SRP 1612

# TECHNICAL DEVELOPMENT REPORT NO. 398

## DYNAMIC SIMULATION TESTS OF SEVERAL AIR TRAFFIC CONTROL SYSTEMS FOR THE KANSAS CITY AREA

**FOR LIMITED DISTRIBUTION**

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March 1959

1647

FEDERAL AVIATION AGENCY
TECHNICAL DEVELOPMENT CENTER
INDIANAPOLIS, INDIANA

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# OF SEVERAL AIR TRAFFIC CONTROL SYSTEMS
# FOR THE KANSAS CITY AREA

## SUMMARY

This report describes a study of various proposed air traffic control procedures and en route layouts for the Kansas City area, in preparation for an anticipated increase in IFR traffic and the full operation of the Mid-Continent International Airport. These studies were conducted through the use of the dynamic air traffic control simulator at the Technical Development Center, Indianapolis, Ind.

Tests indicated that the present system cannot accommodate a large increase of traffic at Mid-Continent International Airport. Modifications to the feeding systems and the departure routes produced a much more efficient layout. An approach procedure tested for north landings at Kansas City Municipal Airport functioned satisfactorily, and produced a decided increase in traffic capacity over the circling approach procedure presently used for north landings.

Numerous changes in the route structure provided the Olathe radar facility with segregated departure and arrival routes for Forbes, Olathe, and Grandview. Predetermined departure routes reduced coordination between arrival and departure controllers, and reduced controller workload further by allowing pilots to take over most of the responsibility for navigating their aircraft to the exit points.

Tests of a common IFR room for the Kansas City-Olathe area effected large reductions in coordination time, and also improved the utilization of available airspace.

## INTRODUCTION

In May 1958, the CAA Office of Air Traffic Control requested the Technical Development Center (TDC) to conduct a study of possible improvements to the air traffic control (ATC) system in the Kansas City area. In December 1958, TDC representatives spent four days observing traffic operations at the Kansas City Air Route Traffic Control (ARTC) Center, Tower, and the Olathe RAPCON to gather background material for this study. Discussions with the local ATC and Third Regional office personnel indicated that several of the problems could be solved locally without recourse to the TDC dynamic ATC simulator. It was decided that the following principal problem areas were to be considered in the simulation tests·

1. The Kansas City terminal area soon will be complicated by a considerable increase of activity at International (Mid-Continent International Airport).

2. Military jet traffic generated in the Olathe area creates an unwieldy coordination problem between the Center and the RAPCON, and within the confines of the RAPCON itself

3. The convergence of over-traffic in the Kansas City terminal area creates a difficult problem for the Center in descending arrivals, in climbing departures, and in separating terminal traffic and over-traffic

4. The lack of an instrument approach to land north at Municipal (Kansas City Municipal Airport) requires the use of a very inefficient circling approach under certain wind conditions

Objectives.

The following objectives for the simulation were established·

1. Provide improved arrival and departure routes to serve either Municipal alone, or both Municipal and International when the volume of traffic increases substantially at the new airport. Locate suitable terminal area feeder fixes to serve each airport as independently as possible.

2. Develop procedures within the Olathe RAPCON which would.

a. Segregate operations of Forbes, Olathe, and Grandview to such a degree that intrafacility coordination would be minimized.

b. Develop suitable departure routes, based on navigational facilities, which would minimize radar vectoring by the departure controllers.

c. Channel arriving jet aircraft over fixes that would serve best the airport of intended landing, and at altitudes that would not conflict with the jet departure procedures.

3. Devise an airway structure as compatible as possible with existing traffic flow, yet designed to bypass most of the over-traffic around the terminal area.

4. Using present safety criteria, establish instrument approach procedures for north approaches to Municipal, and for both north and south approaches to International.

5. Study the operation of a common IFR room in which the functions of the ARTC Center, the Olathe RAPCON, and Kansas City Tower IFR control positions would be incorporated.

Ground Rules

At a meeting with Third Regional office personnel on December 19, 1958, it was decided that the simulation tests should be based on the following assumptions·

1. The area simulated would include the airspace within a radius of 80 nautical miles of the Kansas City VOR.

2. Adequate air/ground communications will exist between control facilities and all IFR flights within the area simulated.

3 Adequate radar or radar/beacon coverage will exist throughout this area.

4. Civil jets will operate at Municipal and International Airports.

5. The future airway structure will be based entirely on VHF navigational aids.

6 Anticipating a probable change, the holding airspace area defined in TSO N20A will be increased in width by 50 per cent for all altitudes below 20,000 feet, as shown in Fig. 1.

7. Civil jets will be controlled in a conventional manner, except that any extended delay will be absorbed at high altitudes when possible.

8. A large percentage of the over-traffic will be rerouted to bypass the Kansas City terminal area.

Simulation tests commenced on January 12 and were concluded on February 6, 1959. A total of 34 runs were made in which approximately 6,000 aircraft flights were simulated. Time limitations prevented the study of a system of an improved airway structure utilizing areas now delegated to the Olathe and Whiteman RAPCON's.

## EVALUATION METHODS

Aircraft delays, arrival rates, and communications data were recorded during each run of the simulation. However, due to the many uncontrollable variables in a simulation study of this magnitude, it was not always possible to accomplish a sufficient number of runs to secure statistically valid results. The controllers from Kansas City Tower and Olathe RAPCON were experienced in the use of radar However, the controllers from the Kansas City ARTC Center had received little or no training previously in radar vectoring or procedures, so that the test results were affected considerably by the learning factor.

A questionnaire was completed by each controller after each run that was concerned with a change in route structure or procedures At the conclusion of the simulation study, a meeting was held at which a tape recording was made of all the opinions expressed by the controllers who participated in the program. The opinions and recommendations were relied upon to a large degree in the evaluation of the tests.

Traffic Samples.

Sample 1, which was used in connection with System A, was based on an actual peak traffic condition which occurred in the Kansas City control area between the hours of 2000 and 2200 GMT on September 23, 1958. To create the desired traffic density for these tests, the traffic between these hours was compressed into a 1 1/2-hour sample. Additional traffic then was injected to build up the desired arrival and departure rates for the airports concerned. This resulted in a sample containing 204 flights, distributed as follows:

| Airport | Arrivals | Departures |
|---|---|---|
| Municipal | 40 | 38 |
| Forbes | 22 | 16 |
| Grandview | 16 | 19 |
| Olathe | 15 | 17 |
| Phillip Billard | 2 | 3 |
| International | 5 | 0 |

11 Overflights

Sample 2, used in tests of Systems B and C, was designed to simulate future traffic conditions in the Kansas City terminal area. This required an increase in the number of operations at International, so that approximately 75 per cent of the operations at International and 25 per cent of the operations at Municipal would be jet-type. This 1 1/2-hour sample contained 206 flights, distributed as follows:

| Airport | Arrivals | Departures |
|---|---|---|
| Municipal | 32 | 33 |
| Forbes | 19 | 21 |
| Grandview | 15 | 15 |
| Olathe | 15 | 14 |
| Phillip Billard | 1 | 3 |
| International | 20 | 18 |

No Overflights

As a result of the development of new jet procedures for the Olathe RAPCON, the need was felt for a high-altitude simulation study. This study was designed to determine if the ARTC could adapt its high-altitude operation to handle jet aircraft departing the Olathe area at "straight" altitudes; that is, 24,000, 25,000, 26,000, and 27,000 feet, and blend this traffic with the existing high-altitude traffic.

In order to simulate this type of traffic situation, a high-altitude sample was devised for use in conjunction with the present jet route structure. This 1-hour sample contained 85 flights, distributed as follows

| Airport | Arrivals | Departures |
|---|---|---|
| Forbes | 9 | 21 |
| Grandview | 8 | 19 |
| Olathe | 3 | 13 |

12 Overflights

In the high-altitude sample, all overflights were at assigned altitudes other than VFR conditions on top. Approximately 67 per cent of all the departures and 60 per cent of all arrivals requested, or were assigned, an altitude of VFR conditions on top. Tops were defined as being 35,000 feet. The location identifiers used in this simulation study are listed in Table I.

Equipment.

Kansas City approach control utilized three simulated airport surveillance radar (ASR) scopes, as shown in Figs 2 and 3. Olathe RAPCON utilized four simulated slant scopes, scan-conversion-type displays (CONRAC), as shown in Figs. 4 and 5 The Kansas City ARTC Center used two superimposed panoramic radar displays (SPANRAD), as shown in Figs. 6 and 7. During the common IFR room tests, the ARTC, approach control, and Olathe RAPCON all utilized SPANRAD's, as shown in Figs. 8 and 9.

Interphone lines were provided for communications between the three facilities. Radio channels were available and assigned as needed to the positions of control. Flight progress boards for tabular display were furnished

For approach spacing operations, curved reference lines at 3, 5, and 7 miles radius from the outer markers were marked on the radar maps. Spacing charts, as shown in Fig. 10, were used as an aid to establish optimum separation between arrivals

## KANSAS CITY TERMINAL AREA TESTS

General.

Tests of the Kansas City terminal area procedures were accomplished simultaneously with the tests of the ARTC Center and Olathe RAPCON procedures One objective of this program was to determine the optimum location and number of clearance limits. Whenever possible, unrestricted arrival and departure routes were provided. Due to the close proximity of Municipal and International Airports, arrivals and departures for both airports were controlled by the same facility. An approach from the southwest with a 27° turn to runway 36 at Municipal was provided during the simulation This allowed a more compatible system for Municipal and International.

The geographical relationship of Municipal and International Airports requires that several of the arrival and departure routes for each airport cross. When these crossings were accomplished by approach control, two methods of controlling arrivals and departures were evaluated. The first method divided responsibilities by airports. Both arrival controllers vectored from identical fixes. One controller vectored to Municipal and the other to International. Departures were divided in a similar manner. This method required coordination between the respective controllers whenever crossings were involved. The second method divided the responsibility by direction, east and west. Each arrival controller was assigned separate feeder fixes. Both controllers vectored to Municipal and International. Departures also were divided by direction. West and northwestbound departures were controlled by one controller; all south, east, and northeastbound departures were handled by the other controller.

Controller opinion favored arrivals being divided by airports. This was based on the fact that it was easier to vector to only one final approach course. Due to the number of altitudes available, departures were controlled more effectively and easily when the responsibility was divided east and west. This method required less coordination and enabled the controller to devote more time to a smaller area.

Procedures for each system required that all arrivals maintain an altitude of at least 5,000 feet until clear of all departure routes. Departures, when necessary, were restricted to 4,000 feet or below until clear of the arrival routes. When separation from arrivals was assured, departures were changed to Center control upon completion of a radar handoff.

For north operations at Municipal, delays were reduced substantially when utilizing the approach from the southwest as compared to approaching from the north and circling to land. These data are illustrated in Fig. 11.

System A.

Procedures.

System A is the present system as shown in Figs. 12, 13, and 14. For comparative purposes, a small amount of traffic was simulated to and from International. Approach control controlled altitudes of 4,000 feet and below at all feeder fixes with the exception of Blue Springs, at which altitudes of 7,000 feet and below were utilized. This was due to the fact that Olathe RAPCON controlled Kansas City arrivals to the Blue Springs VOR from the south, and southbound departures were changed to Olathe-Grandview departure control prior to entering the Olathe area.

Results.

The present feeder fixes are located to serve the only instrument approach system provided at Municipal, which is for south landings. A north operation requires arrivals to approach from this direction and, when contact, to circle and land. Excessive delays therefore are incurred by both departures and arrivals. Arrivals to International from the east create one or more crossing and possible confliction points with arrivals to Municipal. Due to the above, this system is incompatible with IFR operations at International and will not be able to supply the traffic demand of each airport.

If the standard holding airspace is increased, as shown in Fig. 1, the location of Kearney and Missouri City as feeder fixes will not meet the criteria for simultaneous holding at common altitudes.

System B.

Procedures.

This system is illustrated in Figs. 15, 16, and 17. The number of feeder fixes was reduced from the present system, and the altitudes at Blue Springs controlled by approach control were reduced to 5,000 feet and below. During this phase, traffic to and from International was increased.

Results.

System B eliminated several of the crossing points; however, a completely independent arrival system for each airport could not be provided with the route structure and location of the feeder fixes serving this system.

System C.

Procedures.

This system is illustrated in Figs. 18, 19, and 20. System C evolved from findings of Systems A and B, and required the addition of a new VOR at Trimble It also was necessary to realign and reverse the flows of traffic on Victor 10 and Victor 116 Airways. This allowed the ARTC Center to accomplish all necessary crossings outside of the terminal, and provided approach control with independent arrival systems for Municipal and International Airports.

To achieve the desired segregation and meshing farther out, the traffic flow between Chicago and Kansas City was reversed. Departures now proceeded via Victor 10. Arrivals for International were routed via Victor 116. Municipal arrivals were routed via Victor 116 to the Macon VOR, thence via Victor 206 to the Lexington Intersection and Victor 4 to Missouri City. Traffic from the east via St. Louis destined for International proceeded from St. Louis directly to the Macon VOR, where it meshed with the Victor 116 traffic.

Results.

The tests indicated that this system, if implemented in the near future, would serve present needs efficiently. During the interim period, the reversing of the traffic on Victor 10 and Victor 116 would not be necessary. A gradual changeover to System C could be accomplished when the number of operations at International increases to a point where crossings in the terminal area no longer are feasible.

## OLATHE RAPCON TESTS

### General.

The major problems in the Olathe RAPCON areas are created by the large number of turbojet aircraft operating from Forbes Air Force Base (AFB), Olathe Naval Air Station (NAS), and Grandview (Richards-Gebaur) AFB, and their relationship to the heavy flow of intermediate and high-altitude traffic operating in the ARTC area.

Four control positions were established as shown in Fig. 5. These included an Olathe-Grandview departure controller, an Olathe-Grandview arrival controller, a Forbes-Phillip Billard departure controller, and a Forbes-Phillip Billard arrival controller. An extension of the present Olathe area No. 1, to include all of the area northwest of a line drawn from the southwest corner to the northeast corner of caution area 198, was assumed for the entire test period. At Olathe and Grandview, approaches were made only from the south. When landings to the south were necessary, it was assumed that the respective GCA units would vector the aircraft from the approach lane to landing. Low-altitude control between Phillip Billard and the Kansas City Airports was exercised on an approval request basis for each flight.

### System A.

#### Procedures.

These tests were made to determine the ability of the present system to absorb the increased traffic demand imposed by Sample 1. Olathe areas Nos. 1 and 2 are shown in Fig. 21. As in the present system, Olathe RAPCON controlled all altitudes within these areas as well as 4,000 feet and below in the Topeka area. Jet arrivals were fed by the ARTC Center to Emporia, Butler, or St. Joseph VOR's, or the Chanute, Forbes, or Kansas City low-frequency (LF) ranges, usually at cruising altitudes. Propeller-driven (prop) arrivals were fed to Topeka VOR, Butler VOR, Chanute LF range, Forbes LF range, Maple Hill Intersection at 5,000 feet and above, and to Bonner Springs at 6,000 feet and above Props from the east landing at Grandview or Olathe were cleared to Blue Springs at 8,000 feet and above. From these fixes, the arrival controller normally vectored the aircraft to the appropriate final approach course.

Although on-course coded departure routes are in existence, the ARTC Center normally requires aircraft to climb to cruising altitude before leaving the Olathe RAPCON areas. Departures were vectored within the Olathe areas to cruising altitude before being released to the ARTC Center. Coordination was effected between facilities when over-traffic proceeded through the Olathe areas. Five test runs were made, totaling 8 hours 35 minutes.

It became apparent during initial test runs that the present procedure of having the Olathe departure controllers vector departures around the area until they reached cruising altitudes created a serious coordination problem. Traffic patterns were complicated further by the large number of arrival fixes being fed by the ARTC Center. This created mutual interference between the departure and arrival patterns for all three major airports in the Olathe area.

The many crossing points required the controller to coordinate, or at least give his special attention to the situation. This coordination created a progressive time loss which was reflected throughout the system, since any excessive vectoring or lengthy attention which the controller has to give an aircraft reduces the time which he has available for monitoring the over-all traffic picture or for adjusting the spacing between aircraft under his control

The proximity of Victor 10 and Victor 12 Airways to the Forbes approach and departure paths caused some difficulties in that departing aircraft were forced to tunnel out at low altitudes until reaching area No. 1 or area No. 2. Arrivals also were forced to leave these areas at low altitudes and tunnel approximately 30 miles to the airport.

Because of frequent potential conflictions between Forbes-Olathe traffic and Amber 4 traffic, it was decided that Amber 4 should be eliminated and the traffic rerouted via Victor 161.

Traffic flying that portion of Victor 13 and Victor 71 Airways between the Kansas City and Butler VOR's restricted aircraft arriving and departing Grandview and Olathe NAS to a very great degree. That segment of the airway was deleted and traffic was rerouted via Victor 161. Even though it appeared desirable for Grandview and Municipal to operate in the same direction, definite overlaps in flight paths pointed to the need for well-defined altitude restrictions in the area north of Grandview.

System B.

Procedures.

To simplify the coordination and radar vectoring workload, Olathe area No. 1 was subdivided into a number of smaller areas, as shown in Fig. 22, to accommodate a number of segregated arrival and departure routes. These routes were set up so that the pilots could perform most of their own navigation, with very little assistance by the radar controller Following is a list of the subdivided areas.

Area A: Used to provide transition routes for the Olathe-Grandview arrivals coming from the north and northeast. These flights were restricted to 6,000 feet and above until reaching area C. Departures were restricted to 5,000 feet and below until reaching the climb areas.

Area B: Controlled by the Olathe-Grandview departure controller, and used for departures climbing out to Butler or Blue Springs, and over-traffic on Victor 161 and Victor 205W.

Area C: A descent area for traffic landing at Olathe or Grandview.

Area D· Southwest departure route for Olathe traffic and some Grandview traffic. Traffic was restricted to 14,000 feet and below until reaching area E.

Areas E and G· Extension of the southwest departure route. Choice of routes over Emporia or Butler was available. This area was restricted to altitudes of 27,000 feet or below.

Area F: This area was used by traffic to and from Forbes. When Forbes was operating northwest, arrivals utilized this area and maintained an altitude of 15,000 feet and above until clear of area D. When operating southeast, area F was used for departures. They were required to enter area D at 15,000 feet or above.

Five VOR's were used as feeder fixes for jet arrivals. These were Chanute, Butler, Blue Springs, Topeka, and St. Joseph. Feeding altitudes were 28,000 feet and above. Prop arrivals were fed to the Blue Springs, Butler, and Topeka VOR's, as well as the Maple Hill and Bonner Springs Intersections Altitudes for all but Blue Springs were 5,000 feet and above. Blue Springs was fed at 7,000 feet and above. The upper limit of the Olathe areas was determined by the highest altitude the ARTC Center fed above 27,000 feet. Jet departure procedures were designed to follow specific routes and altitude restrictions to the exit fixes, giving the controller more time to concentrate on separation and expediting other traffic. With the aid of operations representatives from Forbes, routes were designed to make maximum use of aircraft performance capabilities, thereby reducing the time the aircraft remained within the Olathe area. Throughout most test runs these jet aircraft were cleared to leave the Olathe areas at 24,000 or 25,000 feet. However, high-altitude test runs indicated that a blocked altitude system was necessary to prevent conflictions from occurring within the ARTC area between jet departures leaving the Olathe areas from different fixes. Departing jets then were given clearances at 24,000, 25,000, 26,000, or 27,000 feet, depending on the exit fix. That portion of Victor 10 and Victor 12 between Bonner Springs and Emporia was relocated to extend from Bonner Springs to the recommended Pomona VOR (located at the Forbes southeast outer marker site) to Emporia VOR.

Results.

Within area No. 1, System B had three less major crossing points and three less convergence points than System A. By limiting the number of feeder fixes, and designating segregated routes for arrivals and departures, an immediate reduction in coordination was noted. The controllers outlined their respective areas on the face of the television screen and were able to keep their traffic within these defined areas.

All controllers agreed that the predetermined jet routes eliminated excessive vectoring and orbital climbs, thereby reducing the workload. Realignment of Victor 10 and Victor 12 provided more room for departures turning out of Olathe NAS. Also, it eliminated the climb restriction to jets departing Forbes. No appreciable increases in workload or delay times were noted when the landing direction was changed. Olathe RAPCON departure delay data, System A as compared to System B, are illustrated in Fig. 23.

System C.

As far as Olathe was concerned, no change from the System B procedures was necessary when System C was tested.

## EN ROUTE TESTS

General.

Limitations of the TDC dynamic ATC simulator confined the simulated radar coverage area to a radius of 80 nautical miles from the Kansas City VOR. The ARTC area was split geographically into two sections, east and west, with the boundary line running north and south of the Kansas City VOR. Each section was divided into two sectors. Each sector was staffed with a team composed of a radio/radar controller, an ANC manual controller, and an assistant controller. Two coordinators were assigned for liaison between the sections and sectors.

The radar arrival controllers identified and tracked all IFR overflights in addition to terminating traffic. Their associated manual controllers kept them informed as to altitude availability at the approach control fixes. They also advised as to what altitude the arrivals could be descended without radar separation. In addition, they maintained current postings on the flight progress boards.

All flights departing from either International or Municipal Airports were assigned a short-range clearance limit and altitude by the appropriate ARTC manual controller. Common preferential departure routes were used for both International and Municipal. Radar handoffs on all departures were made by the Kansas City approach control facility to the appropriate ARTC radar departure controller.

Departures leaving the Olathe RAPCON area to enter the ARTC area were handled in several different ways, depending on the system being tested. Detailed information on the departure procedures is contained in the Olathe RAPCON section of this report.

System A.

Tests of System A, which is shown in Fig. 24, provided radar and procedural training for the ARTC personnel, and also provided a basis for comparative measurements of succeeding systems.

System A was based on existing airways, navigational facilities, and preferential routes, modified as follows.

1. Victor 13 and Victor 71E, between the Butler and Kansas City VOR's, were abrogated to give the Grandview and Olathe Airports more

traffic-free area for arrival and departure traffic and to provide a greater degree of segregation between military jet and civil traffic.

2. Victor 4S was extended from the Admire Intersection to the Pomona Intersection and deleted from the Admire Intersection to the Topeka VOR to give the ARTC Center a one-way airway for westbound departure traffic.

3. The preferential route for westbound traffic departing International or Municipal was changed to Victor 10 to the Pomona Intersection, thence via Victor 4S. The inbound preferential route from the west for International or Municipal was via Victor 4, Topeka VOR, Victor 4N.

Results.

With good radio and radar coverage, the ARTC Center encountered no major problems and had little difficulty in controlling its traffic. The System A route structure appeared adequate to serve the needs of Municipal and Olathe even with an increased amount of traffic provided, however, that traffic at International did not increase.

System B.

This system is illustrated in Fig. 25. Existing airways, navigational facilities, and preferential routes were changed as follows

1. Victor 13 was realigned to lie due north of the Kansas City VOR in line with a proposed VOR site located approximately 30 miles due west of the Lamoni VOR. Victor 13E from the Kansas City VOR to the Lamoni VOR, Victor 15E from the St Joseph VOR to the Lathrop Intersection, and Victor 15 and Victor 205 from the St. Joseph VOR to the Kansas City VOR, were deleted The realignment of Victor 13, and the deletion of the airways as outlined above, provided a three-airway system to serve the Kansas City terminal area and the airports in the north section of the ARTC Center control area

2. Victor 206 from Kirksville to Blue Springs was not used because Victor 10 was able to handle the departure traffic.

3 Victor 13 and Victor 71 were deleted from Kansas City to Butler. Traffic normally flying this route was rerouted via Victor 161. This gave the Grandview and Olathe Airports more room for vectoring arrivals and departures, and provided more separation between military and civil traffic

4. Green 4 and Amber 4 were deleted because all the route structure was based on VOR navigation

5. Victor 10 and Victor 12 were realigned from the Bonner Springs Intersection to a proposed Pomona VOR. The simulation site selected for this new VOR was at the Forbes AFB ILS outer marker. This realignment gave the Forbes AFB more traffic-free area for arrivals and departures.

6. Victor 77 was realigned to the 191° magnetic radial of the St Joseph VOR to provide greater segretation between the Topeka VOR teardrop penetration to Forbes and en route traffic on Victor 77.

In revamping the route system, every effort was made to conform as closely as possible to the interim criteria for VOR route structure. The System B route structure was tested with Traffic Sample 2 to simulate the forecasted increase of traffic activity at International.

Jet aircraft arriving at or departing from airports within the Olathe RAPCON areas were cleared in accordance with the procedures developed during the first phase of this simulation. These procedures are outlined in detail in the Olathe RAPCON section of this report. In the System B tests, the ARTC sector arrangement was changed by positioning all the controllers concerned with arrivals around one SPANRAD and adding another radar controller to aid in the control of the traffic arriving from the east. All controllers concerned with the departing traffic were positioned around another SPANRAD.

Results.

The sector configuration worked satisfactorily because the route structure and procedures for departing traffic required little or no coordination between the arrival and departure controllers Furthermore, this arrangement facilitated feeding operations at all the approach control fixes.

The first major ARTC problem encountered in this phase of the simulation study was the convergence of traffic at the Missouri City Intersection, which was the ultimate clearance limit for all Victor 116 and Victor 4 traffic from the east destined for either Municipal or International. The congestion of traffic at Missouri City pointed out the immediate need for an additional feeder fix on the east side.

The Trimble VOR appeared satisfactory as a clearance limit for flights destined for International if the landing direction at International were south. If the landing direction changed to north, the ARTC Center would clear these flights to the Lansing Intersection.

The second major problem that evolved from this phase of simulation was the difficulty experienced by the ARTC Center in attempting to crossfeed traffic from the Missouri City Intersection to either the Trimble VOR or Lansing Intersection This crossfeeding was accomplished for flights destined to land at International

In all tests when ARTC was performing the function of crossfeeding in the terminal area, the arrival controllers' workload increased substantially and coordination between controllers was approximately doubled.

System C.

This system is illustrated in Fig. 26. The preceding phases of simulation pointed out the obvious need for separate arrival routes from the east to serve Municipal and International. System C was based on the concept that the process of segregating these flights could be accomplished best outside the terminal transition area, that is, 100 miles away from the destination airport. Meshing of these same flights converging at a common point from different routes would be done in the perimeter control sectors where the controllers were concerned solely with en route traffic and not burdened with the complex problem of terminal traffic. After the segregation and meshing control functions were effected, the radar arrival controllers would be concerned only with getting their traffic down to the desired altitude at the approach control feeder fixes. Consequently, the controller workload per flight would become more evenly distributed in the ARTC Center, the end result being more efficient operation.

Results.

This system design relieved the ARTC Center of the necessity for shuttling arrivals around in the Kansas City terminal area in order to get these flights to the primary feeder fixes for the individual airports. Because of this independent route structure, the radar arrival controllers were able to operate independently, reducing coordination and controller workload substantially. Little or no delays were registered at the feeder fixes at the traffic densities encountered in Sample 2.

The major disadvantages disclosed by this simulation study were·

1 When the direction of takeoff at International and Municipal was to the north and a departure desired to proceed east via Victor 12, under peak traffic conditions it became necessary to restrict the departure to an altitude of 4,000 feet or below until clear of the holding traffic at the Blue Springs VOR.

2. When the direction of takeoff was to the south, departures desiring to proceed northeast via Victor 10 were restricted to 4,000 feet or below until clear of the arrival traffic on Victor 116.

The only apparent solution to the problem outlined in item 1, above, was to change the preferential departure route from Victor 12 to Victor 4 Such a change appeared undesirable for the following reasons.

a. The reversal of the traffic flow on Victor 4 and Victor 12 would be contrary to the existing traffic flow on these two airways in the adjacent St. Louis ARTC Center control area and beyond

b. If such a traffic reversal were accomplished, the arrival flights would accrue the penalty formerly borne by the departures.

A great deal of thought was given to the problem outlined in item 2, above By reversing the traffic flow and making Victor 116 the preferential departure route for northeastbound traffic, a reduction of approximately 10 miles of tunneling could be achieved. However, the value gained by this reduction would be offset by the crossing of this departure route with an arrival route within 30 miles of the terminal area. This crossing point would impose an additional climb restriction on the departing aircraft.

Subsequent to the simulation tests and before preparation of this report, TDC personnel made additional map studies, searching for a way to reduce the tunneling distance for east and northeastbound departures on both Victor 10 and Victor 4. Attention was centered on the proposed location of a VOR in the vicinity of the town of Trimble, Mo. A VOR is necessary because of the distance between the Topeka and Kirksville VOR's. The suggested Trimble VOR site is depicted in Fig. 26. This location was selected because it would provide the necessary separation from the holding airspace at the Missouri City Intersection and serve as an excellent approach control feeder fix for either International or Municipal.

Realigning Victor 161 from the proposed Jameson VOR to the Trimble VOR, thence to the Blue Springs VOR, would provide the following minor advantages:

1. The tunneling distance for east and northeastbound departures is reduced.

2. The descent distance for the east and northeast arrival traffic is increased.

3. A north-south route is provided for over-traffic that does not cross the major departure and arrival routes.

## COMMON IFR ROOM TESTS

In this phase, the IFR functions of the Olathe RAPCON, Kansas City approach control, and the Kansas City ARTC Center were combined in a single facility. Two additional SPANRAD's were added to the Center to accommodate this function. Equipment and personnel were arranged as shown in Figs. 8 and 9. This layout permitted direct verbal communication between the various controllers, or through coordinators. The common IFR room concept was tested with Systems B and C, using Traffic Sample 2, in 15 runs totaling about 20 hours of operation.

Results.

The common IFR room permitted total discontinuance of interphones for coordination between controllers of the three agencies involved. All coordination was handled directly from controller to controller, or through the use of a coordinator. Identified radar targets were handed off from sector to sector by removing the target marker from the SPANRAD position relinquishing control and superimposing the marker on the appropriate radar target shown on the SPANRAD position assuming control of the flight. The net result was a large reduction in coordination time and controller workload. Because of the ease with which special arrangements could be coordinated, the utilization of the available airspace was increased substantially.

Although time limitations precluded a complete study of this factor, the simulation tests indicated that the rearrangement of control sectors in a common IFR room layout, to place each controller in the most effective spot in relation to the other controllers, could increase the capabilities of the common IFR room further For example, the grouping of all departure controllers might reduce the amount of coordination required. Further study of this factor would be desirable.

## HIGH-ALTITUDE TESTS

The objective of this phase was to study the effect of the proposed Olathe jet departure procedures on the ARTC Center. This test was conducted using the high-altitude traffic sample, and the jet route structure, which is shown in Fig. 27.

### Results.

Tests indicated that with a high top condition, that is, above 35,000 feet, the entry of Olathe jet traffic into the ARTC area at altitudes of 24,000 or 25,000 feet would be difficult but workable. Unquestionably, it would introduce additional controller workload to take jet departures at 24,000 and climb these flights to their requested altitudes. However, it appeared that the over-all gain achieved by giving the military segment of the flying public better service outweighs the additional controller workload factor

The need was evidenced for an extension of the coded jet departure routes beyond the exit fixes described in the Olathe jet-procedures section. Such an extension should be planned with the idea of keeping the flights proceeding as closely on course as possible, but away from heavily traveled jet airways. This would enable the high-altitude controllers to base their preplanning on a longer predetermined route of flight which, in turn, would facilitate getting flights to the desired altitude before joining the flow of traffic on the established jet airways.

Another advantage gained by the ARTC Center in this system is the sharp reduction in coordination between the high- and low-altitude sectors. Jet aircraft would leave or enter the Olathe area at an altitude within the jurisdiction of the high-altitude sectors. Coordination with low-altitude sectors seldom would be necessary

To implement these high-altitude procedures effectively, the ARTC Center representatives felt that their present high-altitude sector arrangement would have to be changed. In the existing sector configuration, certain high-altitude sectors are interspersed among associated low-altitude sectors to ease coordination between these areas of control. Generally, this interspersion is done in areas where a considerable amount of military traffic is being generated By eliminating coordination between high- and low-altitude sectors, interspersion becomes unnecessary, permitting the high-altitude sectors to be grouped together. Consolidating all control sectors concerned with high-altitude traffic reestablishes the continuity in control desired for high-speed traffic

## CONCLUSIONS

It is concluded that.

1. The existing airway structure is incompatible with an increased traffic volume for the International Airport. System C would serve efficiently either Municipal Airport alone or together with International Airport under peak traffic conditions.

2. An increase in International Airport traffic, or in the size of the standard holding airspace, would require the relocation of some of the present feeder fixes

3. A safer and more efficient operation can be obtained by making one approach control facility responsible for both Municipal and International Airports

4 Until the present volume of traffic increases at the International Airport, approach control can crossfeed arrivals to both airports efficiently When the traffic volume increases, the crossing and segregation of traffic can be accomplished best by the ARTC Center outside of the terminal transition area

5. The addition of an instrument approach system from the south increases the traffic capabilities of Municipal Airport.

6 The present location of that portion of Victor 10 and Victor 12 Airways between Bonner Springs and Emporia, and Green 4 between Kansas City and Wichita, restricts Forbes AFB departures and arrivals unnecessarily

7. Over-traffic on that portion of Victor 13 and Victor 71 Airways between Butler and Kansas City restricts Grandview Airport arrivals and departures and puts civil traffic too close to military jets.

8 Several problems are created by the remaining low-frequency airways. Over-traffic on Amber 4 in Olathe area No. 1 creates a hazard with the military terminal traffic. Because Green 4, east of Kansas City, lies about midway between Victor 4 and Victor 12, yet does not have complete separation from either of these two airways, needless control problems are created

9 The procedures developed and tested for the control of jet traffic in the Olathe RAPCON area are beneficial to both control and pilot personnel alike.

10. The common IFR room concept appears to be highly suitable for all three Kansas City facilities simulated.

## RECOMMENDATIONS

It is recommended that·

1. An instrument approach system from the south be provided for Municipal Airport.

2. The responsibility for the control of IFR traffic at Municipal and International Airports be combined in a single facility.

3. Procedures of the type developed for the control of Olathe RAPCON jet traffic be implemented. The northwest portion of caution area 168 should be made available for flight traffic to provide a more workable area for this system

4. The following airways be abolished in the Kansas City control area Green 4, Amber 4, Victor 13, and Victor 71 between Butler and Kansas City.

5. The route design, preferential airways, and feeder fixes as depicted in System C be used as a guide for future planning

6. Serious consideration be given to the common IFR room concept while plans for a new ARTC operational layout are being formulated. Further study of the optimum arrangement of control positions should be profitable in reducing the coordinator workload.

## TABLE I

## LOCATION IDENTIFIERS

ADE Admire*

BON Bonner Springs*
BUM Butler VOR
BWR Blackwater VOR

CAM Camden*
CNU Chanute VOR and LF/R

DAO Dalton*

EMP Emporia*
EXL Excelsior*

FRY Farley

GVW Grandview AFB

HUT Hutchinson VOR

ICT Wichita VOR and LF/R
IRK Kirksville VOR

JAM Jameson*

KNY Kearney*

LAT Lathrop*
LIY Liberty Homer
LNG Lansing*
LWN Lawson*

MBY Mosby*
MCI Mid-Continent International
MCM Macon VOR
MCY Missouri City*
MHL Marshall VOR
MHX Maple Hill
MKC Municipal, Kansas City VOR and LF/R

NEV Nevada*
NUU Olathe NAS

OSK Oskaloosa*

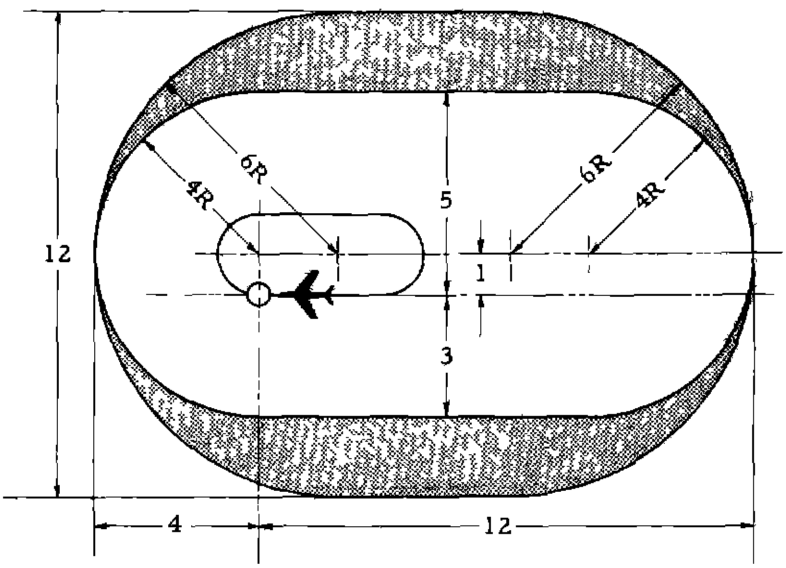
PAW Pawnee City VOR*
PLH Pleasant Hill*
PLT Plattsburg*
POM Pomona*

SGF Springfield VOR
SHA Shawnee*
SHC Schell City*
SLN Salina VOR
STJ St. Joseph VOR
STL St. Louis VOR
STR Santa Rosa*
SZL Whiteman AFB

TBL Trimble VOR*
TIN Tina*
TOE Forbes AFB and Ottawa TVOR
TOG Tonganoxie
TOP Topeka VOR and Phillip Billard

WIN Winchester*

*Denotes unofficial designator.




INNER PATTERN DEPICTS
PRESENT TSO-N20A HOLDING
AIRSPACE RESERVATION

SHADED AREA SHOWS 50 PER CENT
INCREASE IN WIDTH ASSUMED
FOR SIMULATION TESTS

ALL DIMENSIONS ARE IN
STATUTE MILES

FIG. 1 ONE-MINUTE HOLDING PATTERN AREA

FIG. 2 KANSAS CITY APPROACH CONTROL

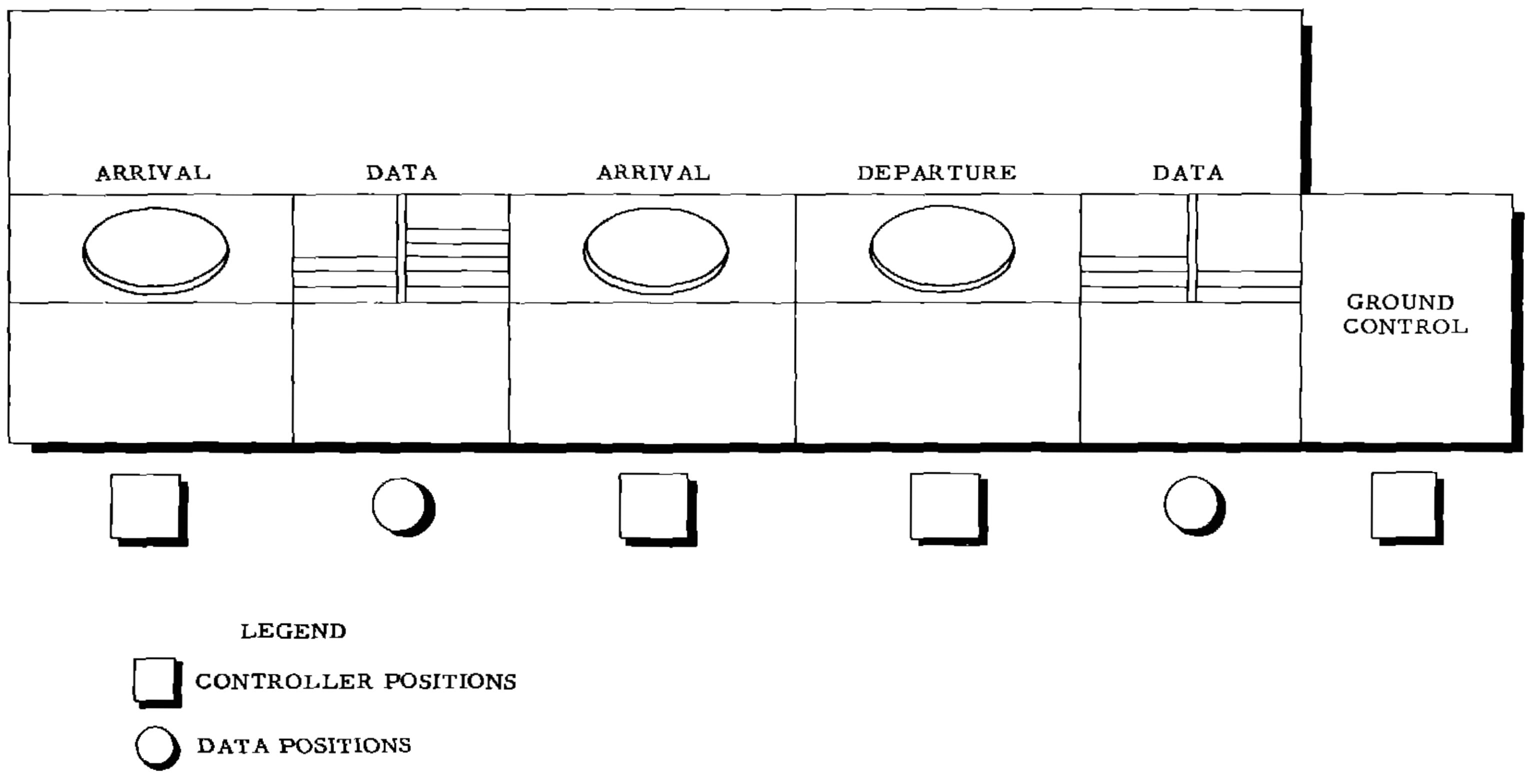



FIG 3 KANSAS CITY APPROACH CONTROL OPERATIONAL LAYOUT

FIG 4 OLATHE RAPCON

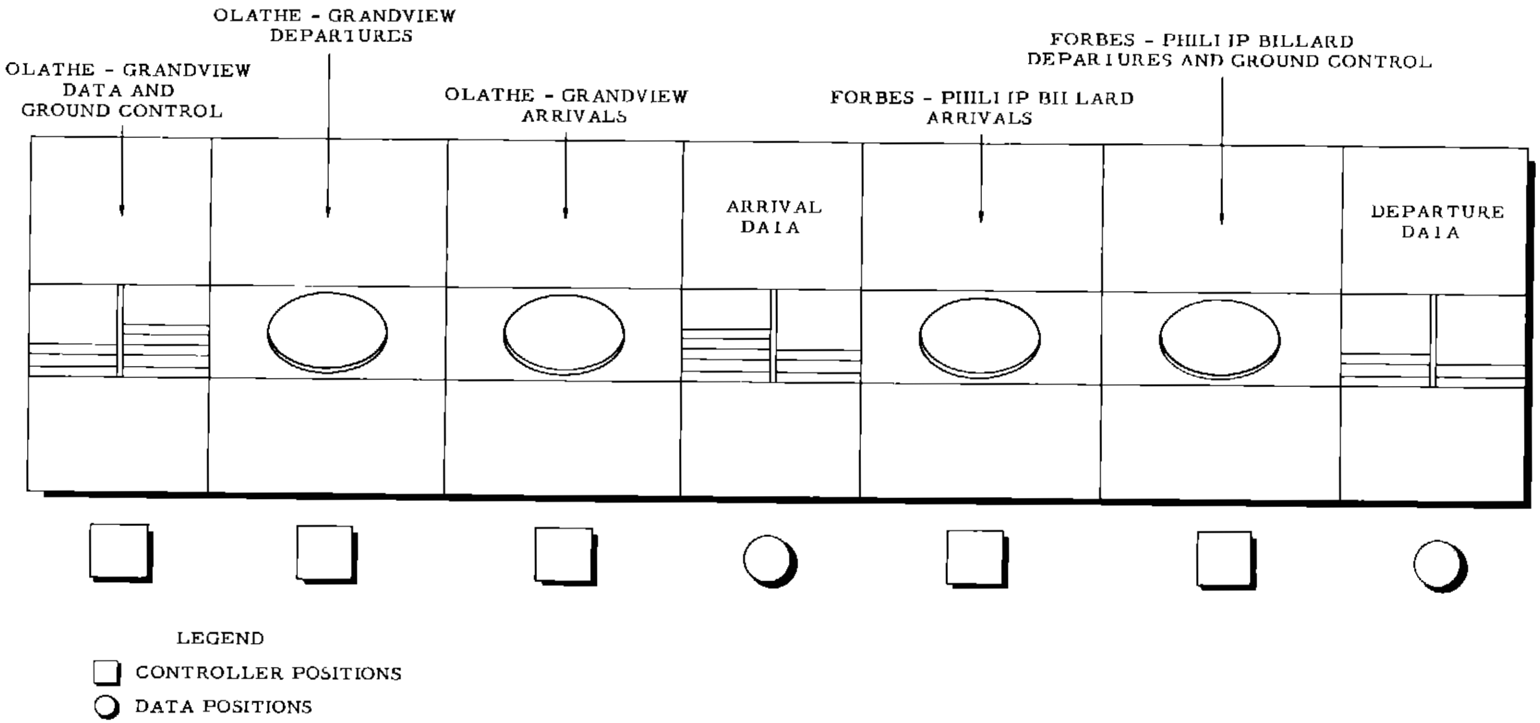



FIG 5 OLATHE RAPCON OPERATIONAL LAYOUT

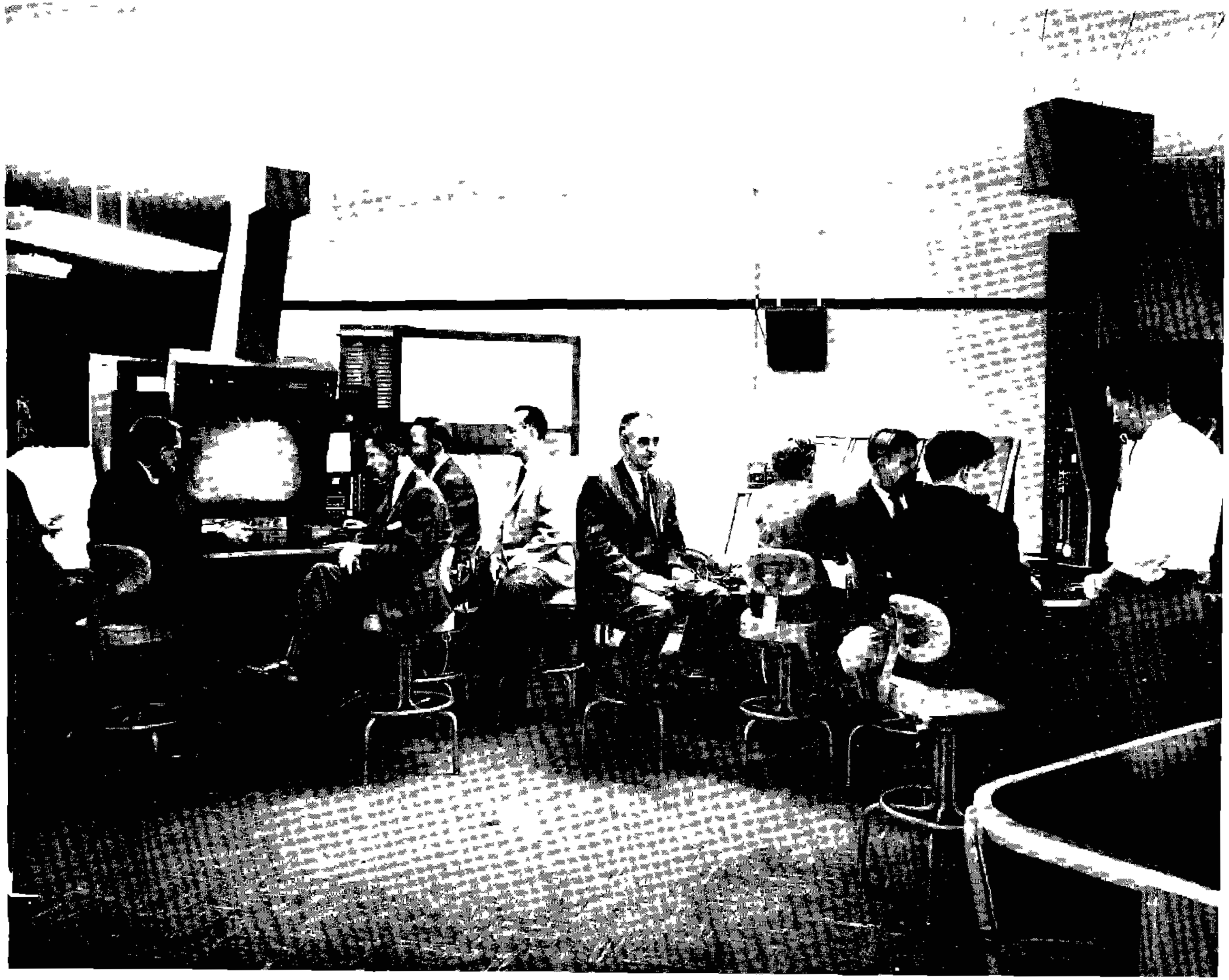


FIG 6 KANSAS CITY ARTC

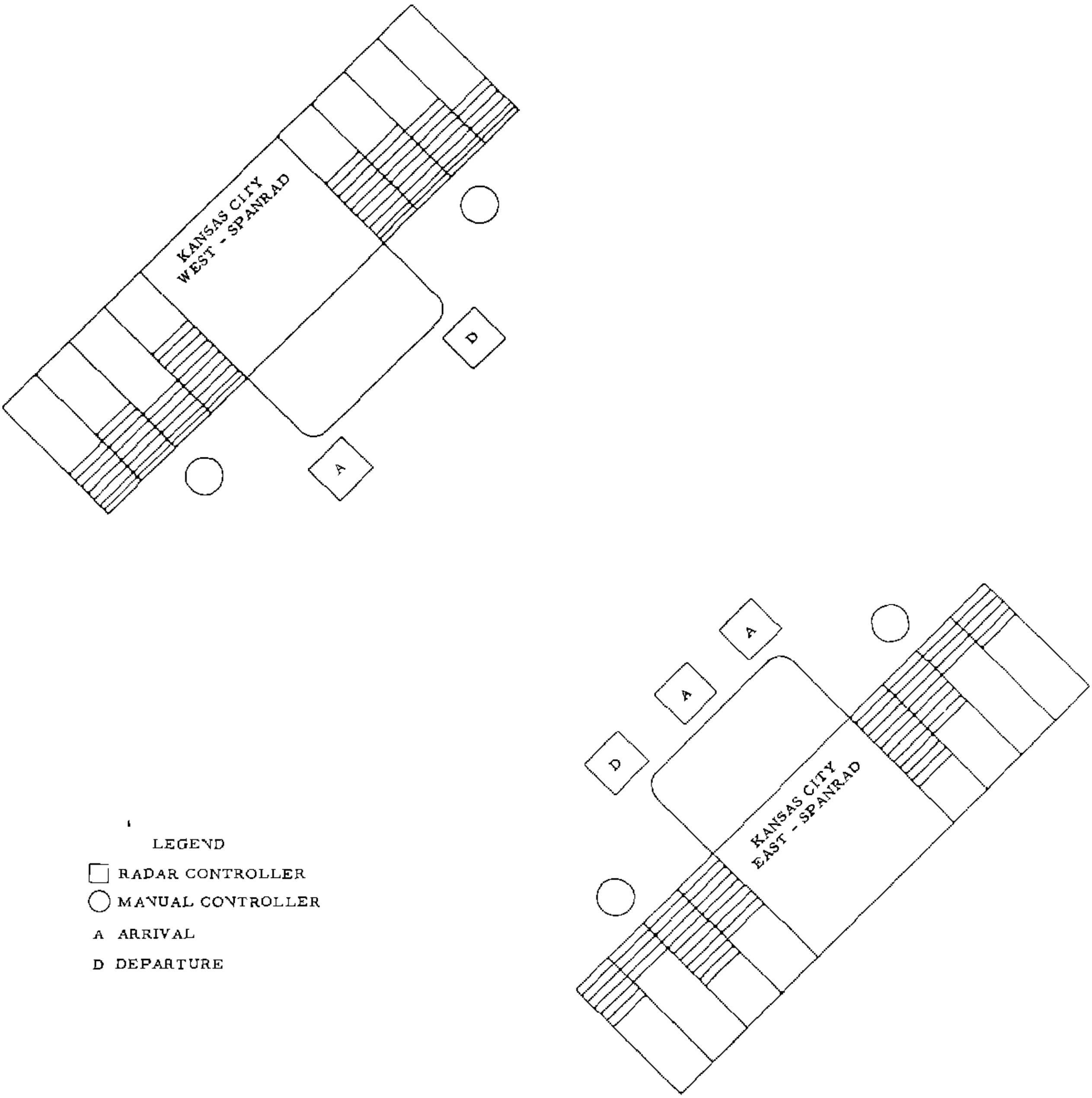



FIG 7 ARTC OPERATIONAL LAYOUT

FIG 8 OLATHE RAPCON AND KANSAS CITY APPROACH CONTROL (COMMON IFR ROOM)

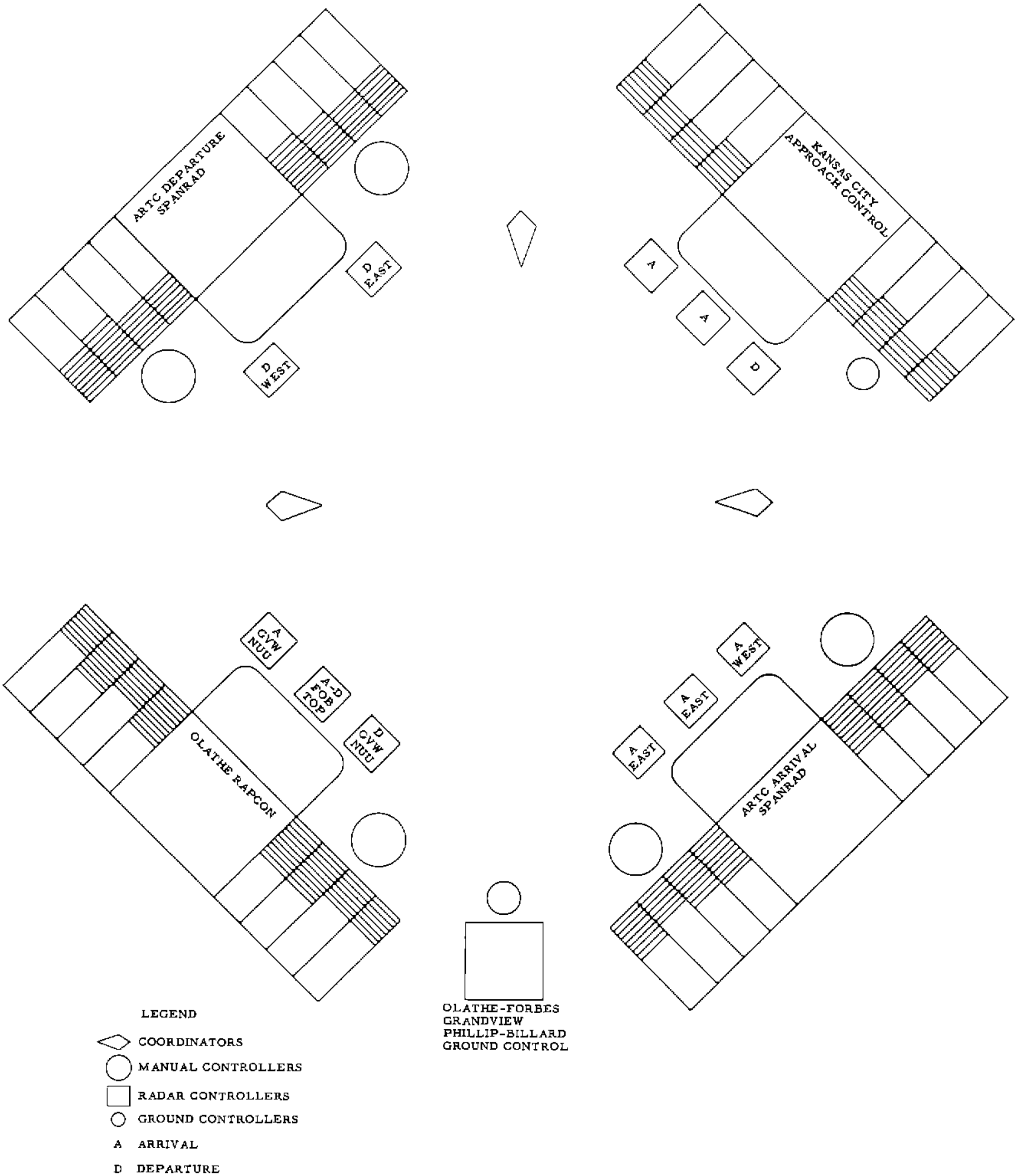
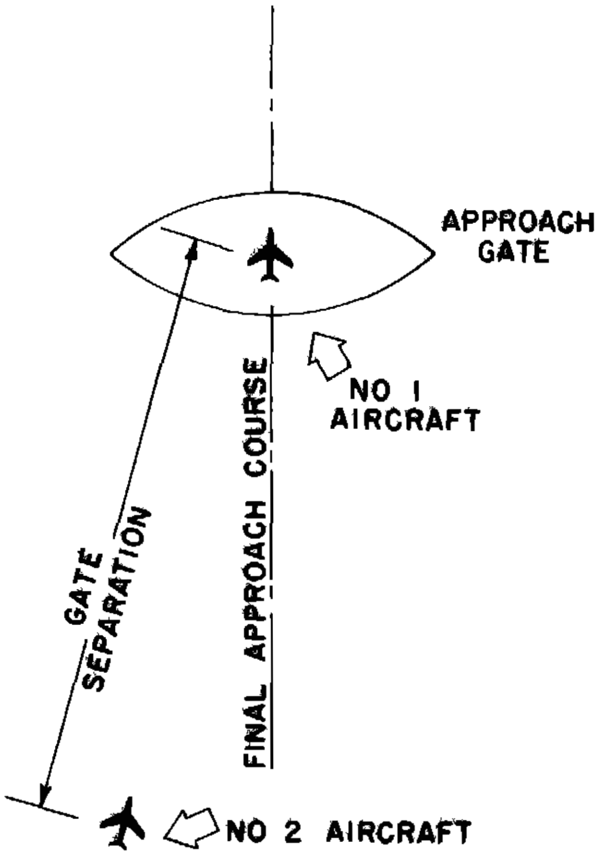



FIG 9 COMMON IFR ROOM LAYOUT




OPTIMUM
AIRCRAFT SPACING

DISTANCE, APPROACH GATE TO TOUCHDOWN, 5 MILES

| AIRCRAFT SEQUENCE | | GATE SEPARATION (MILES) |
|---|---|---|
| NO 1 | NO 2 | |
| S | M | 5 1 |
| S | F | 5 5 |
| S | J | 6.6 |
| M | S | 3 1 |
| M | F | 4.5 |
| M | J | 5 8 |
| F | S | 3.0 |
| F | M | 3.5 |
| F | J | 5.2 |
| J | S M F | 3 0 |
| SAME TYPE | | 4 0 |

| AIRCRAFT CATEGORY | | APPROX. APPROACH SPEED | |
|---|---|---|---|
| | | M P H | KT |
| S | SLOW | 120 | 104 |
| M | MEDIUM | 140 | 122 |
| F | FAST | 150 | 130 |
| J | JET | 180 | 156 |

FIG. 10 SPACING TABLE USED IN APPROACH CONTROL OPERATION

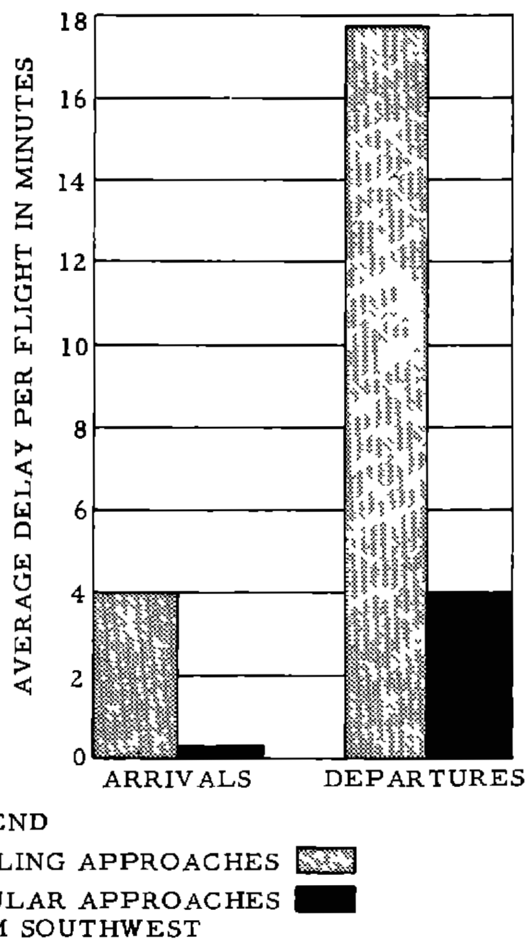



FIG. 11 MUNICIPAL DELAY DATA - NORTH OPERATIONS

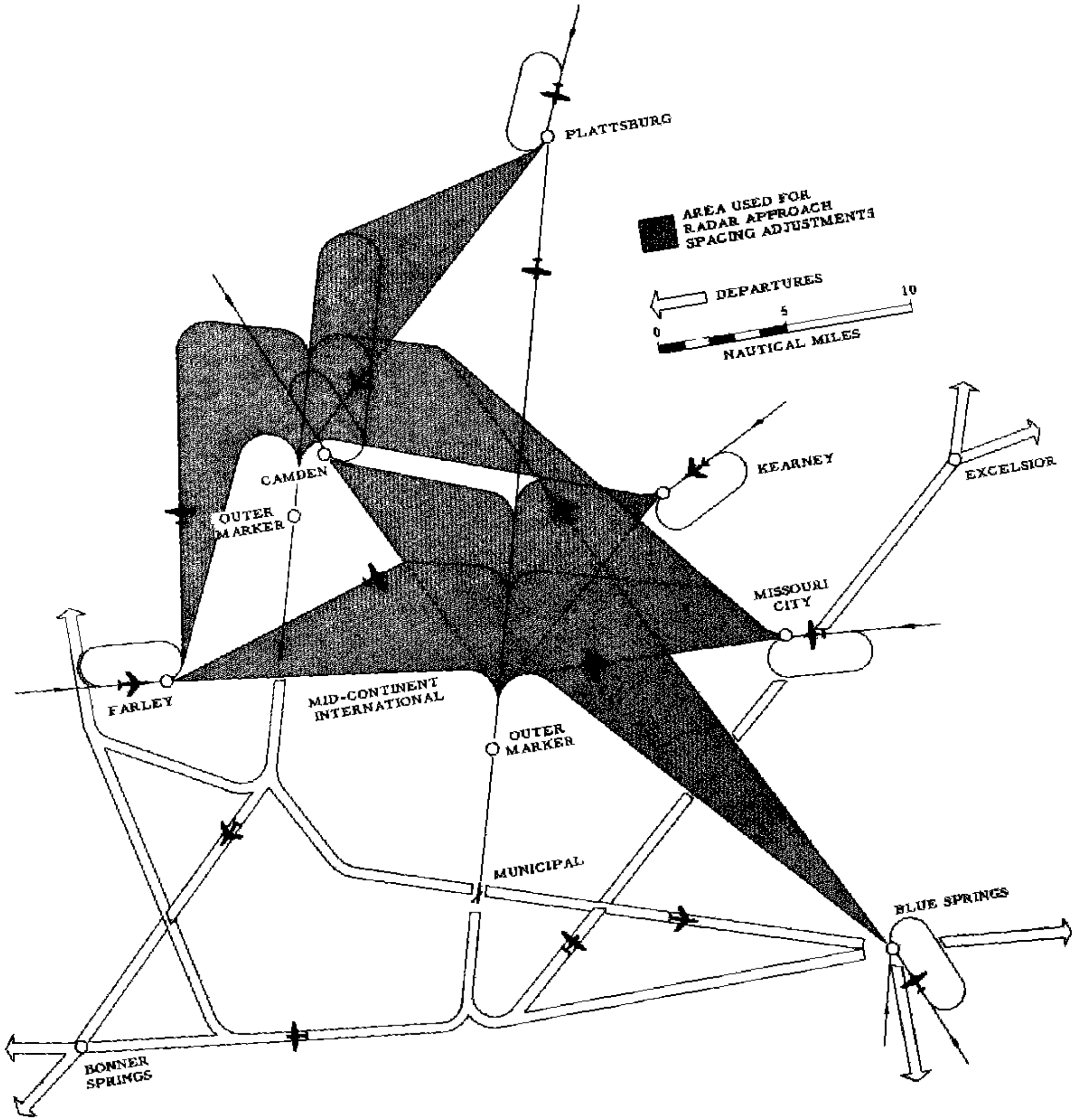



FIG 12 TERMINAL SYSTEM A - SOUTH OPERATIONS

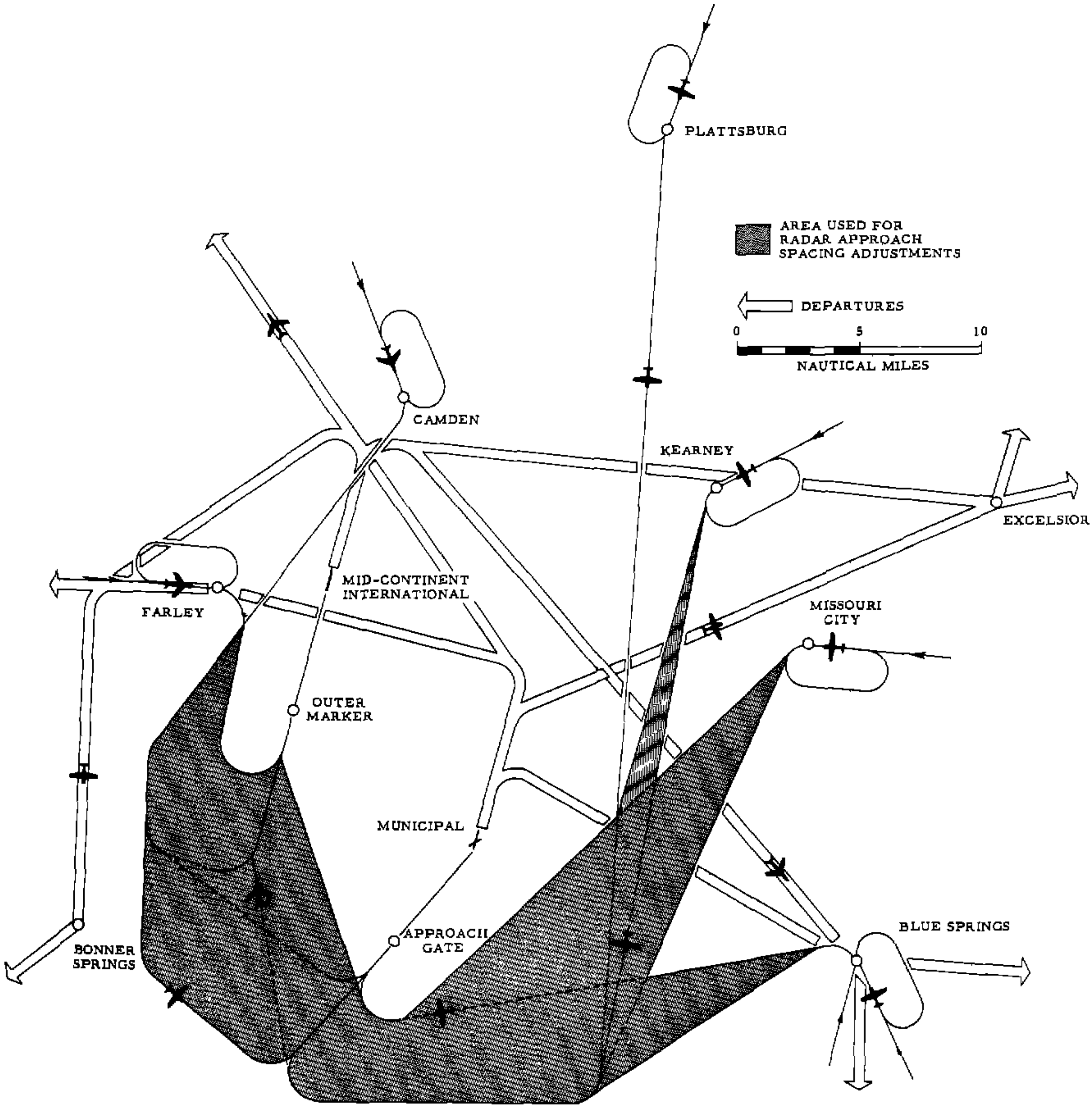



FIG 13 TERMINAL SYSTEM A - NORTH OPERATIONS

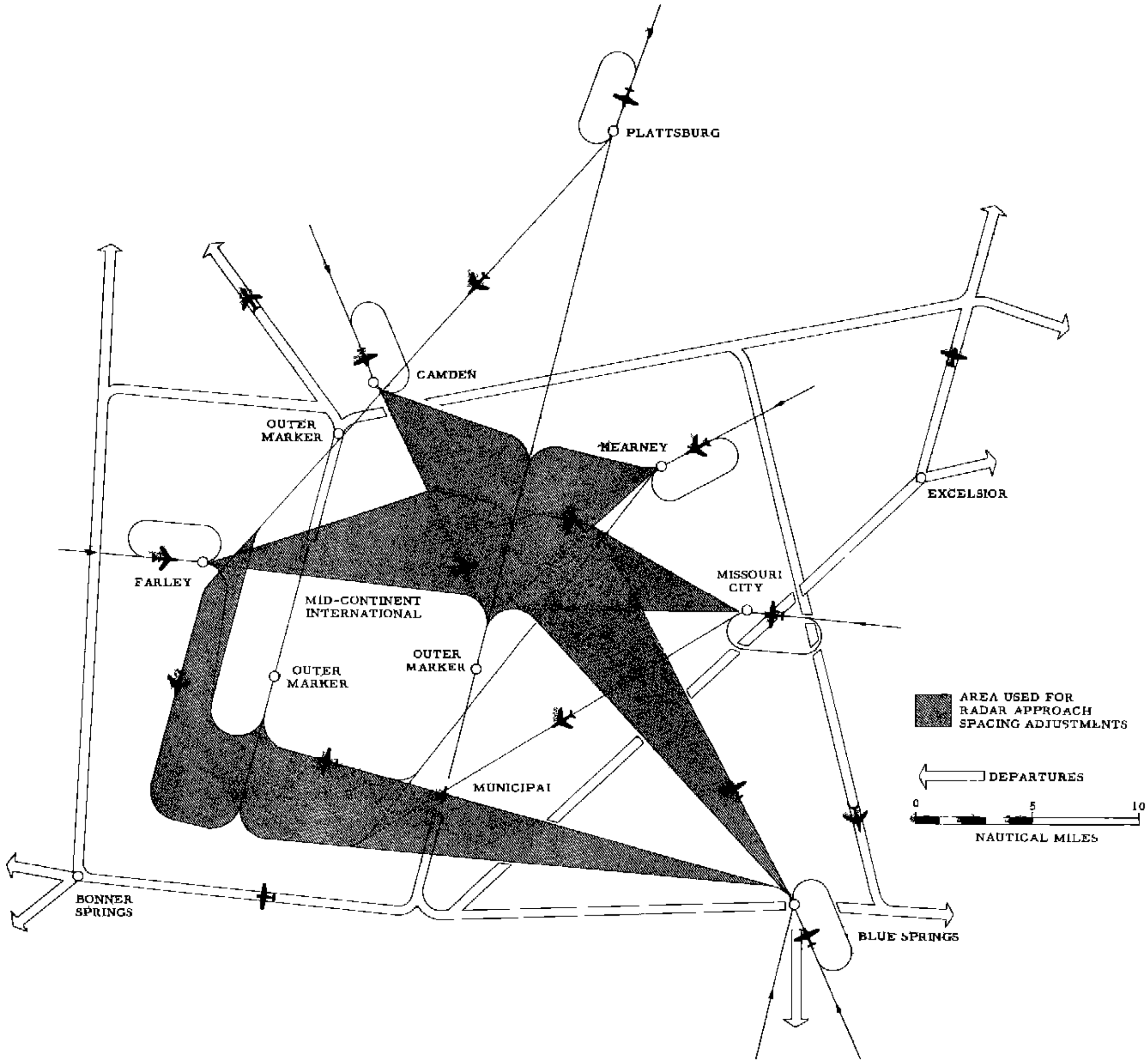



FIG 14 TERMINAL SYSTEM A - NORTH OPERATIONS AT INTERNATIONAL
SOUTH OPERATIONS AT MUNICIPAL

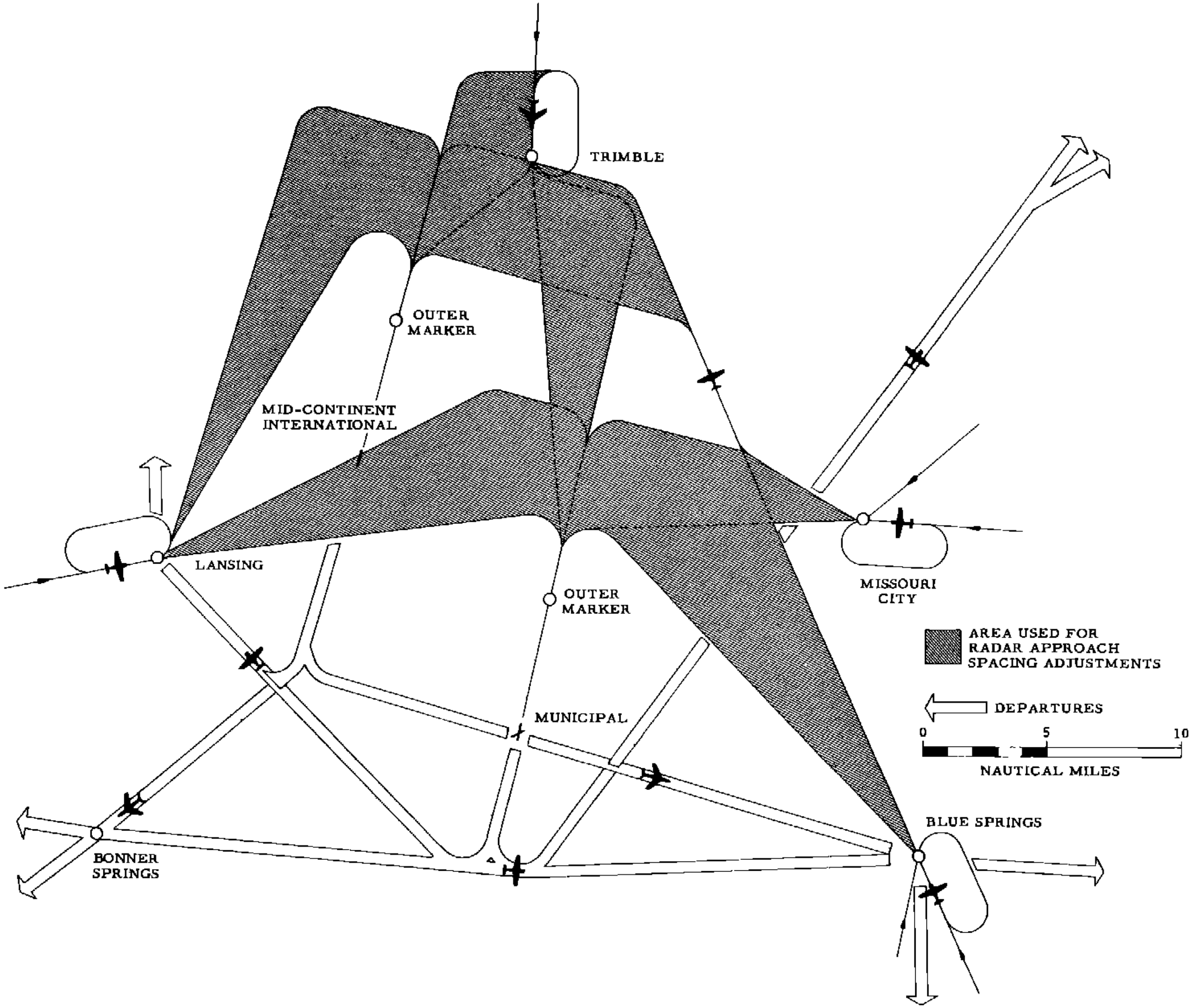



FIG 15 TERMINAL SYSTEM B - SOUTH OPERATIONS

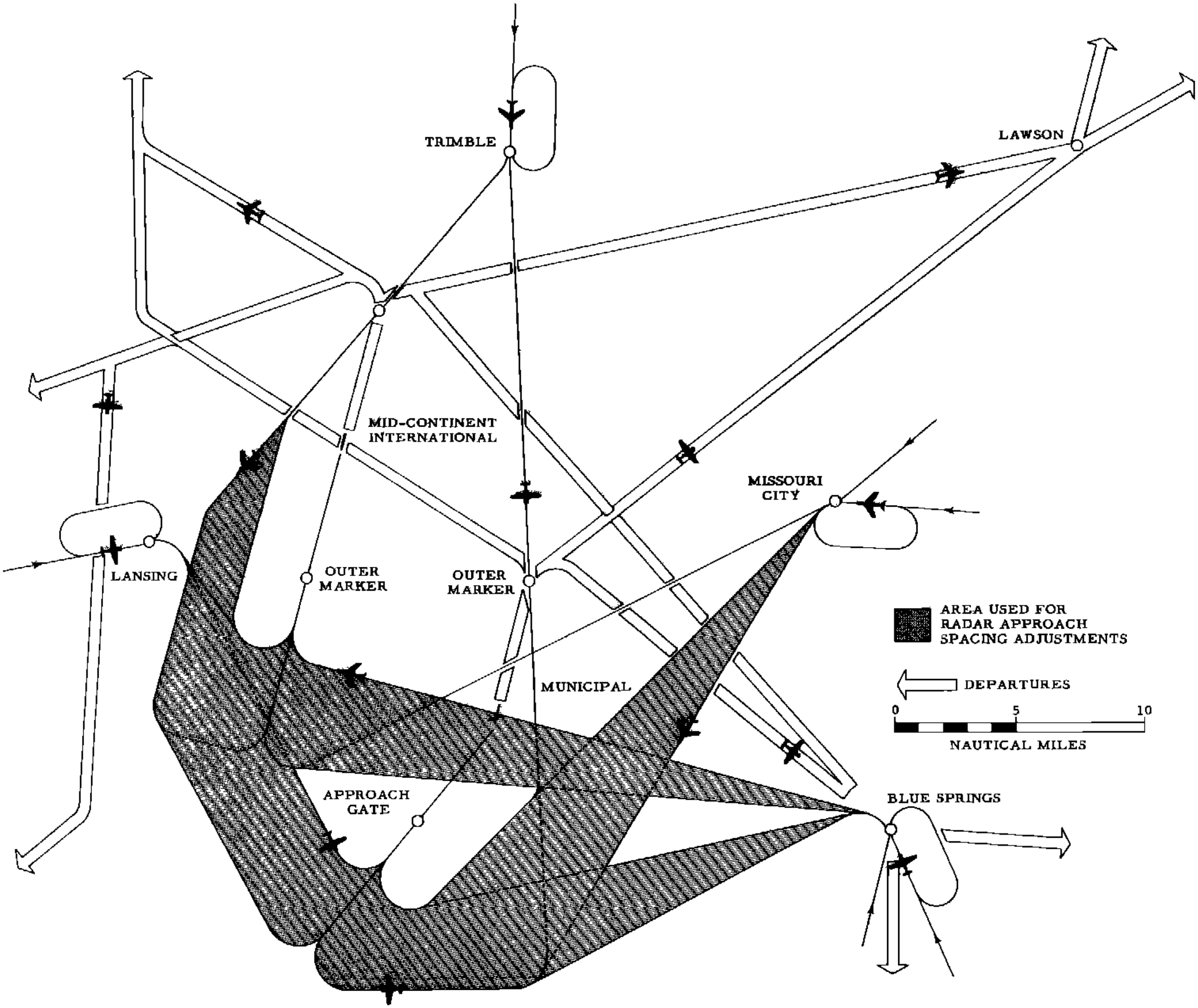



FIG 16 TERMINAL SYSTEM B - NORTH OPERATIONS

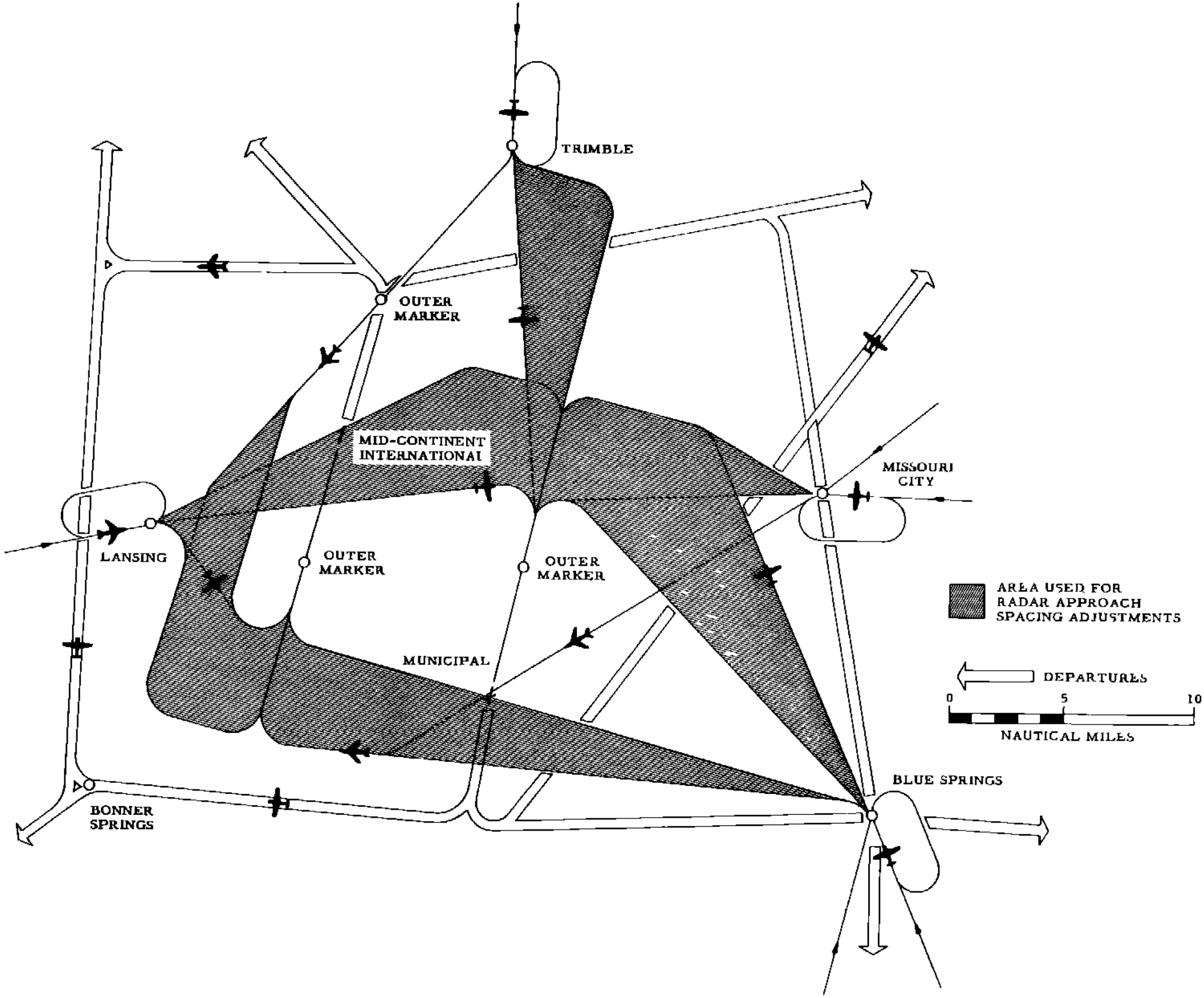



FIG 17 TERMINAL SYSTEM B - NORTH OPERATIONS AT INTERNATIONAL, SOUTH OPERATIONS AT MUNICIPAL

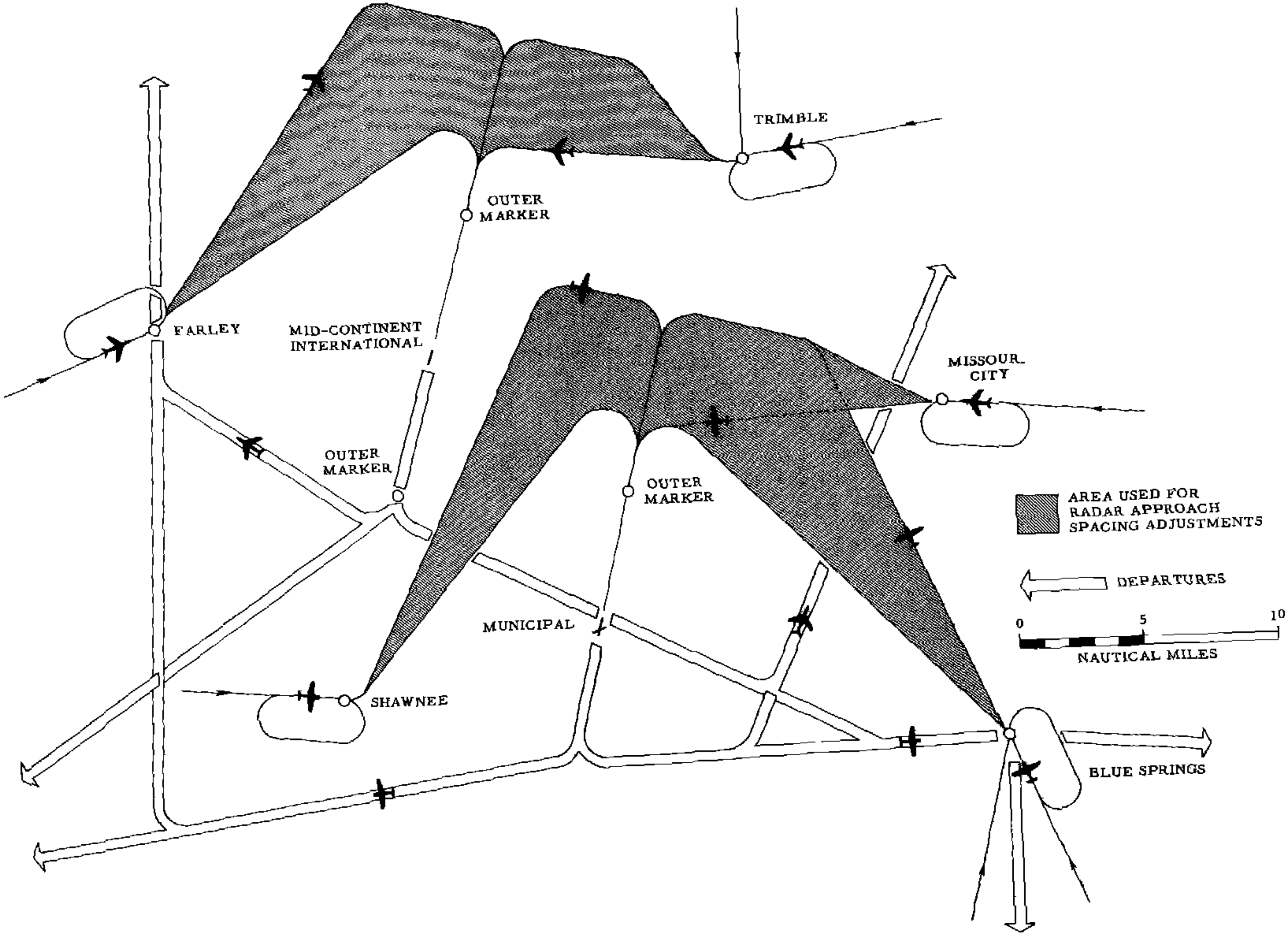



FIG 18 TERMINAL SYSTEM C - SOUTH OPERATIONS

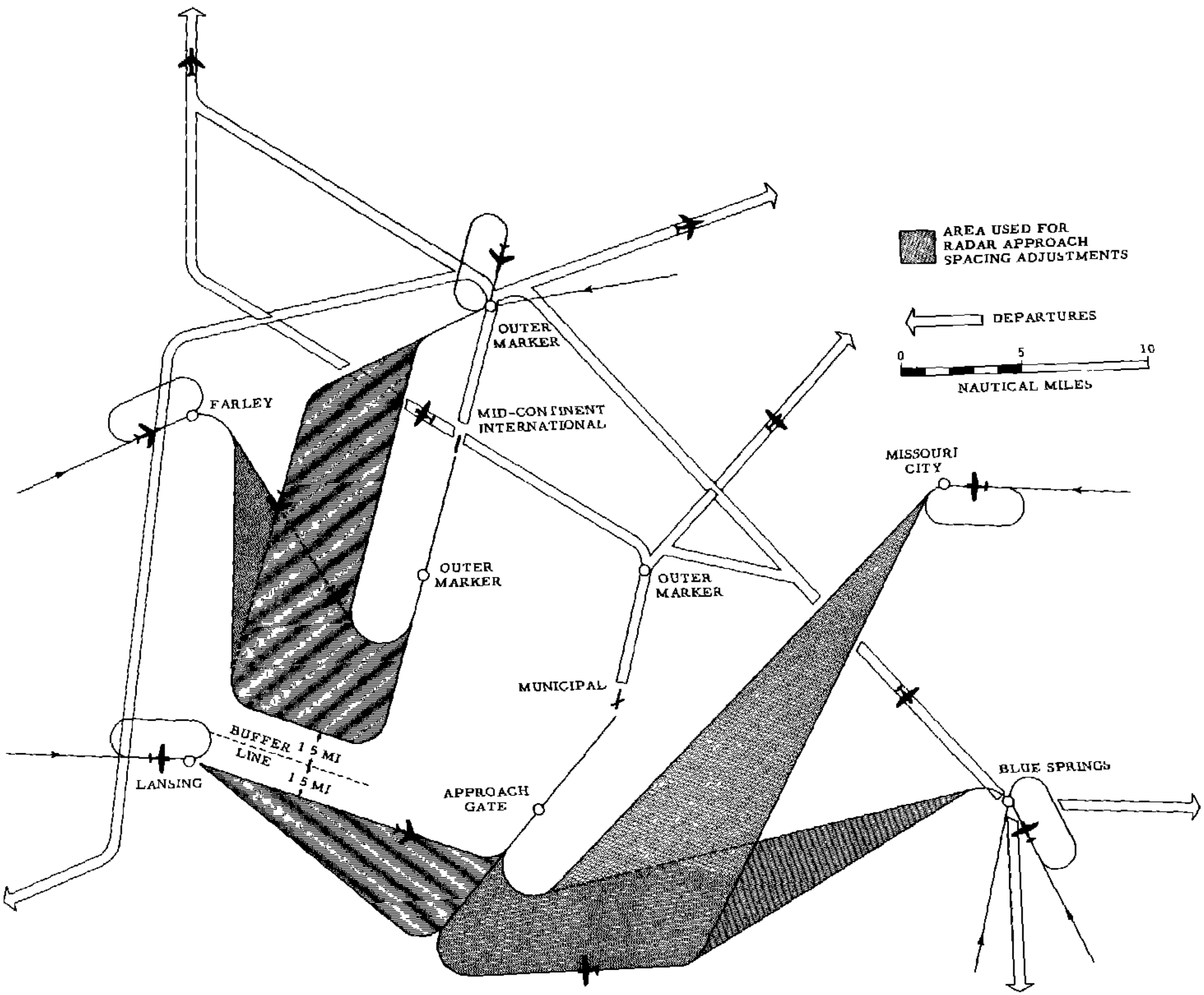



FIG 19 TERMINAL SYSTEM C - NORTH OPERATIONS

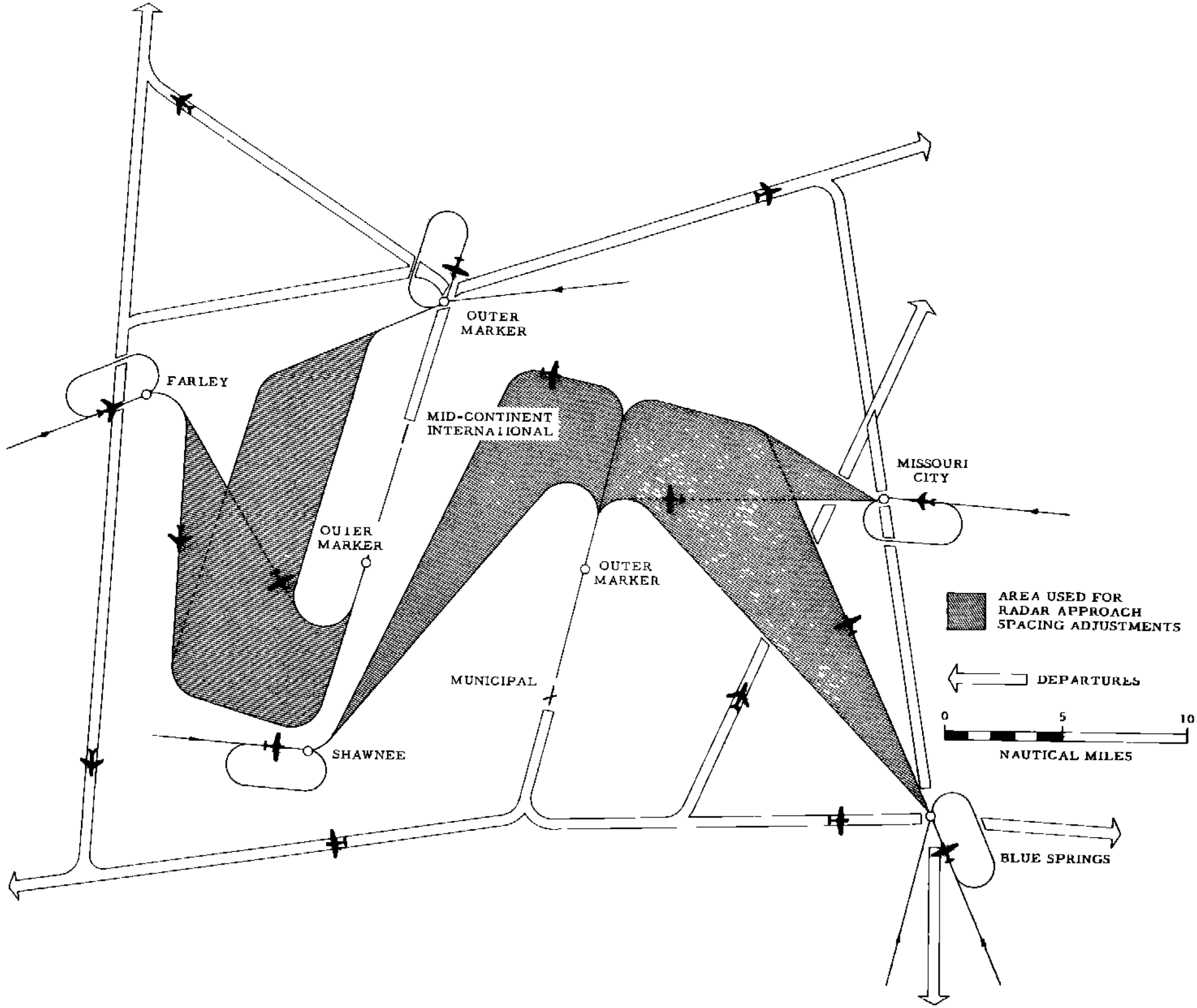



FIG 20 TERMINAL SYSTEM C - NORTH OPERATIONS AT INTERNATIONAL
SOUTH OPERATIONS AT MUNICIPAL

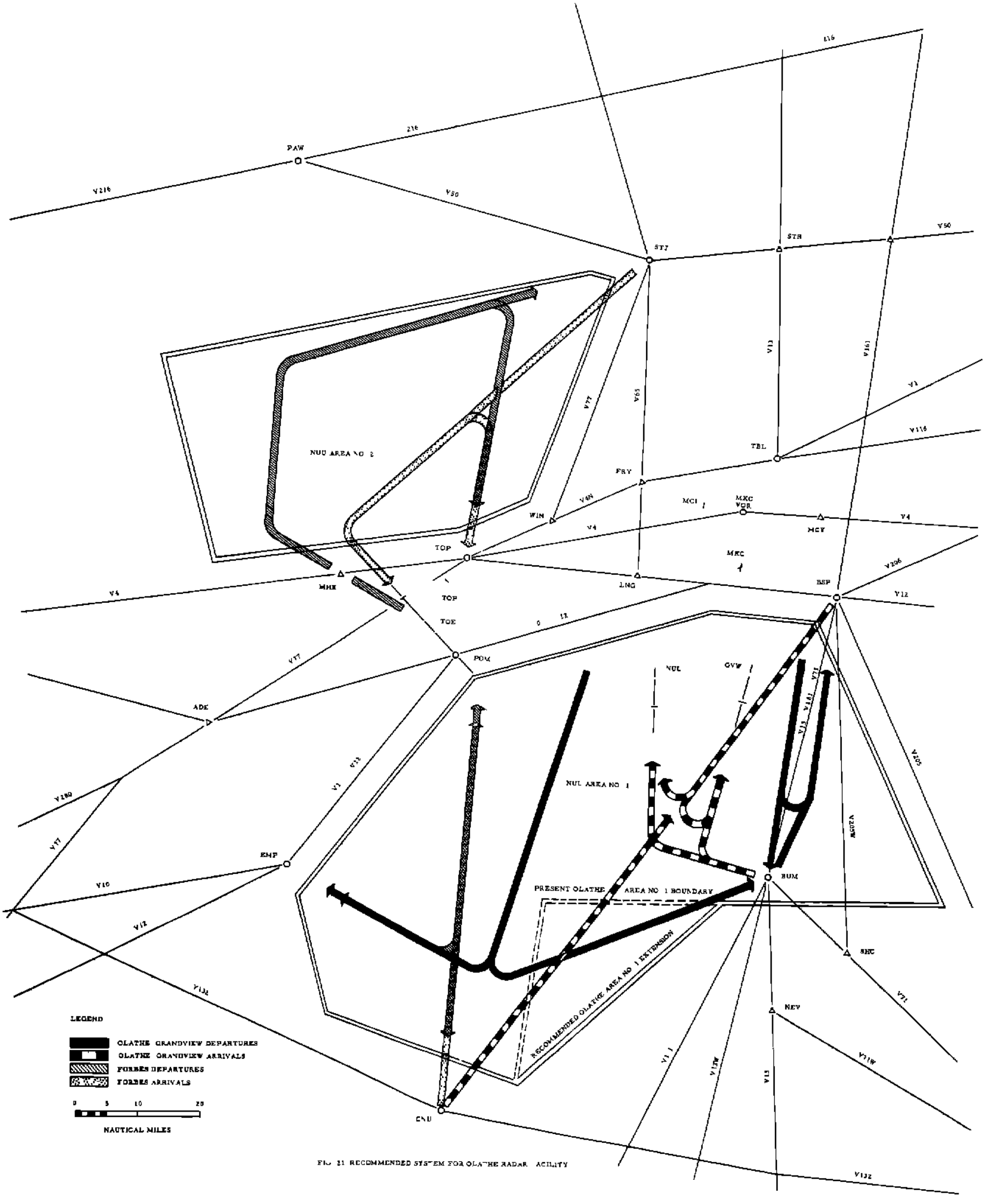



FIG. 21 RECOMMENDED SYSTEM FOR OLATHE RADAR FACILITY

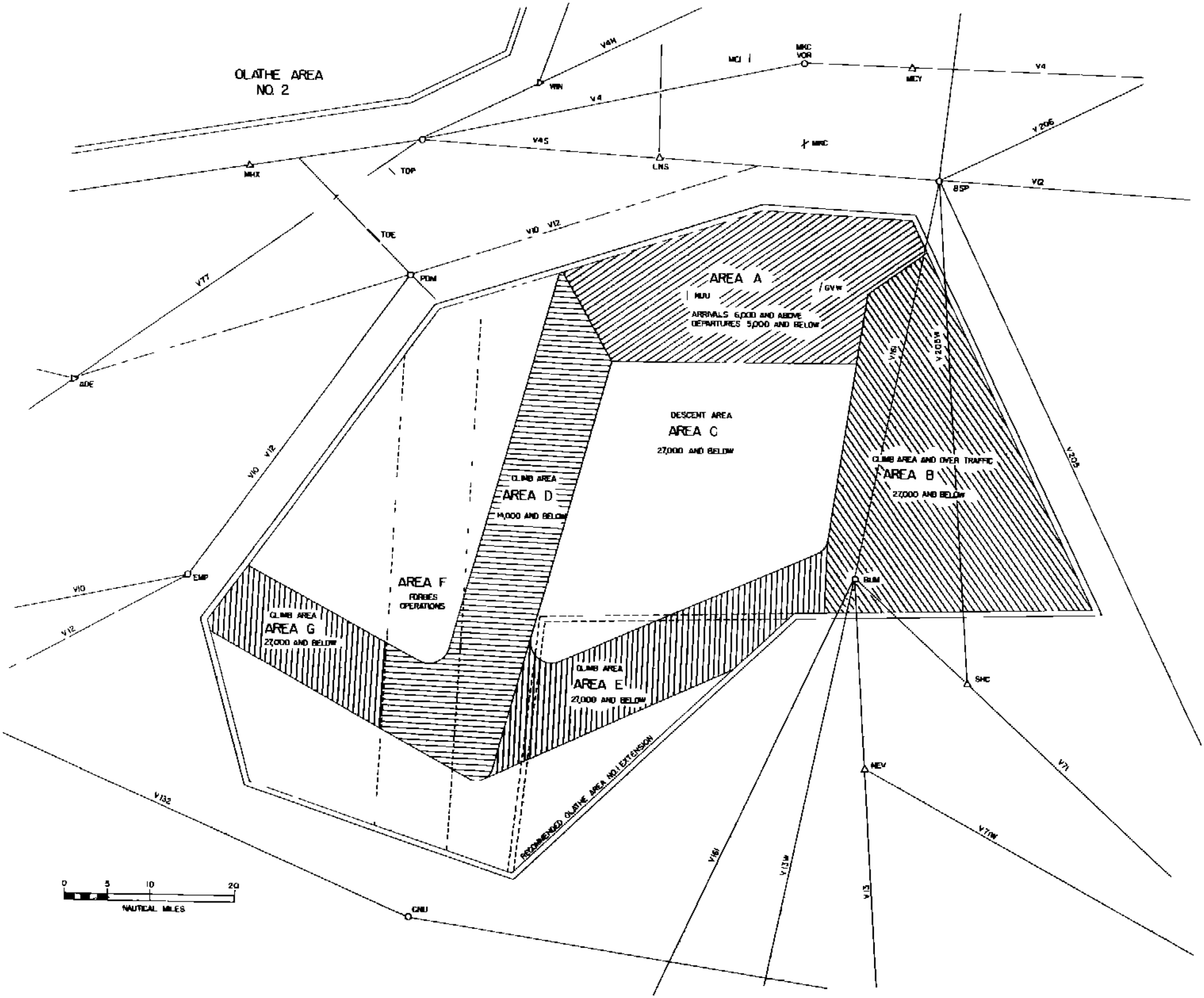



FIG. 22. OLATHE AREA NO. 1 SYSTEM B

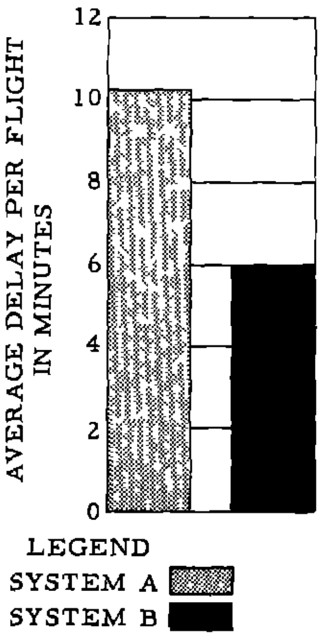



FIG. 23 OLATHE RAPCON DEPARTURE DELAY DATA
NORTH AND SOUTH OPERATIONS

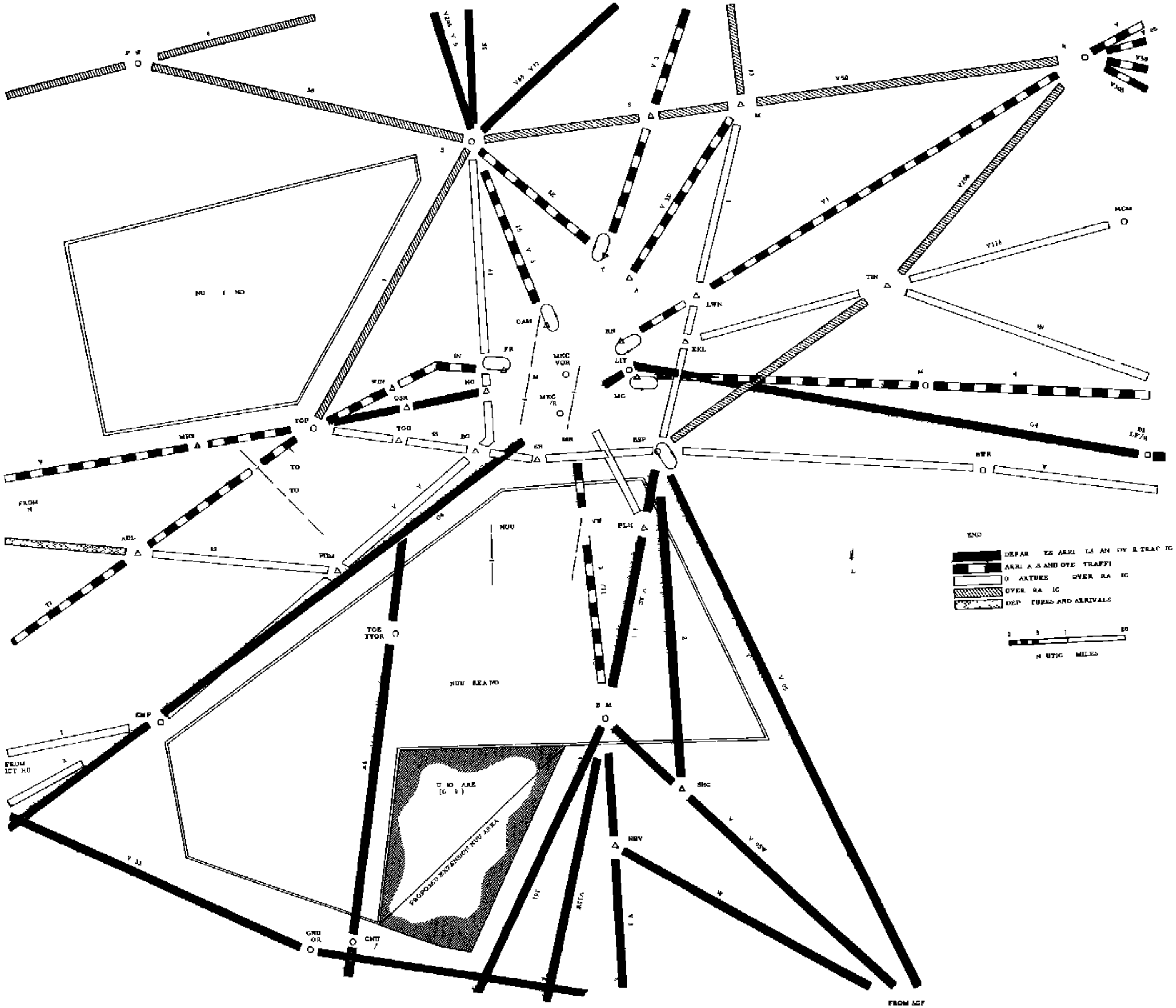
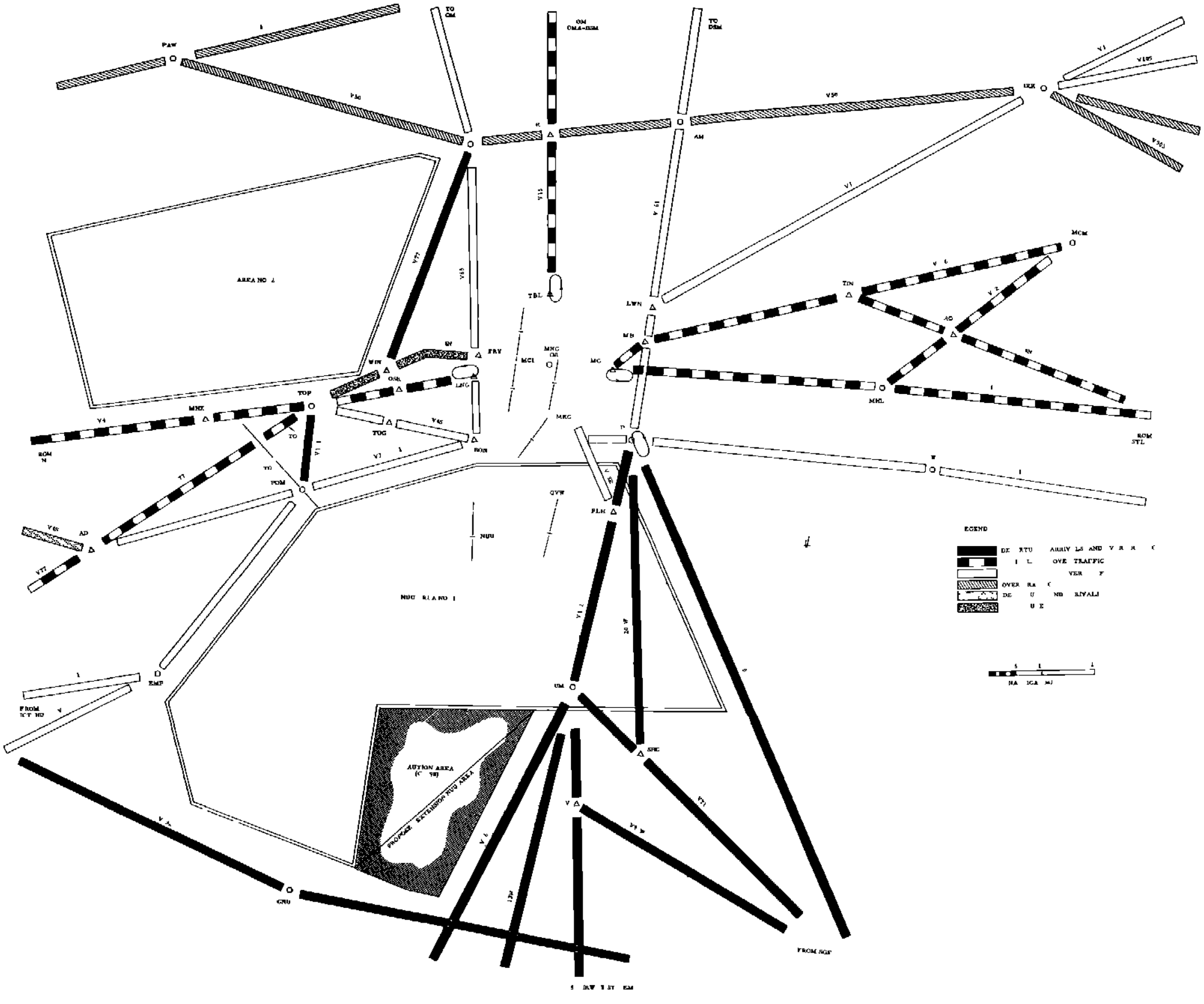
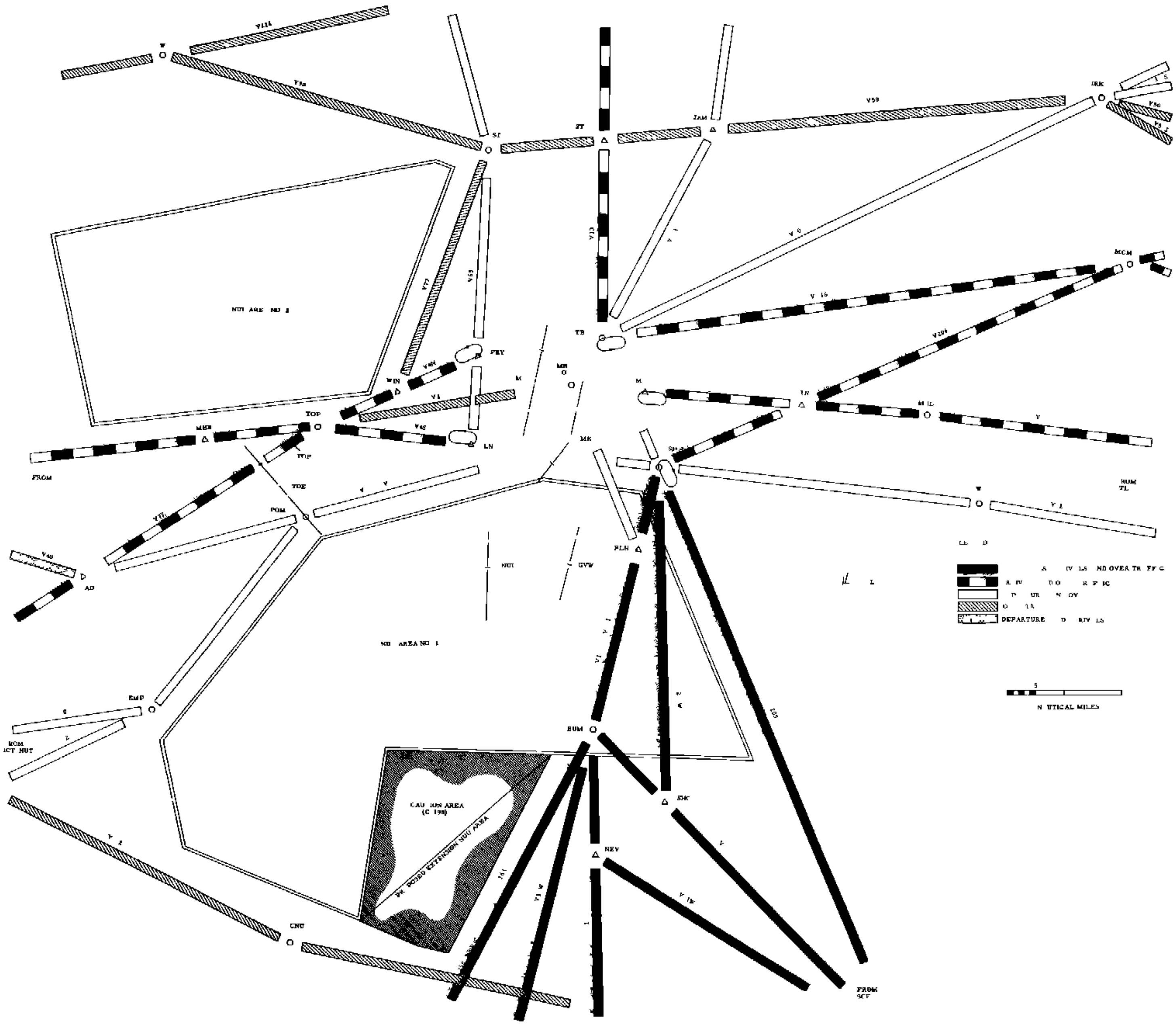



FIG 24 AIRW Y SYSTEM


PAW
TO OM
TO DSM
V1
V105
V30
V56
IRK
V15
V61
V77
V65
AREA NO 4
TBL
LWN
MCM
TIN
FRY
WIN
OSK
LNG
MCI
MKC
TOP
MNX
V4
V45
TOG
BOH
TO
FOM
STL
OVW
FLH
NUU
NUU
EMP
FROM
UM
SPK
V71
GNU
FROM SGF
LEGEND
OVE TRAFFIC




FI 26 AIRWAY ST M

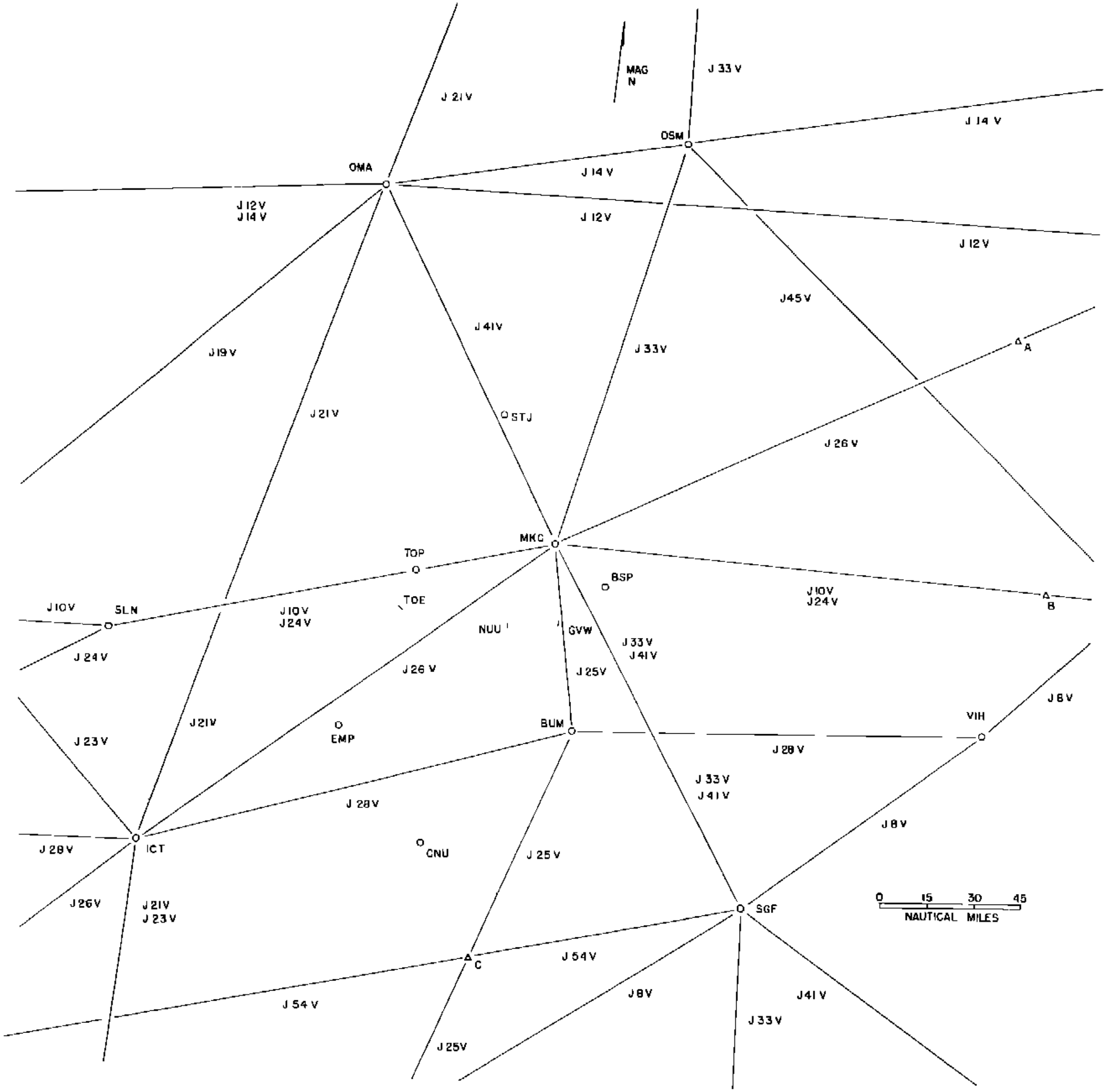



FIGURE 27 HIGH ALTITUDE ROUTE STRUCTURE