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SIMULATION TESTS OF IFR OPERATIONS AT THE PROPOSED DAVIDSONVILLE NAVAL AIR STATION

FOR LIMITED DISTRIBUTION

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SUMMARY

This report describes the results of a simulation study of instrument flight rule operations at the proposed Naval Air Station at Davidsonville, Maryland. The purpose of this study was to determine the effects of this airport on the over-all traffic flow in the Washington-Baltimore area, and to determine the optimum methods of handling air traffic at this facility. All tests were conducted through the use of the Dynamic Air Traffic Simulator at the CAA Technical Development Center.

Tests showed that the operation of the proposed facility at Davidsonville would further complicate an already cramped route structure and would have a particularly restrictive effect on instrument flight rule operations in and out of Andrews Air Force Base. Although some of these effects could be alleviated through the use of a common approach control facility for Andrews and Davidsonville, the proximity of airports and the lack of maneuvering airspace required almost complete dependence on radar-guided approach and departure procedures, and therefore, a high controller workload per aircraft.

During the course of this program, a number of new procedures were developed and tested for the integration of jet aircraft traffic in the terminal area.

INTRODUCTION

In November 1956, the Office of Air Traffic Control requested the Technical Development Center to conduct a simulation study of the proposed Davidsonville Naval Air Station. At a meeting in Washington on December 12, 1956, the Department of the Navy restated their requirement for an air station in the vicinity of Annapolis and furnished drawings of the proposed Davidsonville site. The Navy representative advised that the Navy was prepared to vacate Anacostia when the new site was available, at such time, the U. S. Air Force would vacate Bolling Field and move to Andrews Air Force Base (AFB). The resulting simulation program was based on these assumptions. Due to previous commitments, the actual test runs were postponed until May 1957.

Meanwhile, in February 1957, the Office of Air Traffic Control requested the Technical Development Center (TDC) to conduct a simulation study of the use of Baltimore Friendship Airport as a supplementary airport (primarily as a commercial jet terminal) for the Washington metropolitan area. Due to the proximity of Baltimore and Davidsonville, it was considered necessary to combine the air route phases of the two simulation projects in order to observe the effects of each airport on the flow characteristics of the other. Several TDC air traffic controllers spent a week in the Washington-Baltimore area gathering background data for the two projects. The simulation tests were completed in June 1957.

EVALUATION METHODS

Traffic Samples.

A large sample of recently used flight progress strips, obtained from the Washington Air Route Traffic Control Center, was analyzed to determine the percentage of aircraft operations on each route. Based on these percentages, a two-hour traffic sample was prepared for use in the test runs. This sample was composed of equal numbers of arrivals and departures, distributed as follows:

Airport	Traffic Density (Operations per Hour)
Davidsonville	12
Andrews	20
Baltimore Friendship	32
Washington National	50
Total	114

An additional high-density traffic sample was prepared for use in terminal area studies to develop optimum airport-approach procedures. This sample consisted of a total of 35 jet aircraft and 8 propeller-driven ("prop") aircraft, and had an average density of 33 aircraft per hour. In tests assuming independent approach patterns for Andrews and Davidsonville, the entire arrival sample was fed into Davidsonville. In tests of a combined feeding system for Andrews and Davidsonville, the traffic sample was divided, with 21 arrivals fed into Andrews and 22 into Davidsonville.

Air Route Test Procedures.

For the air route phase of the simulation tests, three Air Route Traffic Control (ARTC) sectors were simulated: an arrival sector, a departure sector, and an enroute sector. All sectors were provided with a large bright-radar display. All operating positions were equipped with interphone and air/ground (A/G) radio communications facilities. Baltimore, Washington, Andrews, and Davidsonville towers were simulated. These towers were equipped with arrival and departure scopes, as well as interphone and A/G radio communications.

Because only 18 target projectors were available, it was necessary to divide the complex Washington-Baltimore area into north and south segments, and to run one segment at a time. Any essential traffic which was common to both segments appeared again in the program when the other segment was simulated.

Terminal Area Test Procedures.

A high-density terminal area phase of the test program was conducted in order to study jet operations in greater detail and to develop optimum approach procedures for Davidsonville. Four categories of jet aircraft were included in the traffic sample. Penetration speeds for each category varied with altitude as shown in Table I. All jet penetrations from an altitude of 20,000 feet were conducted at a standard descent rate of 4,000 feet per minute. The descent was flared below 5,000 feet to permit the aircraft to level off before starting down the final glide slope. At speeds above 200 knots, all turns were made at a rate of 1 1/2 degrees per second. At speeds of less than 200 knots, aircraft made turns at the standard rate of 3 degrees per second.

Two approach controllers were used in the terminal area tests. A feeder controller laddered down jet aircraft to the initial penetration altitude of 20,000 feet, guided them off the feeding fix, cleared them for penetration, and subsequently transferred them to the final controller, who spaced them properly behind other aircraft and turned them into the final approach course. For prop aircraft, the final controller handled both the feeding and the spacing functions. In these tests, it was assumed that either Ground Controlled Approach (GCA) or Instrument Landing System (ILS) would be available as a final approach aid. No GCA communications were simulated.

Maps of the Davidsonville Airport layout furnished by the Navy showed two 8,000-foot runways. One was northwest/southeast, and the other was northeast/southwest. The accompanying wind rose data indicated that the prevailing wind direction was northwest. Thus a northwest heading for the instrument approach system appeared appropriate. This direction also appeared the most suitable for the airport layout shown, because of the northerly instrument approach employed at Andrews AFB. However, it was found that the approach path to the northwest runway at Davidsonville cut across a corner of restricted area 35, about 12 miles southeast of the airport. Unless this airspace could be used for instrument flight rule (IFR) approaches, the presence of the restricted area would make the approach course rather short for jet operations. In view of the understanding that the layout shown was only tentative, the alignment of the northwest runway was moved counterclockwise for the simulation tests so that the center line of the approach course passed two miles east of the restricted area.

TABLE I

JET PENETRATION SPEEDS

(TAS IN KNOTS)

		Aircraft Category	1	2	3	4
		Representative Type	F8U	A4D	F9F	TV2
Altitude MSL		20,000	415	330	305	280
		15,000	410	330	305	280
		10,000	370	305	285	260
		5,000	320	260	240	215
	(approach)	2,000	180	180	170	150

The approach gate assumed for all simulation tests was a site on the final approach course about five miles from the airport. For convenience in establishing optimum separation between arrivals, spacing reference lines 3, 5, and 7 miles from the approach gate were marked on the radar indicator, and a standard spacing table was used by the controller to insure safe separation between successive aircraft.

Measurements.

Delay measurements were recorded during the air route phase of the tests. Arrival delays were computed by comparing the theoretical time at which each aircraft should be over the approach fix on final approach (assuming that no other traffic were involved) with the actual arrival time of such aircraft over the approach fix.

Departure delays were computed by comparing the proposed departure time with the actual departure time. Because of a shortage of target projectors, all arrivals were taken off the screen at the outer marker, instead of being flown to touchdown. Therefore, the departure delays do not include the effects of runway occupancy by landing aircraft.

After the air route phase was completed, the simulation program was interrupted about two weeks for the installation of automatic equipment for communications measurement. This equipment was available during the terminal area phase of the program. Measurements included the number of messages and the total communications time on each channel. No weather information was included in the communications procedures.

AIR ROUTE TEST RESULTS

Route Layouts.

In order to retain as much of the existing system as practicable, the initial simulation tests of the area were conducted using the present navigation system layout shown in Fig. 1. Tests showed that this layout was unworkable at the airport traffic densities being simulated. It was apparent immediately that before Baltimore could accommodate any appreciable increase in traffic, it would be necessary to reroute Victor Airway 3 well clear of the Baltimore area to provide room for jet penetrations. To provide additional routes to handle the increased traffic in and out of the Washington-Baltimore area, numerous other modifications were employed, as shown in Figs. 2 and 3. These changes are itemized in Table II, together with the specific reason for each modification. Later air route tests were conducted on the revised layout. Abbreviations used in route layout maps are listed in Table III.

Effect of Davidsonville Airport Operations on Other Facilities.

Except for occasional southbound Davidsonville arrivals crossing through the Baltimore holding area, Davidsonville operations had very little effect on flight operations at Baltimore Friendship Airport. Baltimore arrival and departure routes were well clear of the Davidsonville area.

The most significant effect of Davidsonville operations on Washington National Airport traffic was the interference between Davidsonville operations and Washington arrivals which crossed the Davidsonville approach area on Victor Airway 16. In this case, heavy activity at either Davidsonville or Andrews could restrict the use of this route for other traffic.

Tests showed that the most serious effect of Davisonville on presently established facilities was the severe restrictions it placed on arrival and departure operations at Andrews AFB. These effects are summarized in detail in Table IV.

Due to the location of Andrews in relation to Washington and the nearby restricted areas, the only Andrews IFR departure routes which are presently free of the Andrews approach path involve use of the airspace east of Andrews. These routes include the jet scramble route, the main departure route to the northeast, and the off-airway climbing area which is used to get

TABLE II

SUMMARY OF CHANGES MADE IN AIRWAY CONFIGURATION

RESTRICTED AREAS ALTERED

	CHANGE	REASON
1.	R-37	To provide airspace for Airways Victor 3 - Victor 140 - Victor 904
2.	R-38	To provide airspace for Airways Victor 904 and relocated Amber 7
3.	R-40	To provide airspace for relocated Airway Amber 7
4.	R-43	To provide airspace for Airway Victor 903
5.	R-54	To provide airspace for Airway Victor 907 and Departure routes from Davidsonville, Andrews, Baltimore, and Washington
6.	C-55	To provide airspace for Airways Victor 268 and Victor 223

PROPOSED VOR LOCATIONS

CHANGE	REASON
1. ROUND HILL, VA. VOR	New independent arrival route to Washington from northwest
2. HAYMARKET, VA. VOR	New independent departure route from Washington to west and southwest
3. CASANOVA, VA. VOR	New independent departure route from Washington to west and southwest
4. CHESTERTOWN, MD. VOR	New routes from Washington, Baltimore, Andrews, and Davidsonville to northeast, east, and southeast
5. QUANTICO LF Range changed to POTOMAC, VA. VOR and relocated 4 statute miles northwest of present QUANTICO site	To provide new independent routes from Washington, Andrews, and Davidsonville to the west and southwest

TABLE II (continued)

SUMMARY OF CHANGES
MADE IN AIRWAY CONFIGURATION

CHANGE	REASON
PROPOSED VOR LOCATIONS	
6. Relocate WESTMINSTER, MD. VOR 6 1/2 statute miles northwest of present location	To provide more airspace for jet penetration at Baltimore
NEW AIRWAYS PROVIDED	
1. Victor 901	To provide a new route for northbound traffic from Davidsonville, Washington, and Andrews, independent of Baltimore
2. Victor 902	To provide independent departure route from Washington to the west and southwest
3. Victor 903	To provide a new route from Davidsonville and Baltimore to and from the south
4. Victor 904	To provide new route for Davidsonsonville, Andrews, and Washington departures to the west
5. Victor 905	To provide a departure route from Baltimore to New York and northeast
6. Victor 906	To provide independent arrival route to Washington from the northwest
7. Victor 907	To provide a route for Dover traffic to bypass Baltimore
8. Victor 908	To provide a route to Davidsonville and Andrews from the north and northeast that will bypass Baltimore
9. Victor 909	To provide a departure route from Washington to the northeast

TABLE II (continued)

SUMMARY OF CHANGES
MADE IN AIRWAY CONFIGURATION

CHANGE	REASON
ROUTE MODIFICATIONS OR PROCEDURAL CHANGES	
1. Victor 3/39 moved west	To provide airspace for jet penetration at Baltimore
2. Victor 44 closed to over traffic between Lisbon, MD, intersection and Baltimore	To allow jet penetration at Baltimore
3. Victor 16/Green 5 closed to over traffic between Ingleside and Doncaster	To provide for Davidsonville-Andrews Radar Approach Control Area
4. Blue 56 closed to over traffic between Coles Point and Andrews LF Range	To provide for Davidsonville-Andrews Radar Approach Control Area
5. Red 20 closed to over traffic between Meekins Neck and Andrews LF Range	To provide for Davidsonville-Andrews Radar Approach Control Area
6. Blue 21 closed to over traffic between Coles Point and Severna Park	To provide for Davidsonville-Andrews Radar Approach Control Area
7. Red 77 changed to a major route replacing Victor 16/Green 5	Davidsonville Airport
8. Amber 7 realigned in vicinity of Doncaster and Grubbs	To provide independent routes for Washington, Andrews, and Davidsonville
9. Victor 223 realigned to the west	To provide airway separation between Victor 223 and Victor 3/39
10. Andrews ADC Scramble procedures eliminated	Davidsonville Airport
11. Victor 268 relocated at the new Westminster location	To provide independent departure routes from Baltimore, Andrews, and Davidsonville to the west and northwest

TABLE II (continued)

SUMMARY OF CHANGES
MADE IN AIRWAY CONFIGURATION

CHANGE	REASON
ROUTE MODIFICATIONS OR PROCEDURAL CHANGES	
12. Victor 33 relocated to the east	To provide jet penetration at Baltimore
13. Victor 93 realigned from Lancaster VOR direct to Baltimore Outer Marker	To provide airspace for additional independent route to Baltimore from the northeast
14. Delete Victor 123 from Riverdale to Baltimore LF Range	Baltimore increased traffic

departures clear of airway traffic before heading on course. Operation of the Davidsonville Airport blocks this airspace. It is true that the magnitude of these effects would depend on the amount of IFR traffic at Davidsonville. However, the light Davidsonville traffic rate of six arrivals and six departures per hour simulated during this phase of the tests produced almost continuous interference as far as Andrews was concerned.

Because of traffic crossover problems accentuated by the close proximity of Andrews and Davidsonville, IFR arrivals in the simulation tests often could not begin descent until arriving over the approach fix. The presence of over traffic on Victor Airway 16 tended to raise Davidsonville and Andrews entry altitudes even higher.

In the initial tests, the over traffic also placed an additional restriction on jet penetrations at Andrews and Davidsonville, as jets had to maintain an altitude clear of the over traffic until off the airway. Because of the extra distance involved, the penetration paths sometimes extended into Red Airway 77. Considerable improvement in these factors was noted when the over traffic was rerouted over Red Airway 77 instead.

Arrival delays were relatively high, mainly because of the time lost in long descents. In the traffic sample tested, Davidsonville arrival delays averaged 7.5 minutes per aircraft when ARTC radar was used and 13 minutes otherwise.

When radar departure procedures were simulated, ground delays averaged 0.5 minutes per aircraft when ARTC radar was used and 2.5 minutes otherwise. Westbound and southwestbound departures from Andrews and Davidsonville required complex circuitous routings, however, involving a very high radar workload, in order to climb to a suitable altitude to clear other traffic before entering the airway.

TABLE III

LOCATION IDENTIFIERS USED ON MAPS

ADW	ANDREWS AFB, MD.
ARV	ARCOLA, VA. LFR
BAL	BALTIMORE, MD. (Friendship)
CAH	CHARLOTTE HALL, VA. Radio Beacon
CES	CHESTERTOWN, MD. - Proposed VOR
CNV	CASANOVA, VA. - Proposed VOR
DAV	DAVIDSONVILLE, MD. - Proposed NAS
DCA	WASHINGTON, D.C.
DCS	DONCASTER, VA. Intersection
DMS	DAMASCUS, MD. Intersection
DOV	DOVER, DEL. VOR
EMI	WESTMINSTER, MD. - Relocated VOR
ESR	WEST CHESTER, PA. VOR
FRR	FRONT ROYAL, VA. VOR
GBS	GRUBBS, VA. Intersection
GTN	GEORGETOWN, D.C. Radio Beacon
GVE	GORDONSVILLE, VA. VOR
HAR	HARRISBURG, PA. VOR
HMK	HAYMARKET, VA. - Proposed VOR
HNT	HUNTINGTON, VA. Radio Beacon
HRN	HERNDON, VA. VOR
ILG	NEW CASTLE, DEL. - Proposed VOR
ING	INGLESIDE, MD. Intersection
LRP	LANCASTER, PA. VOR
LSO	LISBON, MD. Intersection
MRB	MARTINSBURG, W.VA. VOR
MTN	GLENN MARTIN AIRPORT, MD.
NHK	PATUXENT RIVER, VA. LFR
NRV	NORRIS(ville), MD. Intersection
NYG	QUANTICO, VA. LFR
OOD	WOODSTOWN, N. J. VOR
PAR	PARKTON, MD. Intersection
PDP	PORT DEPOSIT, MD. Intersection
PHL	PHILADELPHIA, PA. - Proposed VOR
PTC	POTOMAC, VA. - Proposed VOR
RDH	ROUND HILL, W. VA.- Proposed VOR
RVD	RIVERDALE, MD. Radio Beacon
SBY	SALISBURY, MD. VOR
SHZ	SHADYSIDE, MD. Radio Beacon
SNV	SEVERNA PARK, MD. Intersection
SRI	SPRINGFIELD, VA. Radio Beacon
TPP	TAPPAHANNOCK, VA. LFR

TABLE IV

Effect of Davidsonville on IFR Operations at Andrews AFB

ANDREWS OPERATION	PRESENT ROUTE	EFFECT OF DAVIDSONVILLE	POSSIBLE SOLUTION
Departures to north and jet scrambles	70° heading to south course of Baltimore	Route blocked	Interrupt Davidsonville operations or radar vector around other traffic
Departure to east	110° heading to Shadyside	Route blocked	Same as above
Departures to south	Shadyside B21 Coles Point	Route blocked	Same as above or reroute via Huntingtown
	*B56 Charlotte Hall B50 Coles Point *Huntingtown R20 Meekins Neck	No effect No effect	
Departures to west	*B56 Charlotte Hall - Quantico Climb in pattern east of Andrews, thence west via Washington Range	No effect Route blocked	Interrupt Davidsonville operation or radar vector around other traffic
Arrivals from north	Riverdale - Andrews Shadyside - Andrews	No effect Route blocked	Interrupt Davidsonville operations, overfly or tunnel through stack
Arrivals from east	G5 or V16 Shadyside - Andrews	Route blocked	Same as above
Arrivals from south	Coles Point B56 Andrews Doncaster A7 Andrews	No effect No effect	
Arrivals from west	Springfield - Andrews	No effect	

Legend: *Departure route crosses Andrews approach course
-Direct

Because of the proximity of the two airports, it appeared doubtful that they ever could operate independently of each other under IFR conditions. Although many man-hours were spent during this project in discussions and map studies of this problem, no feasible method of handling simultaneous IFR operation of these two airports was found which did not also involve a high degree of coordination, a high dependence on radar guidance, and consequently, a very high controller workload per aircraft.

Tests indicated that the coordination problem could be alleviated through the establishment of a single approach-control facility to handle IFR operations at both airports. The suggested area of jurisdiction for such a facility is shown in Figs. 2 and 3.

TERMINAL AREA TEST RESULTS

General.

In developing holding and approach pattern layouts for this program, full cognizance had to be taken of the entire Washington-Baltimore area to insure that patterns did not overlap each other, or block usable departure paths, airway routes, or restricted areas needlessly. For this reason, full advantage could not be taken of ideal approach configurations for any single airport. Instead, the resulting systems represented compromises between various competing airspace requirements.

Approach System 1.

In the initial tests, it was assumed that a radio fix was established at the approach gate, and that conventional holding patterns were used for prop and jet aircraft. A conventional teardrop jet penetration pattern was used. Penetration and approach patterns are shown in Fig. 4.

While the conventional jet penetration was satisfactory for single, isolated approaches, tests showed that it was very awkward for use in radar spacing operations, due to its long final approach path and its consequent lack of flexibility. After the aircraft had started its turn at the outer end of the teardrop pattern, it was very difficult for the controller to apply effective path-stretching techniques to secure precise spacing of this aircraft behind the preceding aircraft. As a result, the controller tended to use far too much separation, which thereby reduced the airport-acceptance rate.

Simulation tests showed that this arrangement was very inefficient functionally, primarily due to the presence of holding aircraft on the final approach course. Their presence made it necessary to lengthen the jet penetration pattern, to assure that the jet aircraft would have altitude separation below the lowest holding aircraft before reaching the holding area on final approach. In addition, the display clutter problem caused by the additional aircraft flying in the vicinity of the outer marker made it extremely difficult for the controller to provide radar spacing procedures in securing optimum separation between successive aircraft in the approach sequence.

Approach System 2.

As an improvement over the outer marker stacking system, both the prop and the jet stacks were offset from the final approach course as shown in Fig. 5. The relocation of the holding patterns improved the display clutter problem in the vicinity of the outer marker and consequently made it much easier for controllers to space aircraft on the final approach path. However, tests showed that this layout was still very difficult to work. Because prop and jet aircraft were maneuvering in the same area, the radar display problem in this area was somewhat confusing at times due to overtaking and crossing flight paths.

The holding fix for prop aircraft was farther away from the approach gate than actually was necessary. This increased controller workload considerably by requiring more aircraft to be under radar vector control simultaneously between the holding fix and the outer marker. In turn, this factor added to the radar identification and communications workload.

When the jet vector pattern was deliberately kept away from the prop vector pattern, the jet final approach path tended to become excessively long, thus increasing the difficulties associated with the proper spacing of successive aircraft on the final approach path.

The best feature of this layout was the fact that the jet pattern was aligned crosswise to the initial penetration path. Tests showed that this feature enabled jet aircraft to be peeled off the holding pattern at more accurate intervals since these aircraft could turn into the penetration path almost directly from any point in the holding pattern. This represented a considerable improvement over the usual procedure of peeling aircraft off the end of a holding pattern. The latter procedure is handicapped, where jet aircraft are concerned, by their slow turning rate at high altitudes and their consequent lack of maneuverability.

Approach System 3.

To reduce controller workload and increase safety, jet and prop approach patterns were placed on opposite sides of the final approach course. Dual overhead holding patterns were established at the final approach gate, at both Andrews and Davidsonville, as shown in Fig. 6. All approach patterns were essentially triangular. The segregation feature proved to be an excellent improvement, from the radar controller's standpoint.

Approach System 4.

The air route tests had indicated that Andrews and Davidsonville together would not be able to handle much more IFR traffic than either airport alone, due to mutual interference and the lack of independent routes. In view of this factor, as well as the severe shortage of usable airspace for jet climbouts, tests were made to determine the feasibility of eliminating one jet holding pattern and sharing the other jet pattern to feed both airports. The only practical siting arrangement for a common jet holding pattern appeared to be somewhere between the two final approach courses. Three locations were tested: Columbia, Andrews Range, and Upper Marlboro. The latter site is shown in Fig. 7. Neither of the first two sites allowed adequate room for the jet descent to Davidsonville, without coming uncomfortably close to restricted area 35. The final site was somewhat better. However, the presence of the restricted area continued to limit the flexibility of path-stretching operations which could be employed for jet aircraft.

Prop approaches were made on the west side of the final approach course at Andrews, and on the east side of the approach course at Davidsonville, to continue the segregation policy which had worked out so well in the previous tests. Care had to be taken to keep Andrews prop approaches well clear of the radar vector area for Washington National Airport.

Results indicated that this system was workable, although somewhat more difficult to operate due to restrictions in the amount of airspace available for radar vectoring operations. As would be expected, the use of a single jet holding pattern instead of two tended to raise the entry altitudes of jet aircraft in the problem. Because of the joint use of a single feeding system for these aircraft, this approach system would not be recommended for adoption unless a common radar approach control facility were established for the two fields.

Approach System 5.

In order to keep the Davidsonville prop holding area clear of Red Airway 45 and also to provide more room for radar spacing operations at Washington National Airport, System 3 was modified as shown in Fig. 8. The resulting layout, known as System 5, functioned very well as far as Davidsonville operations were concerned. The presence of holding aircraft flying on the approach course in the vicinity of Andrews Range presented some difficulty in checking the spacing between successive approaches on the Andrews glide path. However, this situation could be resolved easily if a precision approach radar (PAR) were available to monitor the Andrews final approach course.

Measurements.

Communications data from the terminal area tests are shown in Fig. 9. Approach system acceptance rates are shown in Fig. 10.

Navigation Aids.

At a preliminary conference held in Washington on December 12, 1956, the Navy representative stated that all aircraft based at Davidsonville would be equipped with TACAN. For this reason, considerable thought was given during this simulation study to the optimum location for a TACAN facility serving this airport.

Due to the extremely wide "cone" existing over present TACAN facilities, it is desirable that the TACAN information used for establishing a high-altitude jet holding pattern be obtained from a facility a number of miles away rather than a facility directly underneath the holding pattern. Thus, a TACAN facility located in the immediate vicinity of an airport would not be desirable for the establishment of an overhead jet holding pattern.

In the case of Approach System 5, TACAN guidance for the Davidsonville overhead jet pattern could be obtained from a VORTAC site at Herndon, Virginia, while guidance for the overhead jet pattern at Andrews could be obtained from a similar site at Haymarket, Virginia.

It is considered desirable that the TACAN station associated with an airport be able to furnish approach guidance to the pilot, particularly under conditions when radar guidance is not available. Therefore, if a TACAN station is considered for installation at Davidsonville, it should be sited on or very close to the centerline of the northwest/southeast runway. If the station could be located about 5 miles southeast of the airport, it could also serve as the radio fix for the Davidsonville prop holding pattern as shown in Fig. 8. If it is more desirable, however, for economic or security reasons, to site the station on airport property, this would still perform the various desired functions if the prop holding pattern were shifted to a northwest/southeast direction. This pattern would then extend farther out into the jet penetration area, it would be very desirable to reduce the size of the holding area by specifying a maximum outer limit as shown in A of Fig. 11.

Holding Patterns.

Table V lists the areas required for Technical Standard Order (TSO) holding airspace reservations. Because of the critical shortage of airspace in the Washington-Baltimore area, extensive study was given during this project to possible methods of reducing these requirements. The dual-hinge pattern

TABLE V

AREAS OF TSO HOLDING AIRSPACE
RESERVATIONS, IN SQUARE MILES

Altitude MSL	Pattern Length	
	One-Minute	Two-Minute
30,000 and above	1030	1245*
29,000 to 20,000	457	553
19,000 and below	114	138

*For purposes of comparison, the area of the state of Rhode Island is 1248 square miles.

concept shown in A of Fig. 11 appears to be a practical method of exploiting air-derived distance information for this purpose. It could also be utilized by homing alternately on two radio transmitters, as shown in B of Fig. 11.

For a long time it has been realized that aircraft entering holding patterns from the side sometimes overshoot the boundaries of the TSO Area. To correct this condition, a new technique known as the tangential entry procedure was developed and tested during this program. This procedure, which is shown in Fig. 12, can be based on the use of either distance information or dual homing facilities. It avoids the large overshoots encountered at present and gets the aircraft lined up on the proper holding track in a minimum of time. Both techniques functioned very well in the simulation tests.

CONCLUSIONS

Specific Conclusions.

1. Activation of the Davidsonville Airport site would place another major airport in an area which is already crowded as far as present IFR airspace requirements are concerned. The Davidsonville site is too close to Andrews AFB to permit sustained, independent IFR operations at both fields. Because so much of the available airspace would have to be shared, tests indicated that the total IFR capacity of both fields would be little more

than that possible at Andrews alone, so long as present standards apply. This implies that any increase in such operations at Davidsonville will tend to decrease the total possible at Andrews. Heavy IFR traffic at Davidsonville would obviate the use of Victor Airway 16 as a main arrival route for Washington National Airport.

2. Because the total IFR capacity of a given area is limited largely by the number of independent traffic lanes which can function simultaneously, any significant increase in the total IFR capacity of the Davidsonville-Andrews area will require one or more of the following changes:

a. Reduction in the amount of airspace presently set aside for restricted and prohibited areas. It is especially important that action be taken to secure full use of the southern portion of restricted area 54, as shown in Fig. 3.

b. Implementation of new procedures, such as those shown in Figs. 11 and 12, to permit the reduction of TSO holding airspace reservations and jet penetration areas.

c. Implementation of more precise navigational techniques to permit the establishment of multiple airways with less than the ten miles lateral separation presently required.

3. Establishment of a combined radar approach control facility to serve both Davidsonville and Andrews would reduce the coordination problems which would exist otherwise.

General Conclusions.

During this program, the basic problem of integrating multiple-airport jet and prop operations in a severely confined area required the development of a number of techniques and procedures which are expected to have general application in other airport areas as well. The most important developments are listed below.

1. While not as easy to control as the offset holding pattern, it was found that the overhead pattern shown in Fig. 13 functions very well, provided that continuous target tracking is available either through the use of a beacon system or an offset primary radar site.

2. Tests showed that the conventional teardrop penetration pattern, as shown in A of Fig. 13, is poorly adapted for radar spacing operations. From the time the turn is started at the outer end of the pattern, very little can be done to adjust the spacing of this aircraft behind the preceding aircraft.

The triangular penetration path shown in B of Fig. 13 proved far superior. After the aircraft started a turn to the base-leg heading, the radar controller could use simple path-stretching techniques to space this aircraft behind the one ahead.

3. It was found that approach spacing operations for jet aircraft are considerably more difficult to accomplish than those required for propeller aircraft, because of:

a. The very slow turning rate of jet aircraft at high speeds.

b. The need for a relatively long uninterrupted descent path from the initial penetration altitude to the final approach altitude. For example: Category 1 jet aircraft in this problem required approximately 32 miles to descend from 20,000 to 2,000 feet.

c. The large variation between the initial penetration speed and the final approach speed.

To alleviate these problems, the following techniques were developed:

1. Align the jet holding pattern in a direction which will allow aircraft to leave the pattern laterally, instead of at the end, permitting more flexibility and thus enabling the controller to peel off successive aircraft at accurate intervals in spite of the very slow turning rate of the aircraft in the pattern. This pattern arrangement could not be used in certain cases due to the configuration of the available airspace.

2. Require the pilot to report vacating each 5,000-foot level to keep the controller aware of the progress of the descent and thus enable him to keep the penetration path as short as possible and still allow adequate time for descent.

3. Request the pilot to report when he is slowed down at the final approach altitude to help the controller to anticipate when the aircraft will be able to make turns at the standard rate of three degrees per second.

4. Conduct radar path-stretching operations of jet and prop aircraft on opposite sides of the final approach course to simplify the spacing operation and also increase safety by eliminating most of the overtaking situations in the radar vector area.

RECOMMENDATIONS

The following recommendations are contingent on a decision by the Department of the Navy to complete the establishment of the Davidsonville Naval Air Station.

It is recommended that:

1. The approach facilities be set up for final approaches to the northwest.

2. The northwest/southeast runway be shifted counterclockwise so that its extended center line will pass about two miles east of restricted area 35, unless free use of restricted area 35 can be obtained for instrument approach operations.

3. The Davidsonville TACAN facility be sited either on the airport surface, very close to the northwest/southeast runway, or on the final approach course about five miles southeast of the airport.

4. Approach System 5, as described in this report, be adopted for Davidsonville.

5. Immediate action be started to secure as many as possible of the recommended airway and restricted area modifications listed in Table II. It is especially important that free use be obtained of the south end of restricted area 54, as shown in Fig. 3.

6. Action be started to reduce TSO airspace requirements for holding patterns based on TACAN facilities, through the use of specified range limits for each end of the pattern.

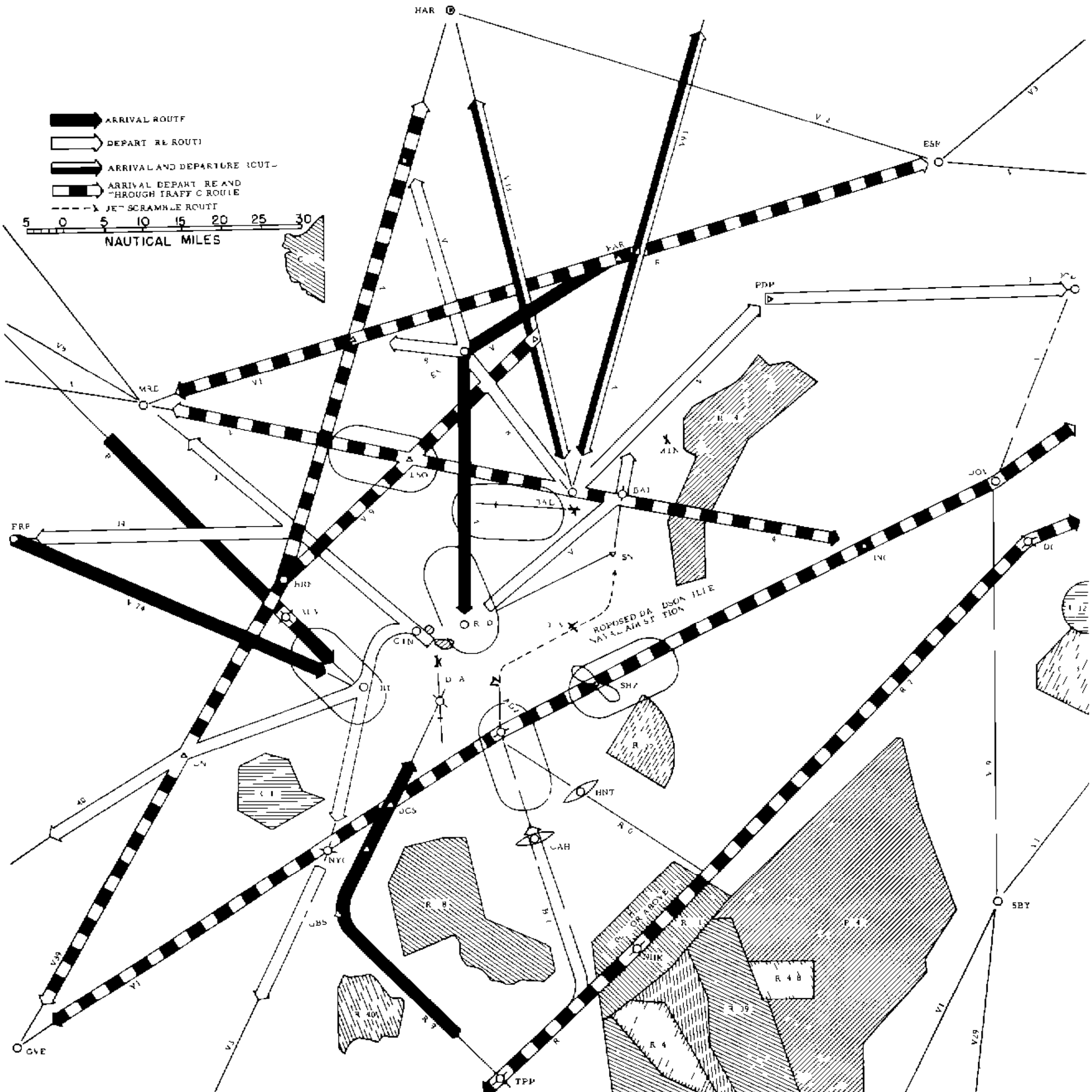


FIG I PRESENT ROUTE STRUCTURE

CAA TECHNICAL DEVELOPMENT CENTER INDIANAPOLIS INDIANA

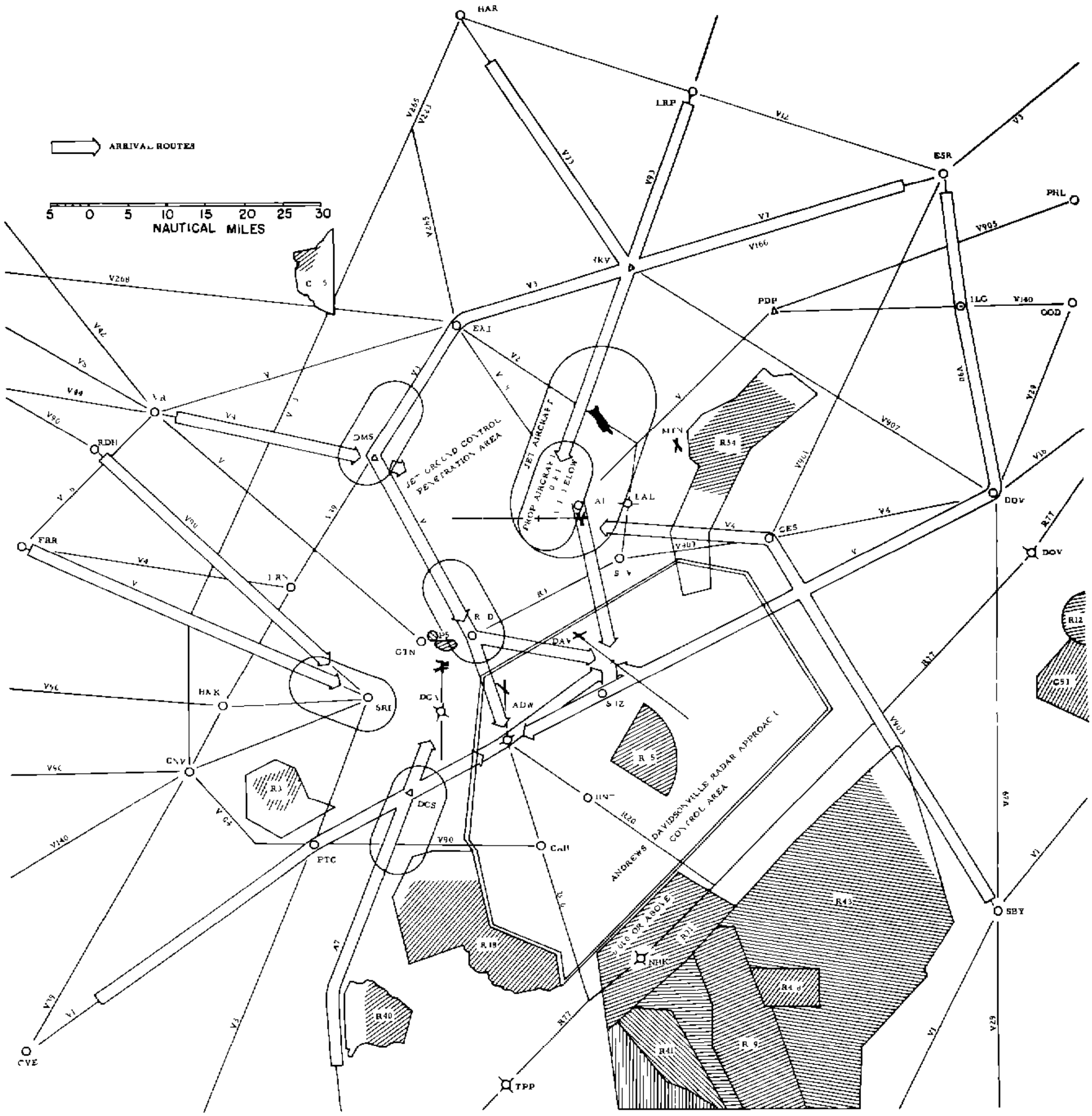


FIG 2 ARRIVAL ROUTES — MODIFIED ROUTE STRUCTURE

CAA TECHNICAL DEVELOPMENT CENTER INDIANAPOLIS INDIANA

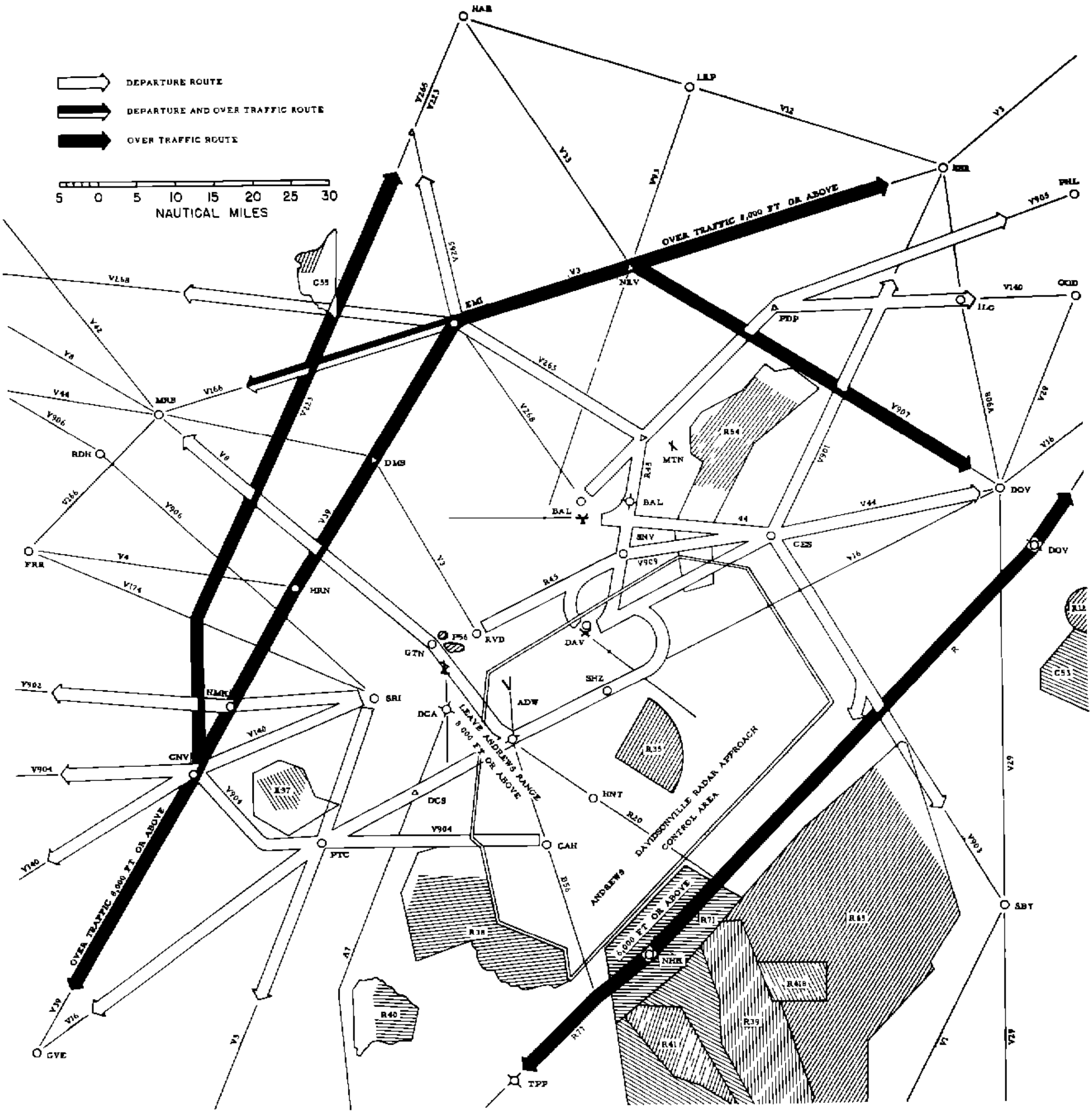


FIG 3 DEPARTURE ROUTES — MODIFIED ROUTE STRUCTURE

CAA TECHNICAL
DEVELOPMENT CENTER
INDIANAPOLIS INDIANA

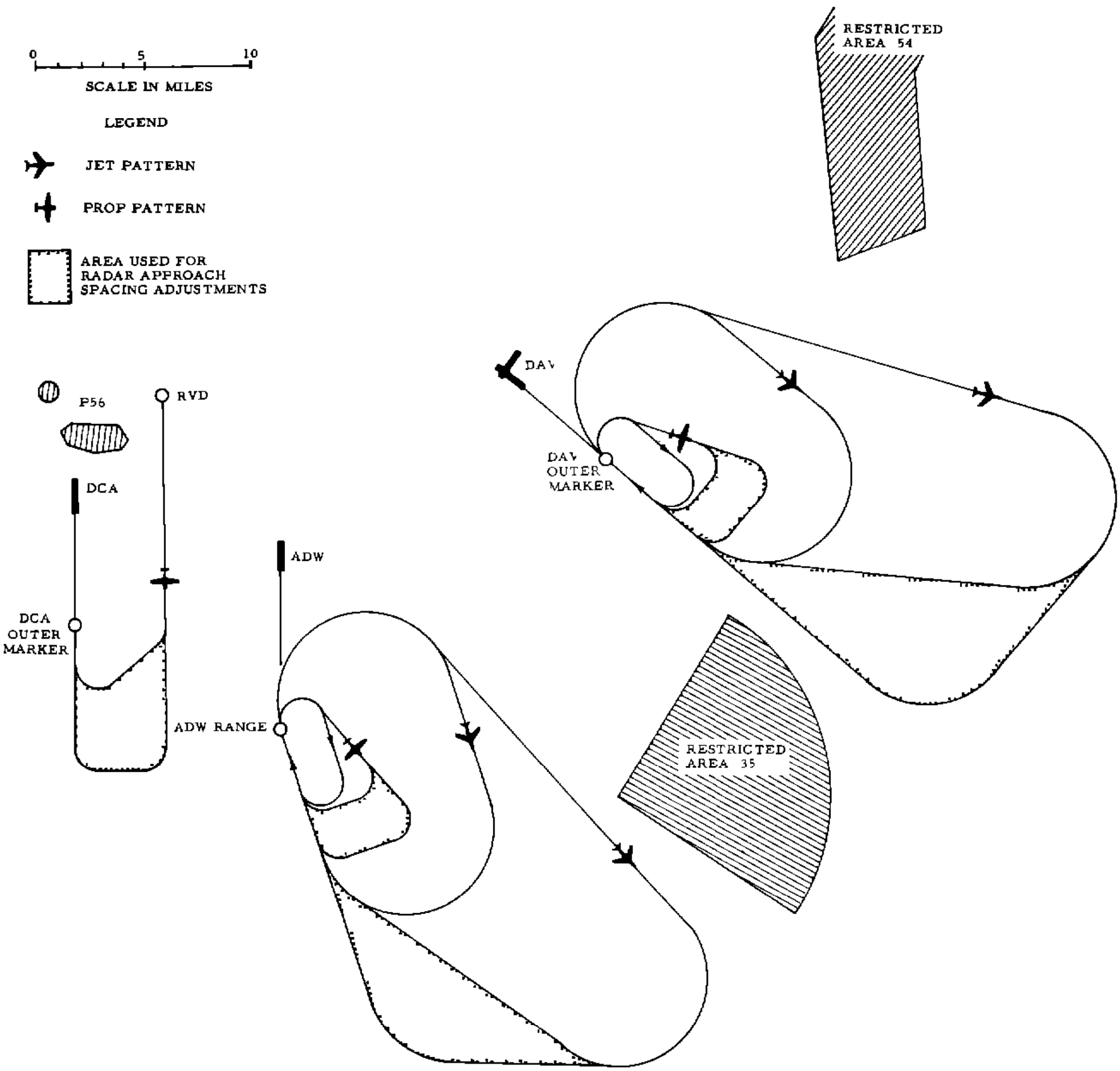


FIG 4 APPROACH SYSTEM 1

CAA TECHNICAL
DEVELOPMENT CENTER
INDIANAPOLIS INDIANA

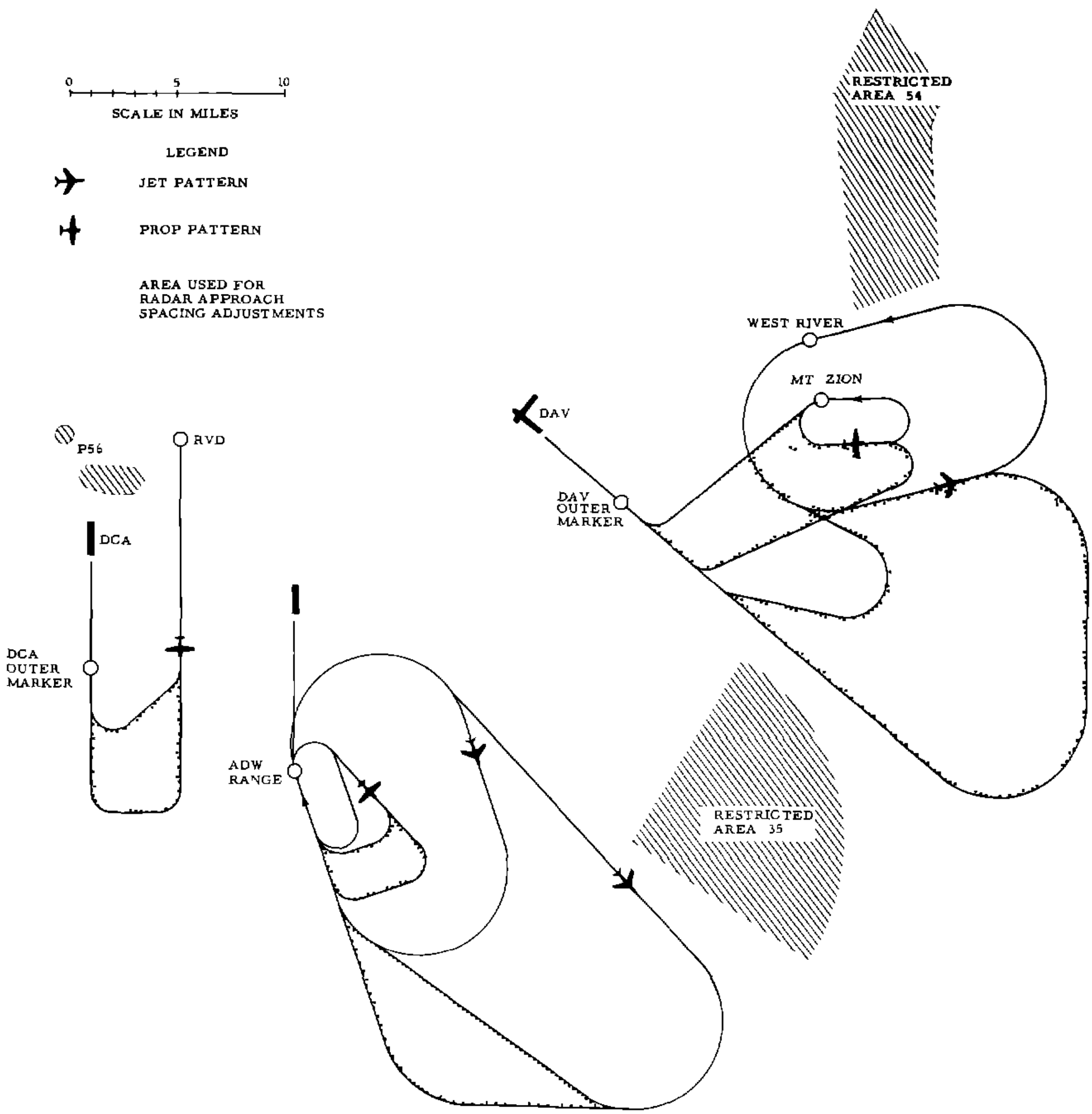


FIG 5 APPROACH SYSTEM 2

CAA TECHNICAL
DEVELOPMENT CENTER
INDIANAPOLIS INDIANA

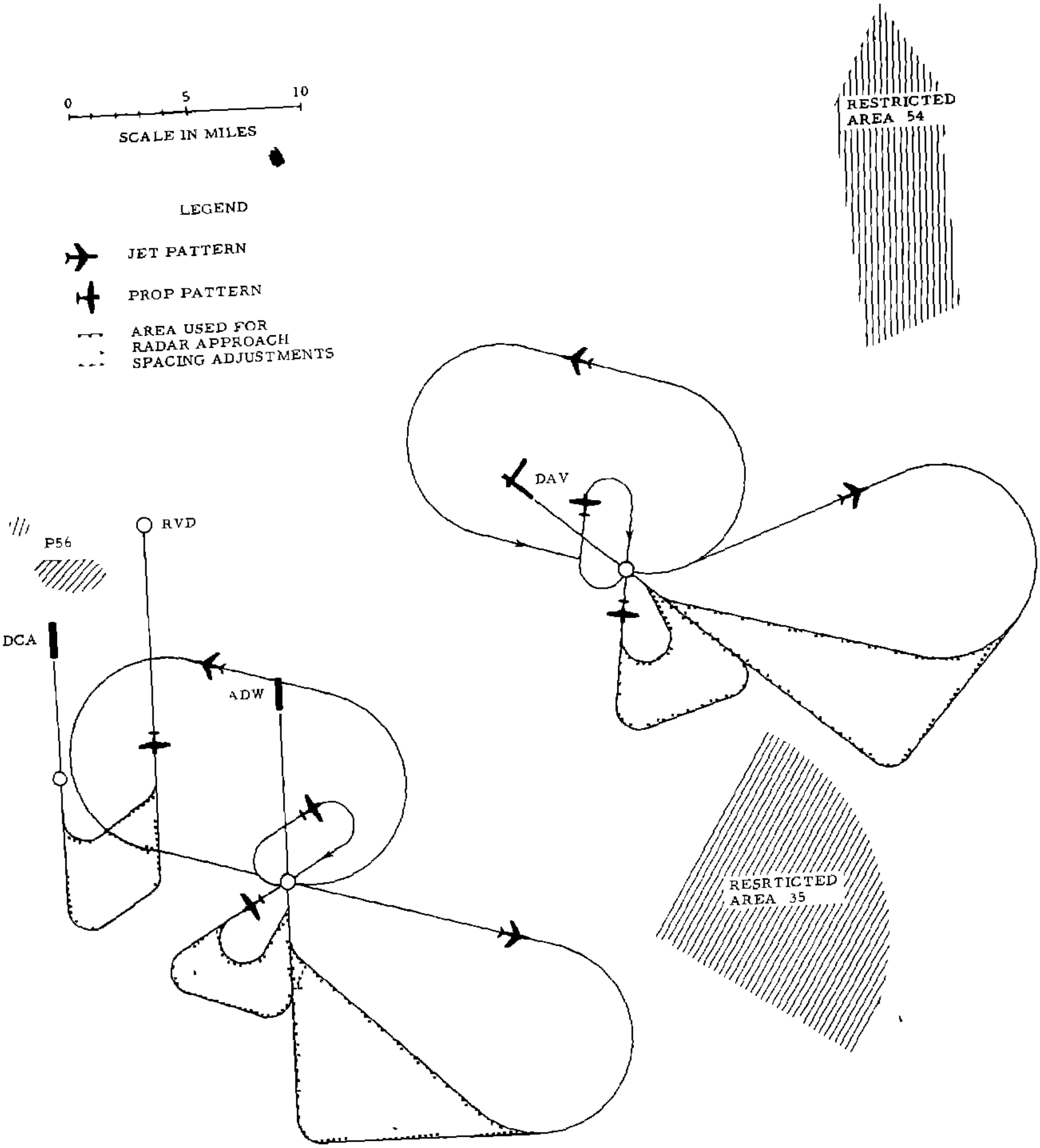


FIG 6 APPROACH SYSTEM 3

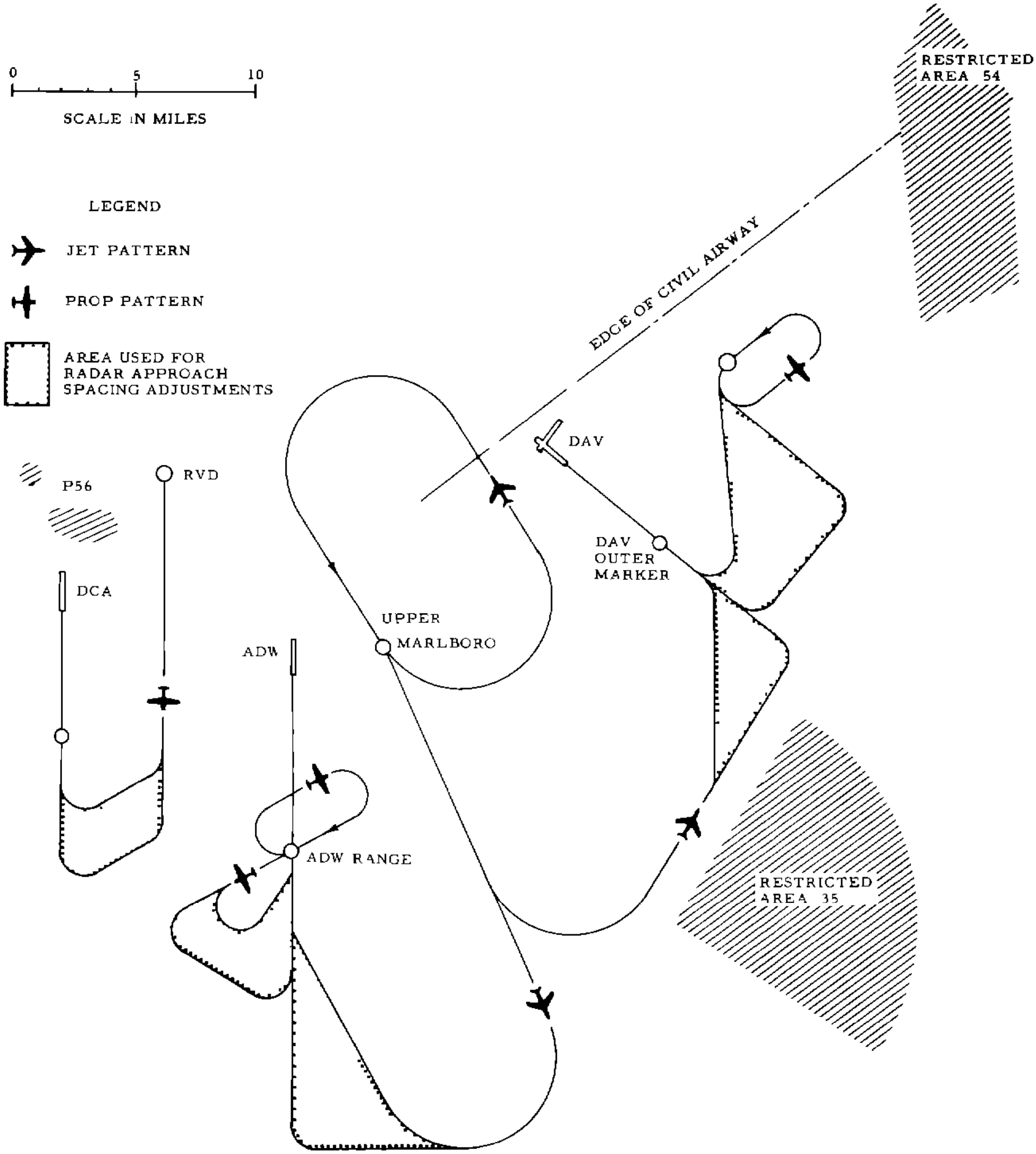


FIG 7 APPROACH SYSTEM 4

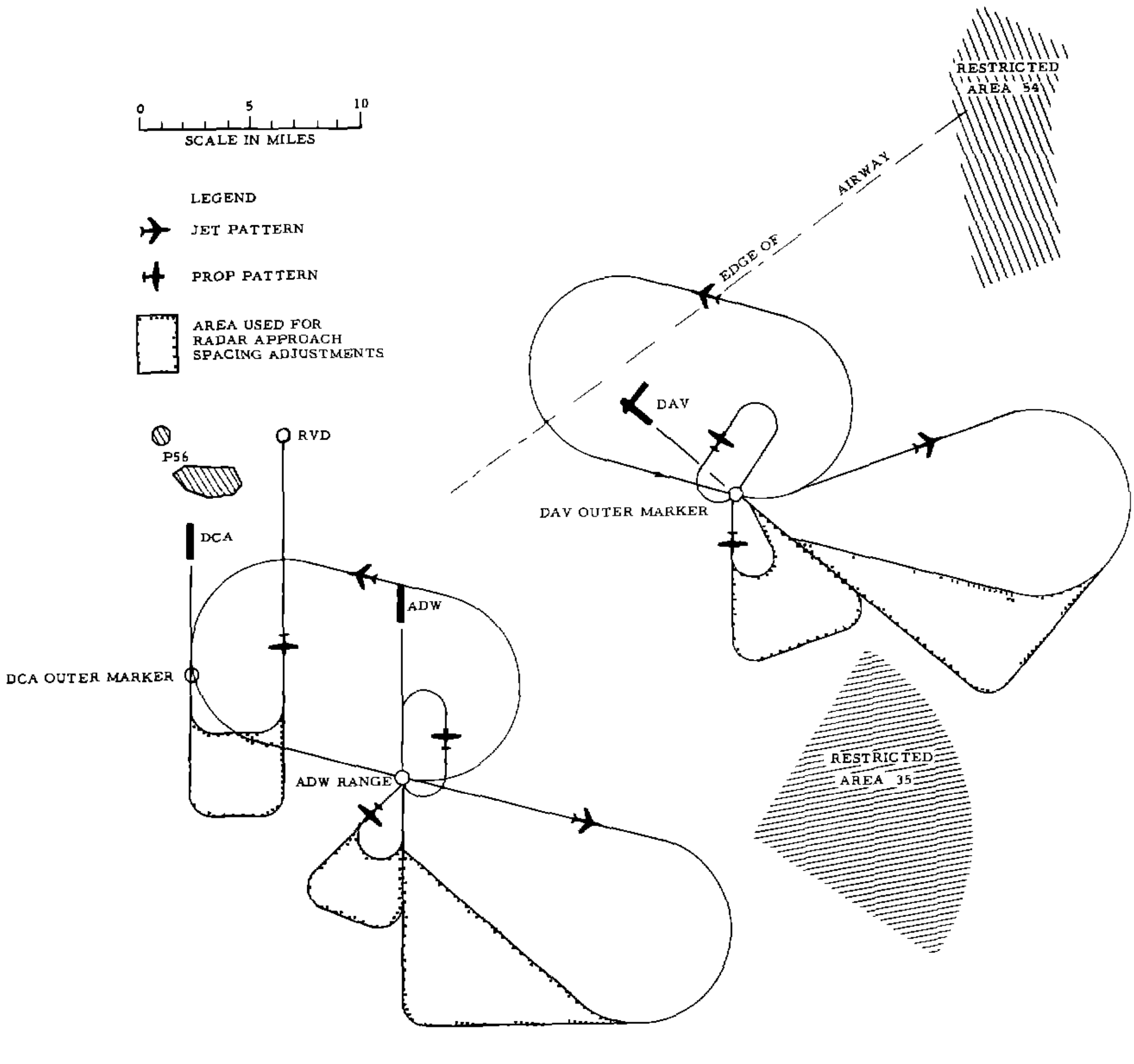


FIG 8 APPROACH SYSTEM 5

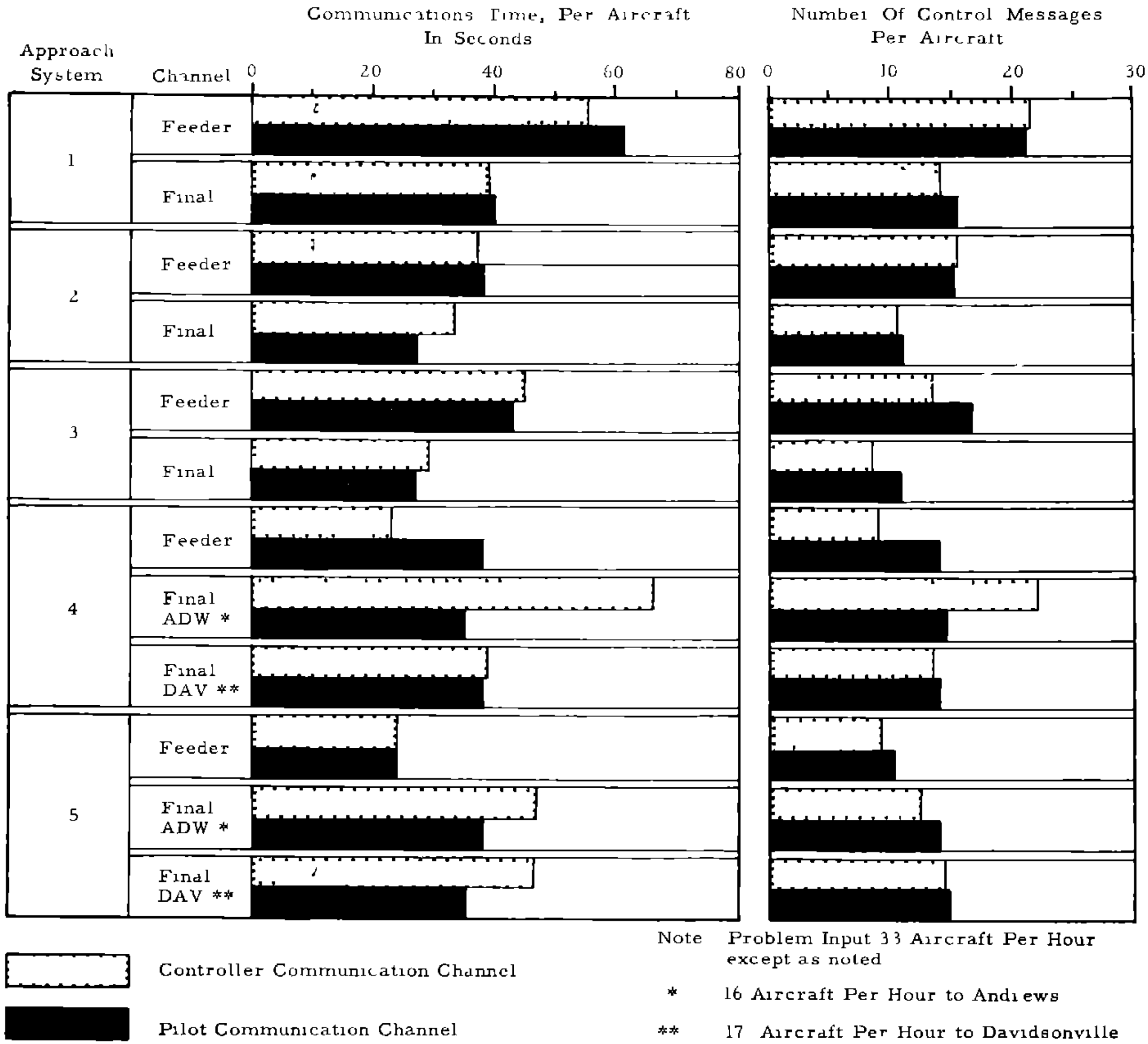
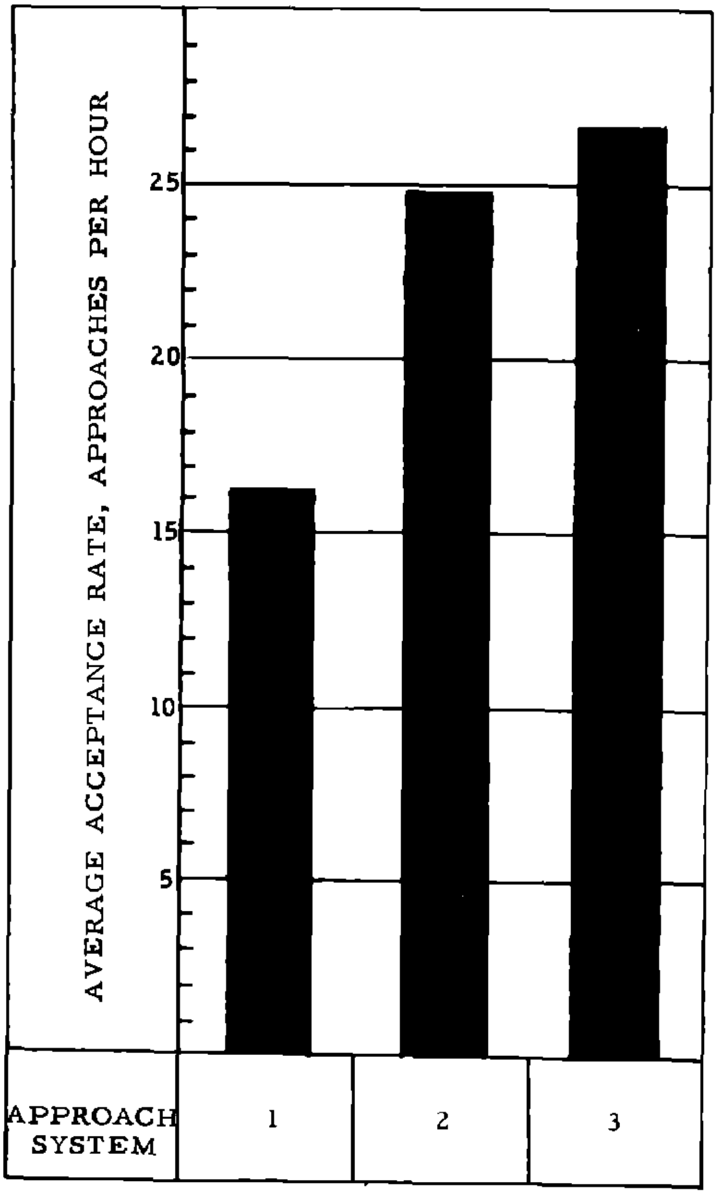


FIG 9 COMMUNICATIONS DATA - TERMINAL AREA TESTS



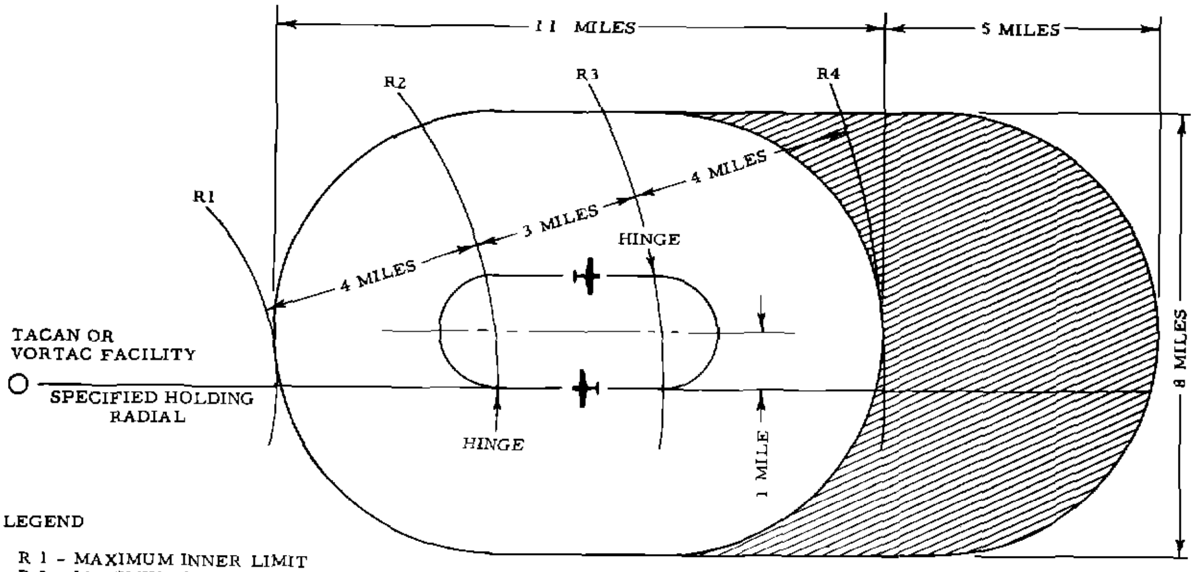
TRAFFIC SAMPLE
35 JETS, 8 PROPS
DEMAND RATE 33
AIRCRAFT PER HOUR

NOTE

APPROACH SYSTEMS 4 AND 5 NOT TESTED AT MAXIMUM DEMAND RATE SYSTEM 4 SHARED JET PATTERN BETWEEN DAVIDSONVILLE AND ANDREWS SYSTEM 5 IS ALMOST IDENTICAL TO SYSTEM 3 AS FAR AS DAVIDSONVILLE PORTION IS CONCERNED.

RATES SHOWN REFLECT LIMITATIONS OF APPROACH SYSTEM ONLY WITHOUT REGARD TO AIR ROUTE RESTRICTIONS

FIG. 10 DAVIDSONVILLE AIRPORT ACCEPTANCE RATES ATTAINED IN TERMINAL AREA TEST PHASE

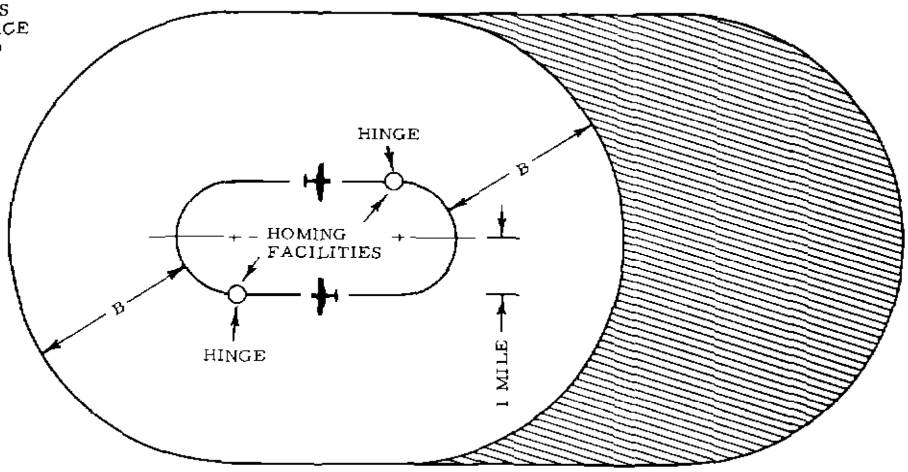


LEGEND

R 1 - MAXIMUM INNER LIMIT
R 2 - MAXIMUM OUTER LIMIT
R 3 - DESIRED TURNING POINT
R 4 - DESIRED TURNING POINT
B - STANDARD 3-MILE TSO BUFFER

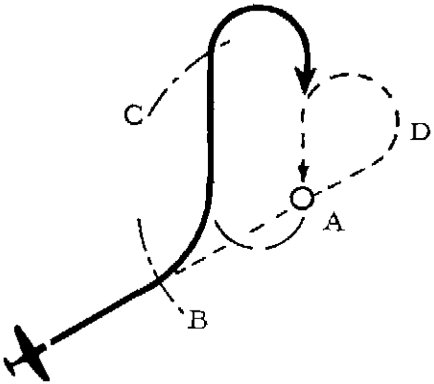
SHADED AREA INDICATES
PORTION OF TSO AIRSPACE
RESERVATION NOT USED

A - USE OF TACAN OR VORTAC



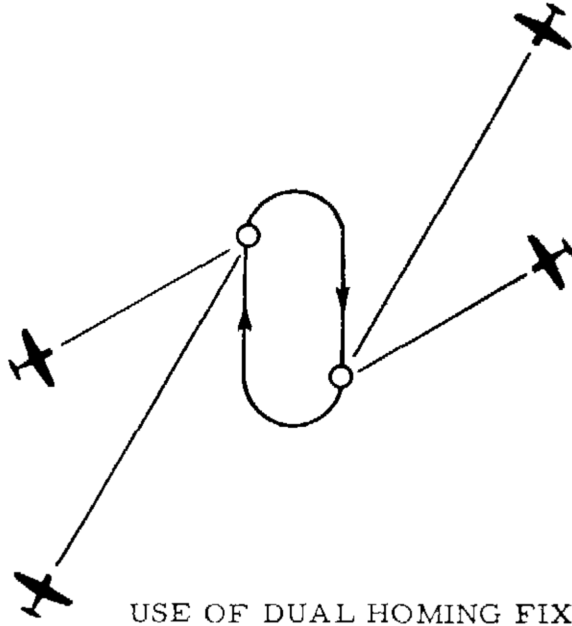
B - USE OF DUAL HOMING FACILITIES

FIG 11 DUAL-HINGE HOLDING PATTERNS



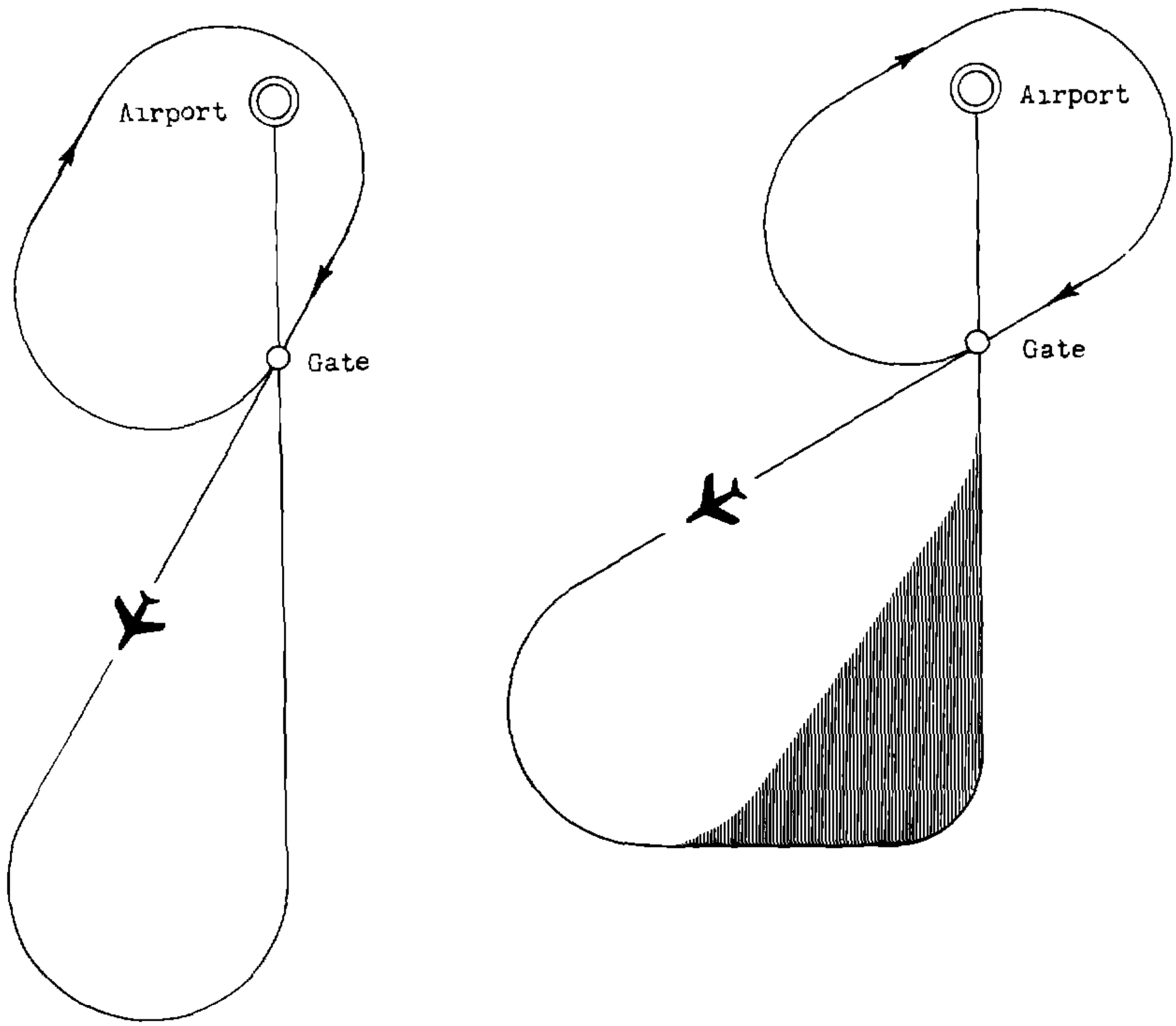
USE OF DISTANCE INFORMATION
TO PERMIT TANGENTIAL ENTRY
TO HOLDING PATTERN OVER TACAN
OR VORTAC STATION

A - RADIO FIX
B - DISTANCE AT WHICH PILOT STARTS TURN TO OUTBOUND HEADING
C - DESIRED TURNING LINE
D - CONVENTIONAL ENTRY PATH



USE OF DUAL HOMING FIXES
TO PERMIT TANGENTIAL ENTRY

FIG. 12 TANGENTIAL ENTRY PROCEDURES



A Conventional
Jet Penetration

B Triangular
Jet Penetration

Shading Indicates Area Available
For Path Stretching

Fig 13 PENETRATIONS FROM OVERHEAD HOLDING PATTERNS