CLASS A AIRCRAFT
POPULATION INTERPOLATION GRAPHS

INSTRUCTIONS: This graph is used at airports consisting of Class A, B, C, and D+E that do not fall in the population groupings given on the capacity graphs. Obtain the converted % of Class A aircraft from this graph in the manner described in the example. Using this % the capacity curves may then be entered directly using linear interpolation between the percentages on the capacity curves for Class A aircraft only.

EXAMPLE: Aircraft Population is 30% A, 50% B, 20% C+D+E. Enter the horizontal scale at 50% B; move up to 30% A and read 37% A from the left scale. Linearly interpolate on the VFR capacity curves between A = 20% and A = 40% to determine the 37% point to use in capacity determination.

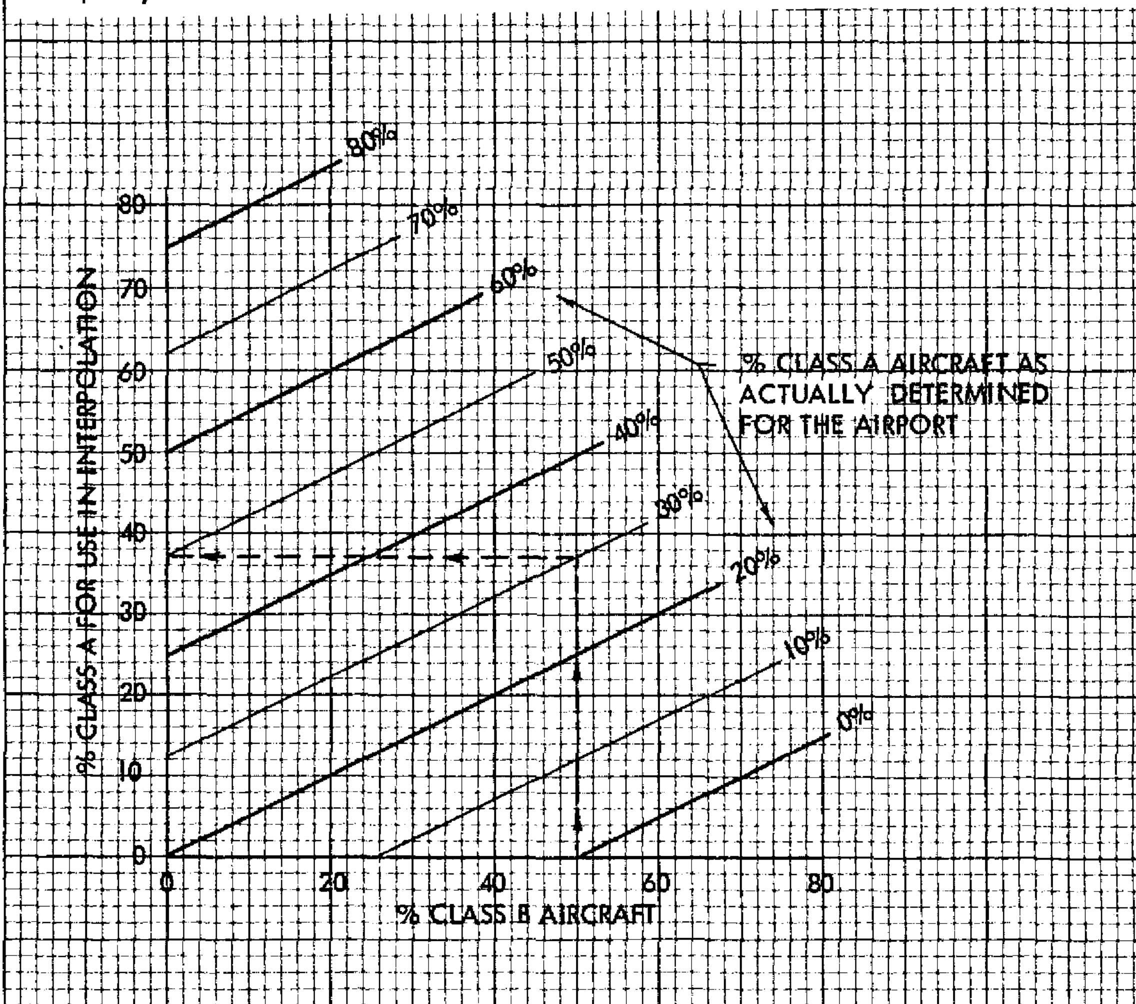


FIGURE 1. CLASS A AIRCRAFT - POPULATION INTERPOLATION -VFR-

VFR
CLASS B AIRCRAFT
POPULATION INTERPOLATION GRAPHS

INSTRUCTIONS: This graph is used at airports consisting of Class B, C, D+E that do not fall in the population groupings given on the capacity graphs. Obtain the converted % of Class B aircraft from this graph in the manner described in the example. Using this % the capacity curves may then be entered directly, using linear interpolation between the percentages on the capacity curves for Class B aircraft only.

EXAMPLE: Aircraft Population is 50% B, 35% C, and 15% D+E. Enter the horizontal scale at 35% C; move up to 50% B and read 56% B from the left scale. Linearly interpolate on the VFR capacity curves between B = 30% and B = 60% to determine the 56% point to use in capacity determination.

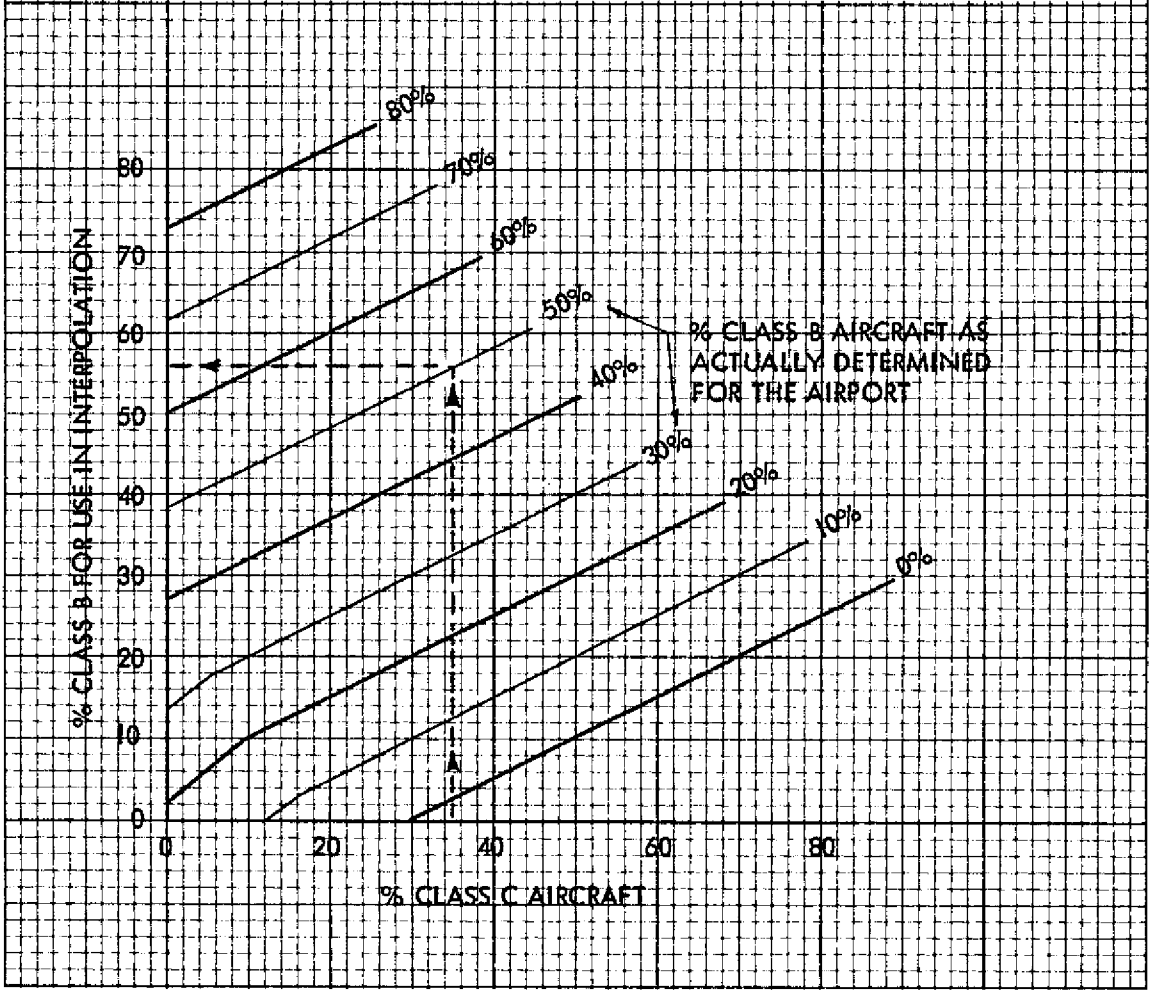


FIGURE 2. CLASS B AIRCRAFT - POPULATION INTERPOLATION
-VFR-

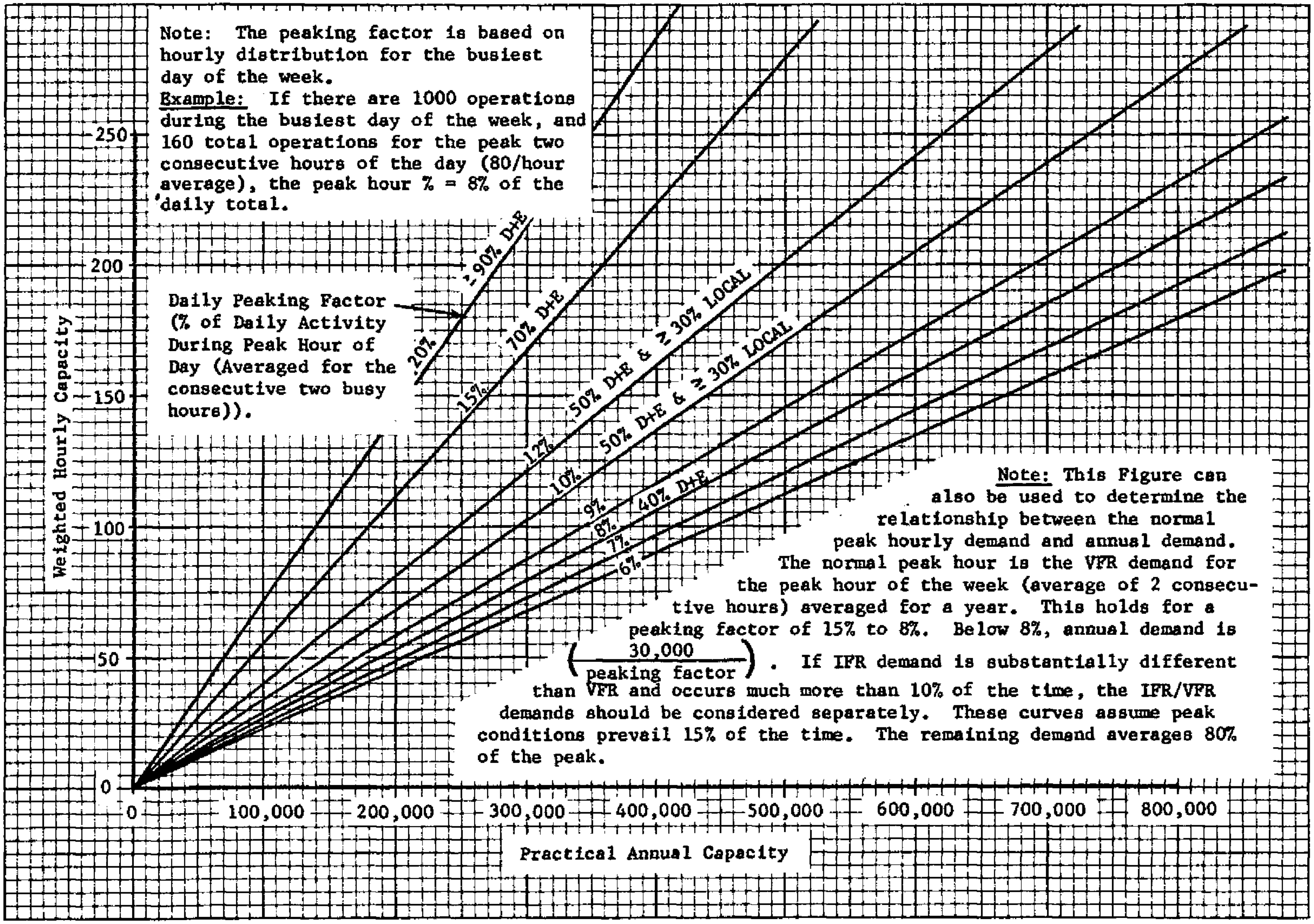


FIGURE 3. WEIGHTED HOURLY VERSUS ANNUAL CAPACITY

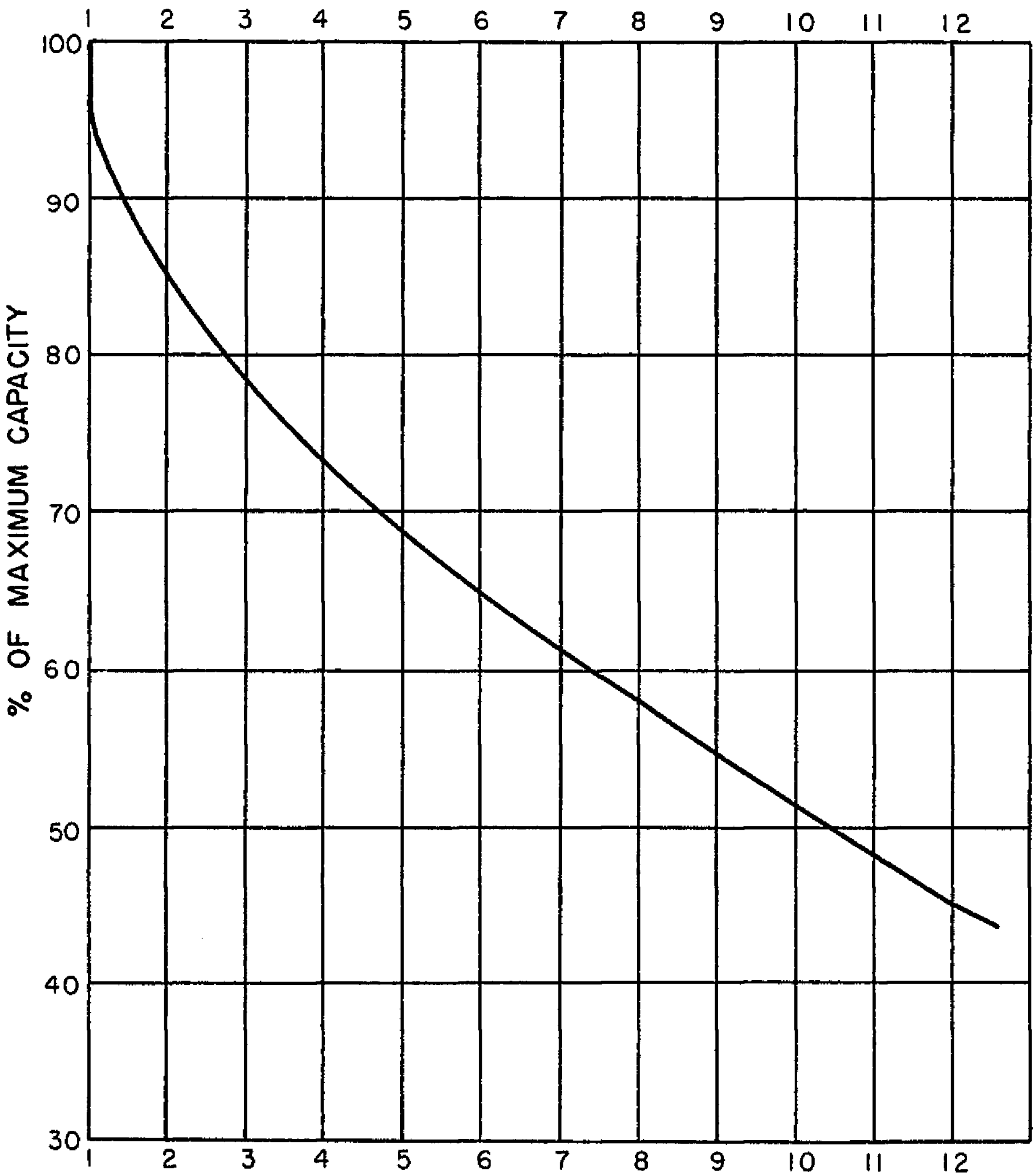
FIGURE 6

FACT SHEET 1980 METRO AREA CAPACITY STUDY

AIRPORT NAME COMMUNITY	OWNERSHIP	GENERAL LOCATION	RUNWAY INFORMATION		CONFIGURATION		ESTIMATED MIX		DEVELOPMENT PLANS		CURRENT ESTIMATED DEMAND			ESTIMATED PANCAP		REMARKS
			DIRECTION	LENGTH	EXISTING	FUTURE	EXISTING	FUTURE	NAP	OTHER	TOTAL	AC	GA	EXISTING	FUTURE	

FIGURE 4

RUNWAY WEIGHTING FOR LOWER CAPACITIES



SOURCE: TABLE 3 APPENDIX 2, AC 150/5060-1A

A MIX	B VFR HOURLY CAPACITY (V)	C IFR HOURLY CAPACITY	D IFR DEMAND AS % OF VFR DEMAND (D_I)	E IFR/DI (I_a)	[1] F % OF MAXIMUM CAPACITY	[2] G WEIGHTING FACTOR (WF_I)	(WF_V)
1			.5				
2			.65				
3			.85				
4			.95				

$$\text{Weighted Hourly Capacity} = WHC = \frac{I_a \times WF_I \times 10\% + V \times WF_V \times 90\%}{WF_I \times 10\% + WF_V \times 90\%}$$

Practical Annual Capacity = PANCAP = WHC X P X T and G

MIX

1 WHC_1 X 1,830 X 1.25 = $PANCAP_1$ = ____________ operations

2 WHC_2 X 2,350 X 1.115 = $PANCAP_2$ = ____________ operations

3 WHC_3 X 3,250 X 1.04 = $PANCAP_3$ = ____________ operations

4 WHC_4 X 3,750 X 1.00 = $PANCAP_4$ = ____________ operations

CONFIGURATION __________ OF TABLE 1.

1/ This column is either column B/E or E/B, whichever produces a percentage less than 100%.

2/ Normally WF_V = 1 since maximum capacity is usually VFR. Therefore, WF_I is obtained from using column F, above, and Figure 6.

FIGURE 5. SAMPLE TABULATION SHEET

APPENDIX 1

METRO AREA AIRPORT SYSTEM CAPACITY STUDIES

The eleven-step approach presented below results in a general determination of numbers and configurations of airports. This analytical approach using the capacity techniques in the body of this circular should not be mistaken as a substitute for a comprehensive metropolitan airport system study. The Federal Aviation Administration strongly encourages development of complete metropolitan area airport studies by qualified airport and urban planning consultants. An in-depth study would include detailed analysis in the areas of ground transportation systems, land-use planning and zoning, urban sprawl, topography, airspace and air navigation requirements, and many other social and economical considerations. In addition, individual airports must be analyzed in detail regarding expansion potential, access, activity growth, future role in the system, etc.

1. From the demand forecast for the period being studied, list the following:

   a. Total annual aircraft operations for the metro area;

   b. The percentage of total annual operations represented by airline, general aviation, and military;

   c. Aircraft mix (population) - percentage by type (see AC 150/5060-1A, Appendix 2, page 2).

2. Prepare a pictorial presentation of the metro area showing locations and types of existing airports (an aeronautical chart may be used).

3. Prepare a fact sheet (see Figure 6) on existing airport facilities within the metro area showing as a minimum:

   a. Airport names

   b. Type ownership (public or private)

   c. General location within metro area (quadrant)

   d. Number, length, and orientation of usable runways

   e. Current demand data for each airport as in step 1 above

   f. Current plans for development (as shown in current National Airport Plan)

   g. Additional information to be developed in steps 4 and 8 below

4. Determine the approximate capacities of existing airports by using either Table 1 or other current detailed studies. Table 1 will be approximately 10 percent high for current capacities. Add this information to the fact sheet.

5. Determine the future availability of privately owned airports based upon local trends and developments. Normally for long-range planning, all privately owned airports should be considered lost to other development. Publicly owned airports are considered to continue to be retained in this long-range approach. More important urban development considerations may require reduction in size or type of operation or elimination of a publicly owned airport. However, for the purpose of this type of analysis, it is assumed the public body would provide equal replacement facilities as needed.

6. Determine the adequacy of present facilities to accommodate forecast annual demand. (Subtract summation of individual capacities from step 4 from forecast annual demand, step 1a).

7. Using Table 1 and local knowledge, determine how each existing airport can be expanded in the most efficient manner to improve its capacity. Only major improvements such as runways or parallel taxiways need to be considered. Consider airspace limitations in determining whether runway improvements can be made at existing airports. FAA Order 7480.1, Guidelines for Airport Spacing and Traffic Pattern Airspace Areas, shows airspace approximations.

8. Determine the new capacities resulting from improvements (Step 7) and add them to the fact sheet.

9. Determine the adequacy of improved existing airports to accommodate forecast annual demand. Demand levels shown in Table 2 should be used in determining the timing for constructing new general aviation (GA) airports and completing final planning for new air carrier (AC) airports.

10. Distribute the balance of the demand that cannot be met by the improved existing airports (Step 9) to new airport locations placed within the metro area based on maximum utilization consistent with airspace and environmental limitations. These new airports should be designated as air carrier or general aviation and should have optimum runway configurations in accordance with Table 1.

11. Add the forecast annual capacities of the improved existing airports to the capacities of the new airports and compare the sum to the forecast demand as a final check on the adequacy of the proposed system and adjust again, if required.

Note that actually locating the airports within the metropolitan area, as stated in Step 11, is beyond the scope of a capacity analysis. However, a rough approximation of locations is desirable at this point to establish "reasonability" of the capacity results. Firm locations will require detailed review of many local factors.

APPENDIX 2

DETERMINATION OF WEIGHTED HOURLY CAPACITY AND PRACTICAL ANNUAL CAPACITY (PANCAP)

In determining the PANCAP for configurations on Table 1, a set procedure is followed. Generally this procedure consists of:

1. Determining the hourly IFR and VFR capacities for each mix on the configuration under study.

2. Adjust the IFR capacity by dividing it by D_I. D_I is equal to IFR demand as a percent of VFR demand and a standard percentage is used for each mix. These standard percentages are based upon a general determination of the amount of aircraft flying in IFR for each particular mix and take into account increased IFR operations by smaller, nonairline aircraft in the post-1975 time period. The percentages are shown in column D of the sample tabulation (see Figure 5).

3. Compare VFR with the adjusted IFR, divide by the larger of the two to obtain the percent of maximum capacity and from the chart on Figure 4 obtain the weighting factor. Figure 4 is merely a graphic form of Table 3, Appendix 2, AC 150/5060-1A.

4. The adjusted IFR and the VFR capacities are changed to reflect the weighting factor and the percent of IFR and VFR weather and are then added together to obtain the weighted hourly capacity. As stated in paragraph 2, 90 percent VFR and 10 percent IFR weather is used for all calculations in Table 1. The equation for this step is:

$$\frac{I_a \text{ X } WF_I \text{ X } 10\% + V \text{ X } WF_V \text{ X } 90\%}{WF_I \text{ X } 10\% + WF_V \text{ X } 90\%} = WHC$$

Where: V = VFR hourly capacity
I_a = IFR hourly capacity adjusted for demand (i.e., D_I).

WF_V or WF_I = Weighing Factor as obtained from Figure 4. One of these numbers is unity in every equation. Normally WF_V is one since VFR capacity is almost always greater than adjusted IFR capacity.

WHC = Weighted hourly capacity

5. Using the weighted hourly capacity (WHC) determined for each mix, the PANCAP is calculated by adjusting each WHC for a certain assumed peaking factor and for assumed training activity. In paragraph 2 these assumed factors for training and peak activity are discussed. Thus, this final step in equation form is:

PANCAP = WHC X P X T & G

Where: PANCAP = Practical annual capacity
WHC = Weighted hourly capacity
P = Multiplication factor to adjust for peaking. This factor, determined from Figure 3, is shown at the bottom of Figure 5 for each of the four mixes.
T & G = Correction factor for touch-and-go activity. This factor, determined from Figure 14 of AC 150/5060-1A, is shown at the bottom of Figure 5 for each of the four mixes.

From the above steps it is seen that the weighted hourly capacity must be calculated before PANCAP can be determined. It is apparent that the assumptions used in the calculation of capacities shown on Table 1 may be altered to fit individual locations. The sample tabulation sheet, Figure 5, is a convenient way to record data and was used in preparing Table 1.

APPENDIX 3

BIBLIOGRAPHY

1. Airport Capacity

a. AC 150/5060-1A, Airport Capacity Criteria Used in Preparing the National Airport Plan.

b. Airport Capacity, A Handbook for Analyzing Airports Designs to Determine Practical Movement Rates and Aircraft Operating Costs; Airborne Instruments Laboratory, Deer Park, Long Island, New York.

c. Staff Study, Alternative Approaches for Reducing Delays in Terminal Areas, Report No. RD-67-70, FAA.

2. Airport Spacing

a. FAA Order 7480.1, Guidelines for Airport Spacing and Traffic Pattern Airspace Areas.

3. Forecasts of Facility Requirements (FAA Publications)

a. Aviation Demand and Facility Requirements Forecasts for Large Air Transportation Hubs Through 1980.

b. Aviation Demand and Facility Requirements Forecasts for Medium Air Transportation Hubs Through 1980.

4. Airport Planning (FAA Publications)

a. Advisory Circular 150/5060-2, Airport Site Selection.

b. Advisory Circular 150/5070-2, Planning the Metropolitan Airport System.

c. Advisory Circular 150/5070-4, Planning for Rapid Urbanization Around Major Metropolitan Airports.

d. Advisory Circular 150/5090-1, Regional Air Carrier Airport Planning.

e. Advisory Circular 150/5310-2, Airport Planning and Airport Layout Plans.

BIBLIOGRAPHY (Cont'd)

5. Airport Planning and Design Standards (FAA Publications)

a. Advisory Circular 150/5300-2, Airport Design Requirements for Terminal Navigational Aids.

b. Advisory Circular 150/5300-4A, Utility Airports.

c. Advisory Circular 150/5325-4, Runway Length Requirements for Airport Design.

d. Advisory Circular 150/5325-5, Aircraft Data.

e. Advisory Circular 150/5330-3, Wind Effect on Runway Orientation.

☆ U. S. GOVERNMENT PRINTING OFFICE : 1978—620-733/60

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Washington, D.C. 20591

Official Business

PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
FEDERAL AVIATION
ADMINISTRATION
DOT 515

U.S.MAIL