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EVALUATION BY SIMULATION TECHNIQUES OF A PROPOSED TRAFFIC CONTROL PROCEDURE FOR THE NEW YORK METROPOLITAN AREA

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GLOSSARY OF LOCATION IDENTIFIERS USED IN ILLUSTRATIONS AND TEXT

ABS	Ambrose
AMB	Amboy
BCH	Branchville
BEL	Belmont
BMD	Belle Mead
BSK	Bushkill
CAS	Cassville
CAT	Chatham
CDW	Caldwell
CEY	Coney Island
CLA	Clason Point
DGR	Dodger
ENW	Englewood
EWR	Newark
FBT	Floyd Bennett
FHD	Freehold
GNC	Glen Cove
HAS	Hastings
HEM	Mitchel
HPN	White Plains
IDL	Idlewild
JER	Jersey
LGA	LaGuardia
LNB	Long Beach
MEN	Menlo Park
MWA	Matawan
NBR	New Brunswick
ORN	Orange
PNJ	Paterson
POU	Poughkeepsie
PTL	Point Lookout
RDB	Red Bank
RWC	New Rochelle
SCO	Scotland
TEB	Teterboro
ZIG	Ziegfield

EVALUATION BY SIMULATION TECHNIQUES OF A PROPOSED TRAFFIC CONTROL PROCEDURE FOR THE NEW YORK METROPOLITAN AREA*

SUMMARY

This report describes a study to determine methods of expediting air traffic to and from the six major airports in the New York metropolitan air-traffic-control area. This study was made with the aid of simulation techniques developed jointly by the Franklin Institute Laboratories for Research and Development and by the Technical Development and Evaluation Center of the Civil Aeronautics Administration. Comparative tests were made of two different arrangements of radio navigational facilities. These configurations included the one in use at present as well as a system in which the present configuration was modified to provide more independent arrival routes A map showing one possible arrangement using VHF omnirange stations is also included in this study

Results of these tests indicate that the modified system described in this report should substantially increase the acceptance rate of this metropolitan area

INTRODUCTION

Control of instrument-flight-rule (IFR) traffic in the New York area presents an extremely complex problem due to the location of the airports The proximity of these airports seriously restricts the amount of airspace which can safely be used for the maneuvering of aircraft in each of the approach-control areas Three major and three secondary airports are located within a 17-mile radius of the LaGuardia Airport

At the present time, the greatest percentage of the arrival traffic proceeding to the New York metropolitan area is from the west and the southwest Additionally, some arrivals from the north are routed to arrive from a westerly direction This congestion of arriving traffic on one airway has necessarily resulted in many aircraft reaching approach areas at high altitudes with little traffic beneath them This condition is due to the use of Army-Navy-CAA (ANC) procedures for the control of air traffic instead of the use of radar separation at the confliction points.

Departures have proved to be a difficult problem, particularly those which are southwestbound or westbound These problems of conflicting air traffic exist on other routes in this area, but to a lesser degree

To provide a more orderly flow of air traffic in the New York metropolitan area, the Office of Federal Airways requested the Technical Development and Evaluation Center to study the New York problem through the use of the dynamic air-traffic-control (ATC) simulator To obtain needed background, TDEC air-traffic-control specialists visited the installations of the New York area prior to beginning simulation tests.

The New York simulation tests were specifically directed toward the development of a traffic-control system possessing the following characteristics

1. The system should permit approach controllers to expedite the movement of arrival traffic to the landing area
2. The system should be designed for use with radar-vectoring techniques. It should also be capable of functioning efficiently during periods when the radar is inoperative
3. Because of frequency-allocation problems, the system should require a minimum number of additional low-frequency radio facilities
4. The system should be arranged to require a minimum amount of co-ordination between control agencies.
5. The system should provide, where possible, expeditious approaches from at least two directions.
6. The system should provide for an efficient flow of departure traffic.

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*Manuscript submitted for publication September 1953.

EVALUATION PROCEDURE

The equipment used for this evaluation was the dynamic air-traffic-control simulator at the Technical Development and Evaluation Center in Indianapolis, Indiana. A description of this equipment can be found in another report.[1]

It should be noted that the arrival tests took into account only the internal restrictions of the terminal area. For example, the tests were conducted with the assumption that the New York Center could feed inbound aircraft into the various approach-control zones at rates up to 30 arrivals per hour.

A study of departure traffic resulted in the provision of primary routes and, where possible, of alternate routes that could be used during certain traffic conditions. Allocation of specific altitudes was attempted at some points of confliction.

Actual flight-progress strips of an IFR day were obtained from the CAA Air Route Traffic Control (ARTC) Center at New York. With the aid of the Franklin Institute, these strips were analyzed, and the maximum three-hour period of the day's traffic was selected for the original traffic sample. These strips furnished a typical sequence of the following combinations of data:

Aircraft Identification
Type of Aircraft.
Arrival Route
Destination Airport
Altitude at the various reporting points en route to destination
Time over these reporting points

At first, it was thought that the actual traffic sample would be fed into the dynamic simulator, however, the three-hour sample taken from the actual strips gave an average arrival rate of only nine aircraft per hour for LaGuardia Airport. This was also the approximate rate for the New York International (Idlewild) Airport. No arrivals were cleared to the Newark Airport that day because the airport was closed to IFR operation during this period. Since an arrival rate of nine aircraft per hour represents a small amount of traffic when radar is used, it was decided that a two-hour arrival sample should be constructed by mixing the arrival traffic of the third hour with that of the first two hours. This action resulted in an arrival rate of approximately 15 aircraft per hour for both the LaGuardia and the Idlewild airports. After this mixing was accomplished, altitudes were adjusted at the reporting points if the strips indicated that a confliction would have occurred between any two aircraft.

Since no traffic strips were available for the Newark Airport, a traffic sample was constructed for the Newark-Teterboro area and was integrated with the other two samples. The traffic sample of approximately 45 aircraft arrivals per hour for the entire metropolitan area was studied. Where conflictions would have occurred at some reporting fixes, the altitudes assigned to conflicting aircraft were adjusted.

After experience in the operation of both systems with radar was gained through the use of these traffic samples, it was decided to construct a heavily loaded sample of traffic to be used with the modified system. This was done to locate bottlenecks which might appear in the system under heavier traffic conditions. The arrival rate in this sample was 31 aircraft per hour for the LaGuardia area and the Newark area. The arrival rate for the Idlewild area was 25 aircraft per hour. No effort was made to idealize the input of these traffic samples. In fact, the altitudes for arrivals were deliberately assigned so that most of the arriving traffic was in inverse stacking order.

Three arbitrary classes of aircraft were used with speed programming as shown in Table I.

Because of the limited number of simulator consoles (one of which is required to simulate each aircraft), it was not possible to conduct simultaneous tests of arriving aircraft in the entire area. Therefore, comparative tests of the different systems were conducted as follows:

1. Tests were made using arriving aircraft only for one airport area at a time. It was assumed in these tests that specific airspace areas were blocked for the exclusive use

[1] Richard E. Baker, Arthur L. Grant, and Tirey K. Vickers, "Development of a Dynamic Air Traffic Control Simulator," CAA Technical Development Report No. 191, October 1953.

TABLE I

SPEEDS OF AIRCRAFT CLASSES

Aircraft Type	Cruising Speed (mph)	Intermediate Speed* (mph)	Approach Speed** (mph)	Descent Rate (fpm)
Slow	180	150	120	500
Medium	240	190	140	500
Fast	290	220	150	1000

* In zone extending from ten miles to five miles from the approach fix
** In zone extending from five miles from the approach fix to the point of touchdown

of departures and arrivals at the various airports Two route systems were simulated One was the present system and the other the modified system described in a later section The average demand rate used with the present system was approximately 45 arrivals per hour for the entire metropolitan area The average demand rate used with the modified system was approximately 45 arrivals per hour A second sample had a demand rate of approximately 85 arrivals per hour for the area

2 One test with the modified system was made using one-half the input to the Newark Airport and one-half to the LaGuardia Airport This test was to investigate the resulting radar display when traffic was confined to restricted airspace
3 Another test with the modified system was made using one-half the input to both the Newark and the LaGuardia Airports This test simulated the sudden closing of LaGuardia Airport due to weather Traffic at the two LaGuardia holding points was integrated into the Newark traffic as soon as practicable for landing at Newark Airport

After practice runs had been made for the purpose of working out the many details of each area tested, the measurement tests were begun These runs were made under as nearly standard conditions as possible In addition to controllers from TDEC, personnel from the New York ARTC Center, the LaGuardia tower, the Newark tower, the Idlewild tower, and the Teterboro tower participated in controlling the traffic for these tests

The basic problem data furnished the theoretical time at which each arriving aircraft should be inbound over the approach fix and at final-approach altitude, if no other traffic were involved Through use of an Esterline-Angus recorder, the simulation pilots recorded the actual arrival time of each aircraft over the appropriate approach fix By comparison of the theoretical arrival time with the actual arrival time, it was possible to determine the absolute delay to each inbound aircraft

Voice communications included pilot reports and all approach-control clearances necessary to bring each aircraft to a point where final approach could be continued by a ground-controlled approach system (GCA) or by a pilot using instrument-landing-system (ILS) facilities Weather reports were issued as required The number of separate communications contacts on each channel was recorded through the use of electric counters The total live time of each channel was recorded by means of electric clocks

The results of all tests were included in the calculation of the final averages which are listed in Figs 1, 2, and 3 Since the radar experience of the controllers who participated in these tests varied over an extremely wide range, the results should be typical of those which could be expected in actual operations of this nature with present control personnel It should be pointed out that the numerical results of these tests may not necessarily be duplicated in actual operations because of unavoidable differences between laboratory conditions and actual operating conditions However, since all simulation tests were made under the same laboratory conditions, the simulation results show the relative differences between the performance characteristics of the various systems tested

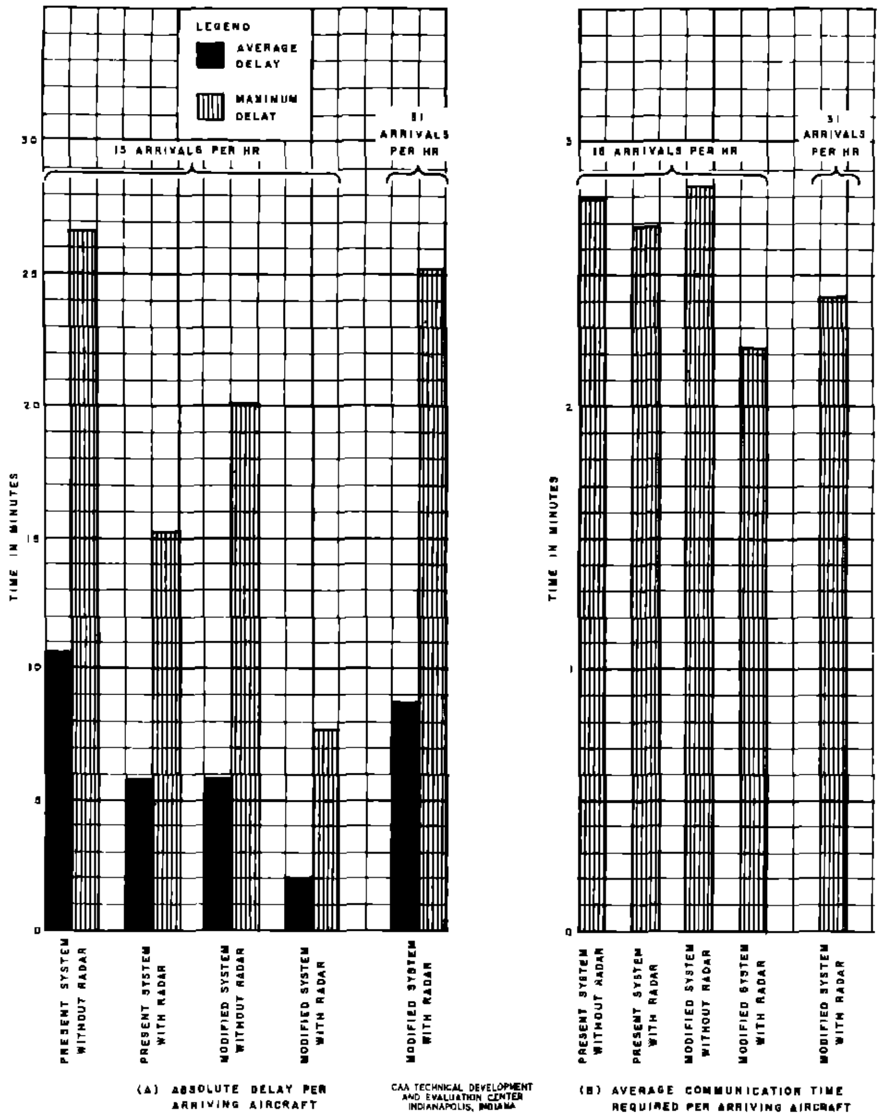

Fig 1 Summary of Simulation Tests, LaGuardia Area

TESTS AND RESULTS ON PRESENT SYSTEM

In order to establish a basis of comparison for evaluating possible improvements in the New York metropolitan-area traffic-control system, the present arrangement of navigational aids was tested both with and without radar.

A map of the existing arrangement of facilities in this area is shown in Fig 4 The holding patterns used in these tests are shown in Fig 5 The routes and holding areas used in simulating the present-day procedures conformed as closely as practicable to those stated in the joint CAA - Air Transport Association (ATA) study of IFR traffic in the New York metropolitan area for the winter of 1952-1953[2] and to those in available operations letters

[2] "Minutes of the Joint CAA-AOD-ATA-ALPA Meeting, September 28 – 30, 1953," CAA First Region, October 1953 (Unpublished)

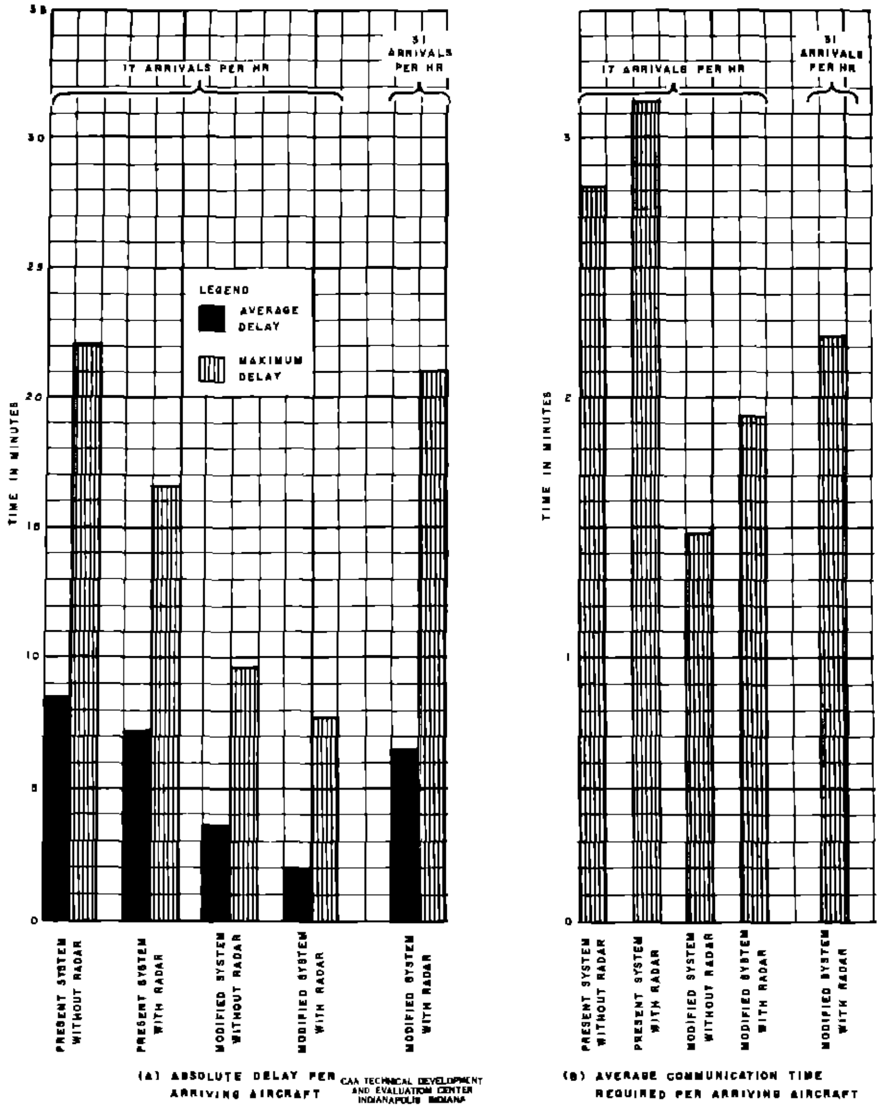

Fig 2 Summary of Simulated Tests, Newark Area

Two approach-control positions, each using separate single-channel simplex communications, were operated during the arrival tests of the three approach-control areas. One controller handled arriving traffic in the final-approach, or primary-holding, stack while another controlled traffic holding in the secondary patterns.

A third position, that of a terminal-area controller, was simulated This controller handled arriving traffic nearing the approach-control area He used a simplex communications channel, and the position was assumed to be in the ARTC Center where there is available complete information concerning air traffic in the metropolitan area

The functions and purposes of these positions of operation were the same during tests of the present system both with or without radar.

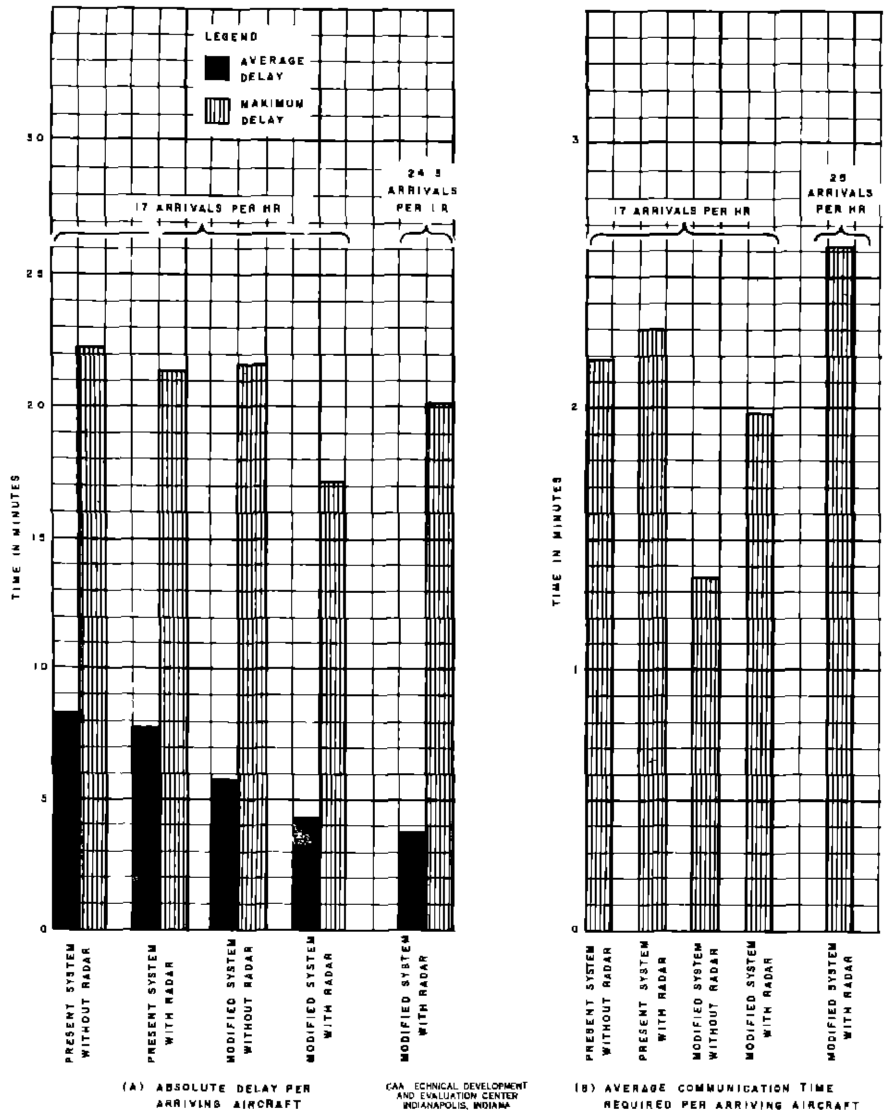

Fig 3 Summary of Simulated Tests, Idlewild Area

LaGuardia Airport

Arrival-Control Procedures

Figure 4 shows the inbound routes used both with and without radar Primary holding was accomplished at the Flatbush marker at altitudes of 1500 through 4500 feet Secondary holding was accomplished at the Flatbush marker from 5500 through 9500 feet and at the Holmes marker (the middle marker of the LaGuardia ILS) at altitudes of 5500 feet and above It was occasionally necessary to use the Matawan range station as a secondary holding fix because of the heavy arrival rate from the west and southwest.

Without radar, standard timed approaches conducted from the Flatbush marker used a minimum interval of three minutes The Flatbush primary-approach stack was fed from the secondary holding stacks.

The tests conducted with radar used the identical sample of arrivals and holding points as was used without radar control The principal difference was in the application of radar-control procedures.

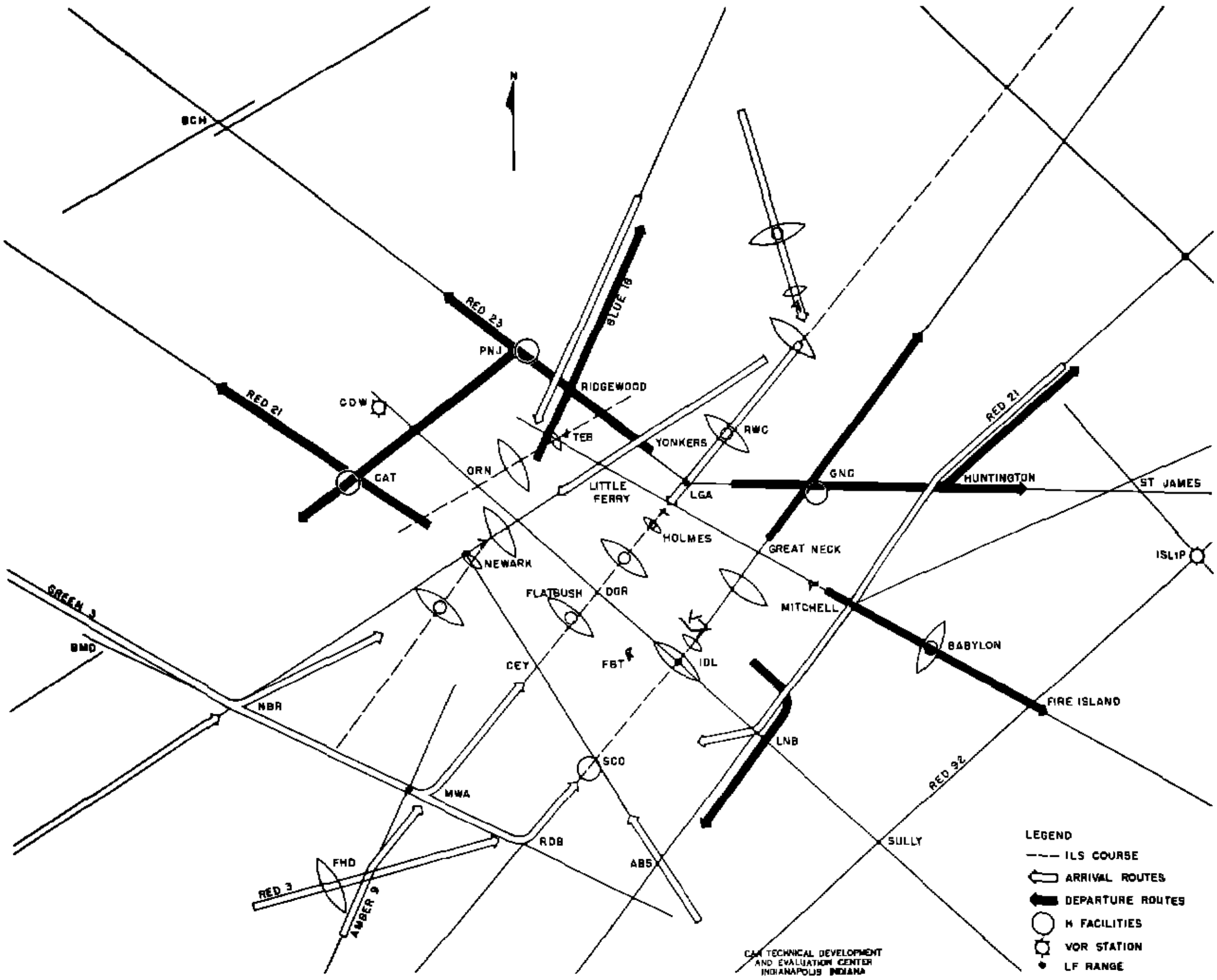

Fig 4 Primary Arrival and Departure Routes Used in Simulation of Present Navigational Aids of the New York Metropolitan Area

Departure Procedures.

Departure routes are shown in Fig. 4. No tests were conducted of traffic departing the LaGuardia airport since the main purpose of this phase was to locate restrictions to the flow of the arrival traffic

Results and Observations

Delays and communications times are shown graphically in Fig 1. Examination of data collected during this phase indicates that the major delay to arriving aircraft at Flatbush was due to high entry altitudes in the terminal area. When the actual strip postings were checked, it appeared that these high entry altitudes resulted from the sharing of common routes by the arrivals. As an example, traffic destined for LaGuardia from the west shared Green airway 3 with traffic destined for Newark and Idlewild Airports. In many instances, these aircraft could not be cleared for descent to lower altitudes until north of the Matawan range station As a result, many aircraft were delayed after reaching the Flatbush fan marker because of excess altitude.

An approach interval of at least three minutes from the Flatbush fan marker is desirable because of the danger of one aircraft overtaking another while on this 11-mile final approach.

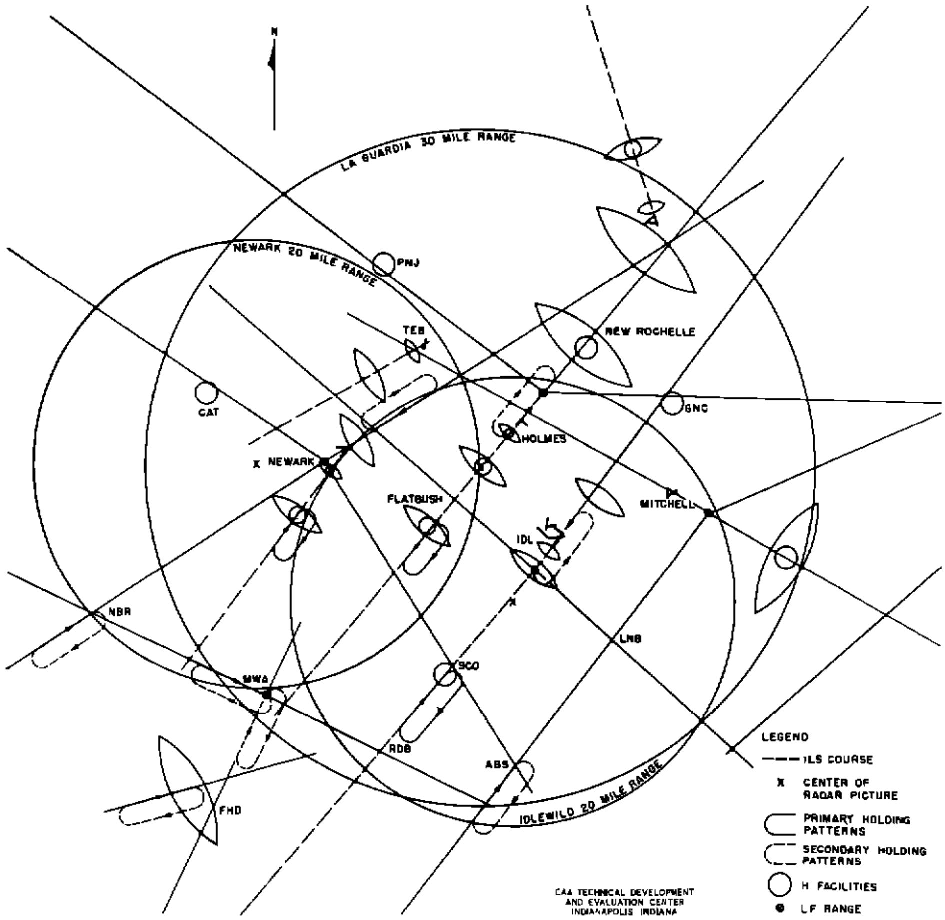

Fig. 5 Primary and Secondary Holding Patterns
Used in Simulation Tests of Present-System Radar Coverage

If this fix could be relocated nearer the LaGuardia outer marker, an approach interval of two minutes might be used

The simulator data indicates that the application of radar-vectoring procedures to the present system will lessen the delay per aircraft, as shown in the comparative figures Much of the delay when radar is used results from high entry altitudes

With radar coverage of the area as shown in Fig. 5, it was often possible to change the altitude of arriving aircraft by the use of radar procedures and to bring first arrivals in first and thus provide a more efficient flow of traffic to the airport

Because the final-approach stack was located on the final-approach course, it was difficult to use the radar effectively in identification and vectoring procedures to space arrivals properly on the final approach The use of radar for this purpose was further restricted because of the proximity of the Newark area on the west and that of Idlewild on the east.

Newark-Teterboro Area

Arrival-Control Procedures

The present navigational aids on routes in this area are shown in Fig 4. The control positions previously described were used in this phase Where possible, the present procedures governing approach control in the Newark area were used in these tests. For example. the traffic destined for the Teterboro Airport was cleared to the Newark outer marker, and the transition and approach on the Teterboro ILS were controlled by the Newark approach controllers.

The primary holding stack was at the Newark outer marker of the ILS system at altitudes of 1500 through 4500 feet The secondary holding stacks were at New Brunswick and at the Newark outer marker at altitudes of 5500 feet and above. Occasionally it was necessary to use the Jersey intersection as an additional secondary holding fix for arrivals from the north and the northeast

Without the use of radar, a minimum interval of two minutes was used for successive approaches from the Newark outer marker to the Newark airport Approaches to Teterboro Airport were treated as Newark approaches until reaching an altitude of 2500 feet At this time the aircraft were cleared for an ILS approach to Teterboro and maintained 2500 feet altitude until they intercepted the front course of the Teterboro ILS.

With radar procedures, these tests were conducted with the use of the identical sample of arrivals and the identical navigational aids described in the preceding section. The difference was in the application of radar procedures in the Newark approach-control area

Departure Procedures

Departure routes are shown in Fig 4 No tests were conducted of traffic departing these airports since the main purpose of this phase was to locate restrictions to the flow of the arrival traffic

Results and Observations.

Delays and communications times are shown graphically in Fig. 2 Examination of the data collected during these tests indicates that much of the delay to arriving aircraft was due to the high altitudes of aircraft entering the approach-control area For example, all aircraft from the west for all airports in the metropolitan area arrive on Green airway 3. Therefore, ARTC is not always able to arrange the arrivals in the most suitable stacking order with the first arrivals at the lowest altitudes. The location of the outer marker, when used as the primary holding fix, is considered adequate for making timed approaches with two-minute intervals Since this stack was located on the final-approach course, it was difficult to use radar effectively to identify and to space aircraft on final approach after a holding stack had formed at the outer marker

With radar coverage of the area as shown in Fig. 5, it was often possible to change the altitude of arriving aircraft by the use of radar procedures and to bring first arrivals in first The use of radar provides for a constant flow of arrivals into Newark Airport while an aircraft is making transition to the Teterboro ILS. The use of radar should eliminate the necessity for an aircraft making transition to the Teterboro ILS to make a procedure turn away from the Teterboro outer marker before continuing the approach Radar controllers would help these aircraft turn directly to the final-approach course in the vicinity of the Orange intersection.

Idlewild Area

Arrival-Control Procedures

The present navigational facilities and routes used are shown in Fig 4. Control positions as previously described were also used in this phase One basic departure from present procedures was simulated for this portion of the tests In the first study of this area it was noted that Mitchel Air Force Base was provided with an area in which to exercise approach control for their own aircraft. It was decided that a better utilization of the available airspace would result if one agency controlled arriving and departing aircraft in the area encompassing the three airports· Floyd Bennett Naval Air Station, Idlewild Airport, and Mitchel Air Force Base This procedure would eliminate the need for co-ordination between airport-traffic controllers of different airports concerning the use of altitudes in these areas The facts that Idlewild Airport is the major airport of these three and is located between the other two influenced the decision to have approach-control service provided for all three airports by the Idlewild approach controllers

The primary holding stack was at the Scotland intersection at altitudes of 2500 feet and up It was occasionally necessary to hold aircraft in secondary holding stacks at the Freehold intersection, the Matawan range station, the Ambrose intersection, and the Idlewild range station.

It was assumed that aircraft destined for Mitchel Air Force Base and the Floyd Bennett Naval Air Station would be cleared to the Scotland intersection together with aircraft destined for the Idlewild Airport. The landing runway for IFR traffic at Mitchel Air Force Base was changed to Runway 5. The landing runway at Floyd Bennett was Runway 1. The Idlewild approach controller handled traffic in the Scotland stack. Traffic destined for the Mitchel Air Force Base would leave the Scotland marker northeastbound when an altitude of 2500 feet was reached and would proceed to the Idlewild range. At this point, the aircraft would become the responsibility of the Mitchel Air Force Base radar controllers and would complete approach into Mitchel. Traffic for Floyd Bennett Naval Air Station would be stepped down to 1500 feet in the holding pattern at Scotland and would become the responsibility of the Floyd Bennett radar controllers for the approach into Floyd Bennett. Three-minute timed approaches were conducted from Scotland for successive Idlewild arrivals.

When radar procedures were used, these tests were conducted with the identical samples of arrivals and identical holding points described in the preceding section. The principal difference was in the application of radar-control procedures in the Idlewild approach-control area.

Departure Procedures.

Departure routes are shown in Fig. 4. No tests were conducted of traffic departing from this area since the main purpose of this phase was to locate restrictions to the flow of arrival aircraft Since all arrivals in the area were under the control of one agency, it should have been possible for the departure controllers to use the airspace more efficiently than was previously possible.

Arrivals destined for the Mitchel Air Force Base were guided to the Idlewild range and were turned on final approach for Runway 5 at Mitchel. Because these aircraft shared a common approach channel with other arrivals destined for the Idlewild Airport, there would be ample time for the arrival controller to co-ordinate the information concerning the Mitchel Air Force Base arrival with the departure controller If radar departure procedures were being used, the departure traffic would be affected very little since the Mitchel arrival would also be under surveillance by the departure controller.

Results and Observations.

Delays and communications times are shown graphically in Fig. 3 Examination of the data collected during this phase indicates that the majority of the delays to arriving aircraft at the Scotland intersection were due to the high altitude at which aircraft entered the approach-control area. The reasons for this condition are the same as those described in the section dealing with the LaGuardia Airport, that is, too many arrivals destined for several approach-control areas use common airways to enter the metropolitan area.

The location of the Scotland intersection and marker necessitates a minimum approach interval of three minutes. Because of the water area, it does not appear practicable to move the Scotland marker nearer the outer marker. The outer marker of the Idlewild ILS is considered to be too close to the airport for use as a point from which to make an adequate ILS approach.

The results indicate that the use of radar procedures in the Idlewild area tends to lessen the delays per aircraft. When the radar coverage of the area was used as shown in Fig. 5, it was often possible to unscramble reversed sequences in order to land first arrivals first

Since a holding stack at the Scotland fan marker was located on the final-approach course, it was very difficult for radar controllers to identify and to accurately space aircraft once the holding stack had formed

Summary of Observations.

Since a large percentage of arrival traffic in the New York area converges at the New Brunswick intersection and at the Matawan range station, it is probable that ARTC controllers will continue to have difficulty in arranging the altitude of these arrivals in the desired sequence for entry into the approach-control zones It is believed that this condition is true to a lesser degree for traffic arriving from the north and the northeast.

The use of air/ground communication channels by ARTC controllers will aid in the more efficient sequencing of arrivals entering approach-control areas This procedure will eliminate much of the delay encountered in the relaying of messages through other agencies

The departure routes conflict with arrival routes in many places There appears to be no easy solution to the problem of providing independent departure routes for each airport in the area, except to select certain altitudes at the conflicting points and to specify that these routes and altitudes are to be used only for departure traffic from a designated area.

There is no ready solution to the problem of providing the Teterboro airport with its own approach-control zone without seriously restricting the flow of traffic at the LaGuardia and Newark airports. An aircraft departing from the Teterboro airport and taking off to the northeast may immediately conflict with westbound departures from the LaGuardia Airport A departing aircraft taking off to the southwest from Teterboro would be in a position to conflict with departures from the Newark airport if IFR weather conditions should prevail

When the amounts of airspace required for a civil airway, a holding pattern, approach-control zones, and the areas used by departing aircraft are considered, it can be shown that there is not enough airspace in this area to provide each of the airports with an independent system without restricting the traffic flow at the major air terminal, LaGuardia Airport

The application of radar arrival procedures to the present system will aid in reducing delays to aircraft, however, full utilization of radar techniques cannot be realized when traffic is near the saturation point and as long as the holding stack is located on the final-approach course. Tests have repeatedly shown that when the holding pattern is offset from the final-approach course a controller can more easily identify and space aircraft on the final-approach course by the use of velocity control and of path-stretching techniques.

Of the three major airports in the metropolitan area, it appears that LaGuardia Airport because of its geographical location in relation to the other two is the one whose area restricts the traffic flow at the other two. Figure 6 shows the traffic flow in the area if the LaGuardia Airport were to become a secondary airport or if it were to be closed

TESTS AND RESULTS ON MODIFIED SYSTEM

Rearrangment of Navigational Aids.

The location of the airports with respect to each other and the primary direction of landing creates the problem of equitable division of the available airspace. Since the LaGuardia Airport receives approximately 63 per cent of the instrument approaches in this area, it was decided to provide this airport with the best of the available airspace regardless of the limitations that might be imposed on other areas.

The remainder of the area was divided into two approach-control areas. Newark personnel were assumed to be the approach controllers for the Teterboro and Newark airports. The traffic to these airports made approaches from a common holding fix Idlewild approach control assumed control of traffic destined for Mitchel Air Force Base, Floyd Bennett Naval Air Station, and Idlewild Airport This traffic normally made approaches from a common holding fix. Since the Newark and Teterboro airports receive approximately 21 per cent of the instrument approaches into this area, it was decided to provide these airports with the best of the remaining routes. It was also found that there was enough airspace to the southwest of these airports to establish two clearance limits to be used by ARTC.

The Idlewild area receives approximately 16 per cent of the instrument approaches of arrivals into the metropolitan area. It was determined that, at the time of this study, little traffic arrives for this area from the west or northwest, a factor which simplified the problem The routes into this area from other directions appeared to be satisfactory. It seemed desirable to provide this area with two holding fixes to be used as primary clearance limits. However, because of the large water area southwest of Idlewild Airport, this was not considered practicable.

In an effort to eliminate the deficiencies which were found during tests of the present arrangement of navigational facilities, a rearrangement of these facilities was tested during this phase. This arrangement, which is shown in Fig. 7, included the following changes

1. The west course of the Newark range was moved approximately 12° south to cross Windgap, Pennsylvania. This forms a new Red airway 21.
2. The west course of the Idlewild range was moved to cross the Caldwell VOR station. This newly realigned course of the Idlewild range station would become a one-way airway for westbound departures from Teterboro and Newark Airports and would be shared occasionally by departures from the LaGuardia Airport.

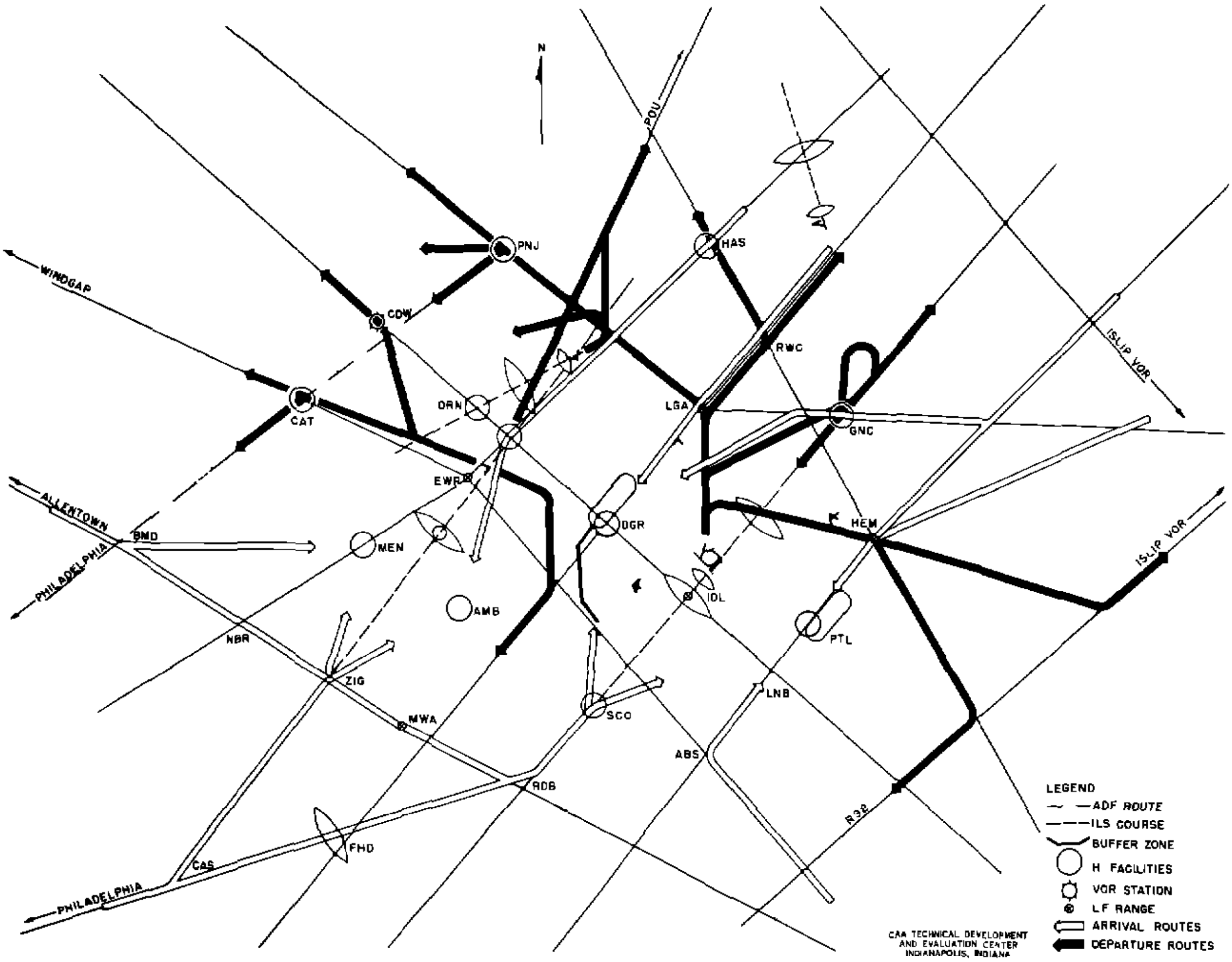

Fig 6 Flow of Traffic in the New York Metropolitan Area, LaGuardia Airport Closed

3 The northeast course of the Newark range was moved approximately 12° north to cross the outer marker of the Westchester County Airport.

4 The north course of the Idlewild range was moved 3° east and was made a reciprocal of the southwest course of that range. This change also provided an airway which is to the northeast and which parallels route P on the west

5 The west course of the Mitchel Air Force Base range station was moved 30° north, and the east course was made the reciprocal of this new northwest course It is realized that this change would no longer provide this airport with a low-frequency-range course for use by aircraft on an approach to runway 30 However, this entire traffic-flow system is based primarily on radar control into all of the major airports plus the use of ILS equipment for final-approach guidance into the civil airports It is assumed that Mitchel Air Force Base would be provided with radar of the precision-approach type to be used for final-approach guidance to that airport However, should it be temporarily without the use of this radar, many aircraft would be able to make an automatic direction finder (ADF) approach from the Mitchel range station.

By moving the west course of the Mitchel range, a new route for northwestbound departures was provided whenever landings were being made to runway 4 at LaGuardia and Idlewild Airports.

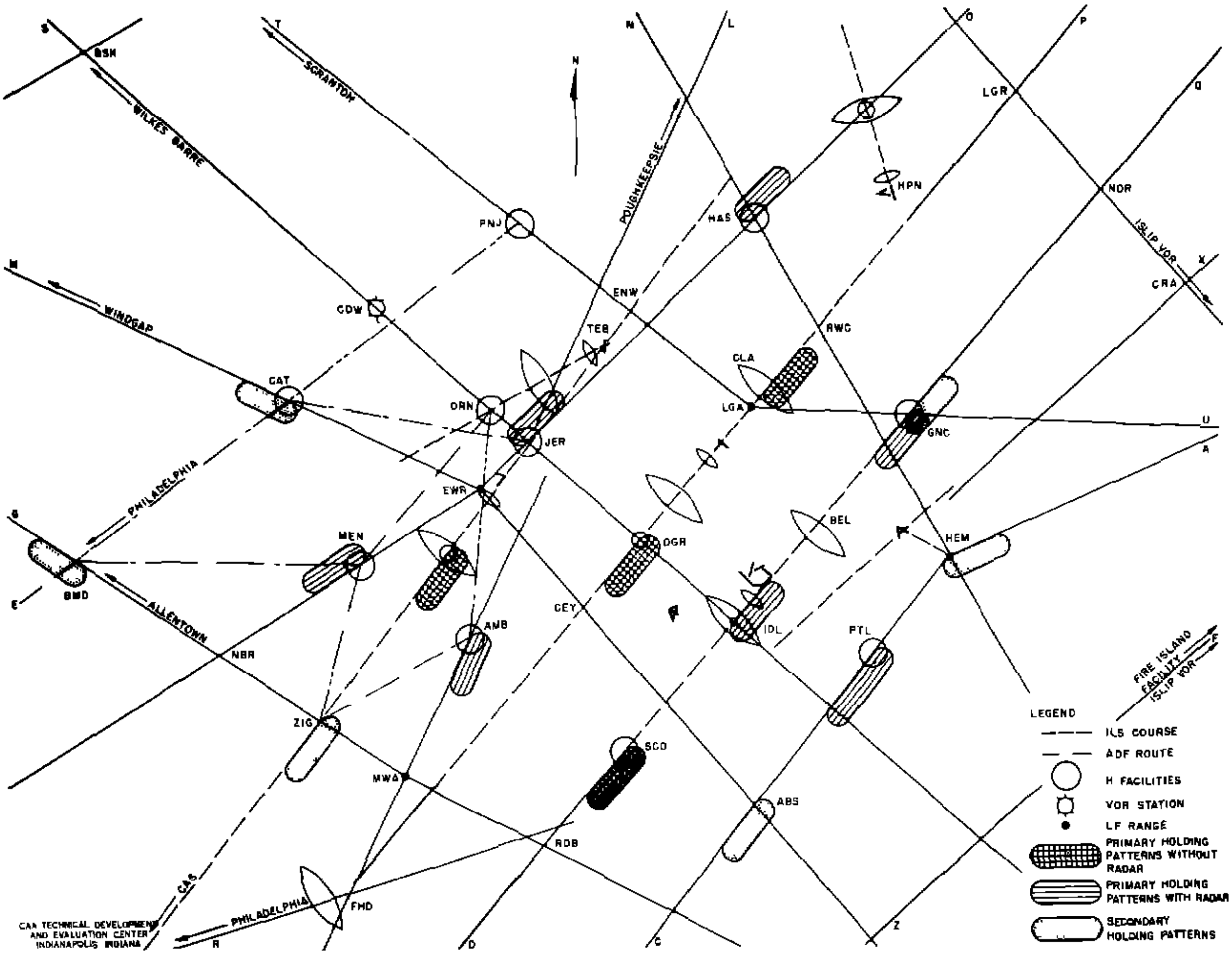

Fig 7 Modified System With Holding Patterns

6. The east course of the Newark range was moved 10° north to compensate for the moving of the west course of the range to the south This change moves the position of the Ambrose intersection northward a few miles
7. The Paterson homing facility was moved approximately four miles northwestward along the northwest course of the LaGuardia range.
8. The Chatham H-facility was moved four miles to the southwest and was located on the new west course of the Newark range station.

Changes 7 and 8 are desirable, provided the minimum en route altitude is not raised. It was thought that, by moving this route to the west as far as possible, arriving traffic on route M could descend to cross the Jersey intersection at the desired altitude of 4000 feet The moving of these markers would also provide room for the establishment of one holding pattern at the Orange marker for use by Newark radar control when it is necessary to make landings to the southwest at Newark This will be practical only after the Calco stack is removed

9 A homing facility was installed at the Jersey intersection to be used as a clearance limit for LaGuardia arrivals. The Jersey intersection is formed by the northwest course of the Idlewild range station and the northeast course of the Newark range station.
10 A homing facility was installed at the Hastings intersection to be used as a clearance limit by LaGuardia arrivals when landings are being made on runway 22 The Hastings

intersection is formed by the northwest course of the Mitchel range station and the northeast course of the Newark range station

11 A homing facility was installed on the southwest course of the Mitchel range station and approximately eight miles south of it to be used as a clearance limit for arrivals destined for Mitchel Air Force Base, Idlewild Airport, and Floyd Bennett Naval Air Station

12 A homing facility was installed seven miles southeast of the Newark outer marker on the northwest course of the Matawan range station to be used as a clearance limit for aircraft arriving at the Newark or Teterboro airports

13. A homing facility was installed seven miles southwest of the Newark outer marker on the southwest course of the Newark range to be used as a clearance limit for aircraft arriving at the Newark and Teterboro airports

14 The south course of the Poughkeepsie range station was moved westward to cross the Jersey intersection

15 A homing facility was installed at the Orange intersection to be used by pilots of aircraft to make the transition from the Newark outer marker to the Teterboro ILS course

16 The New Rochelle fan marker was relocated four miles southwestward of the present location to be used by arriving aircraft as a point to begin descent when landing on runway 22 at LaGuardia Airport.

17 A homing facility was installed at the Dodger intersection to be used for primary holding of LaGuardia arrivals when radar is inoperative.

18 The power of the Idlewild range was increased to that of a high-powered range station

19 The H-facility at Fire Island was considered as being a facility of at least 50 watts power and as being operated continuously.

Most of the H-markers described in the preceding are used to mark important intersections and to provide navigational guidance on some routes A difficult problem exists in obtaining frequencies to be used by additional low-frequency radio aids. However, by the decommissioning of some of the compass locators at the ILS sites, it is believed that sufficient frequencies would be available The following list shows one possible solution to this problem of rearrangement.

Decommission	Relocate As
Newark middle-marker compass locator	Orange H-facility
White Plains middle-marker compass locator	Hastings H-facility
LaGuardia middle-marker compass locator	Jersey H-facility
LaGuardia outer-marker compass locator	Dodger H-facility
Flatbush H-facility	Amboy H-facility
Babylon H-facility	Point Lookout H-facility
New Rochelle H-facility	Menlo Park H-facility

LaGuardia Airport With Radar.

1. Operating Positions

For the radar-control phase of the tests, two radar sector controllers, each using a separate single-channel simplex frequency, were used. One of these controlled arrivals at the Jersey intersection (the Jersey sector) and vectored aircraft from this point to the final-approach extension. The other radar controller handled arrivals at the Idlewild range. To avoid confusion with the Idlewild Airport, the holding pattern at the Idlewild range was called the Jamaica holding pattern and the sector was called the Jamaica sector This sector controller guided arrivals by radar from this pattern to the final-approach course of the LaGuardia ILS. Figure 8 shows the areas that could be used for radar vectoring by these controllers

A position of a terminal controller was established in order to best utilize available routes and altitudes assigned to LaGuardia arrivals This controller normally communicated

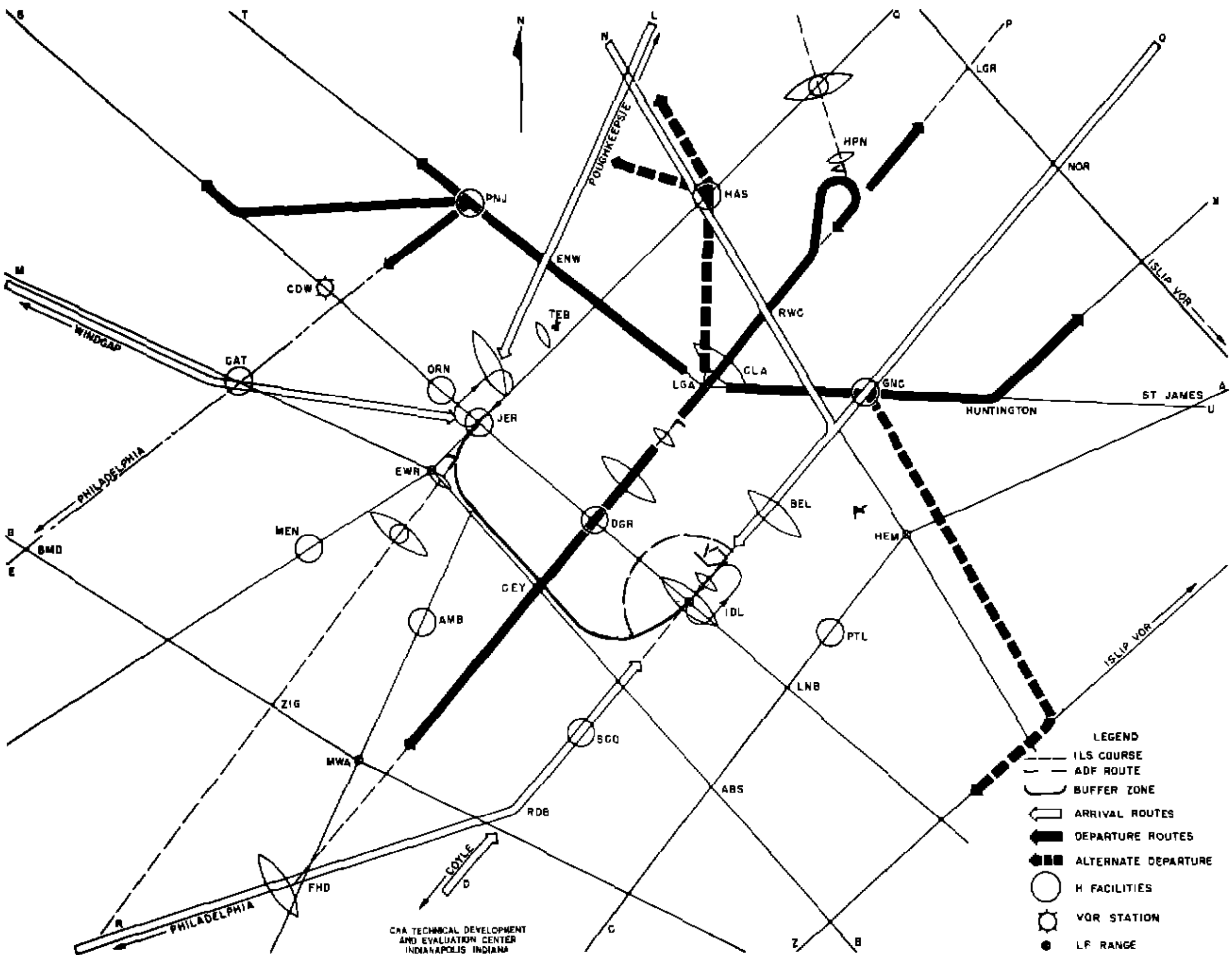

Fig 8 Arrival and Departure Routes, LaGuardia Airport (Landing Northeast)

with aircraft beyond the extent of radar coverage and controlled aircraft in the secondary holding stacks For convenience of simulation, the location of this third position was assumed to be physically adjacent to the radar-sector positions in order to facilitate immediate co-ordination with them. In addition, this position was assumed to be able to continuously communicate with the ARTC Center

2 Arrival-Control Procedures During Northeast Landings

Arrival routes for the LaGuardia Airport are shown in Fig. 8 Arrivals destined for LaGuardia Airport on route M were descended to a minimum altitude of 7000 feet until past conflicting departure traffic or unless identified by means of radar prior to crossing Chatham and unless provided with radar separation across the Paterson-to-Belle Mead route The minimum altitude in the holding pattern at Jersey intersection was 4000 feet.

Arrivals destined for LaGuardia from the north via route L were normally cleared to the Jersey intersection and were restricted to cross the west course of the LaGuardia range at 6000 feet or above. An alternate routing for these arrivals was via route L and N to the Glen Cove intersection and via route Q to the Idlewild range station (Jamaica holding pattern)

Arrivals from the northeast were cleared to the Jamaica pattern via route Q and were restricted to cross the Glen Cove intersection at 6000 feet or above. The minimum altitude in the Jamaica holding pattern was 3500 feet.

Arrivals from the south and southwest were cleared via routes R and D to cross the Scotland intersection and the Idlewild range at 3500 feet or above and were instructed to remain on the east side of the southwest course of the Idlewild range until past the Scotland H-facility in order to provide clearance from the Amboy holding pattern at Newark Arrivals for LaGuardia were guided by radar from the Jersey pattern and the Jamaica pattern until the final-approach course was intercepted at least two miles southwest of the LaGuardia ILS outer marker Because of the limited space southwest of the Dodger intersection in which to perform these radar functions without encroaching upon Newark's Amboy holding-pattern airspace, a buffer zone was inscribed on the map between the Jamaica and Jersey holding patterns It was the responsibility of the radar controllers to keep LaGuardia traffic inside this area.

Because of the proximity of Manhattan Island on the west side of the final-approach course to LaGuardia, it was necessary for aircraft which had missed an approach or had become separated by less than three miles from the preceding aircraft on the final course to turn only to the east In these cases, the pilots were advised to return to the frequency of the Jamaica sector radar controller for further instructions

Because of the location of the Floyd Bennett Naval Air Station, traffic being guided from the Jamaica pattern for LaGuardia was restricted to an altitude of not less than 2500 feet until past the zone around the Floyd Bennett Naval Air Station, as shown by a dashed semicircle in Fig 8

3 Arrival-Control Procedures During Southwest Landings

When wind conditions made it necessary for aircraft at LaGuardia to land to the southwest, traffic from routes M and L were cleared to the Hastings homing facility as a clearance limit Under these conditions it was no longer necessary for arrivals from the west to use 7000 feet at Chatham This traffic was cleared to cross Chatham at 8000 feet and to cross the Englewood intersection at 6000 feet. The minimum holding altitude at Hastings was 4000 feet. Traffic arriving from route L could be descended to 4000 feet prior to entering the Hastings pattern

Traffic arriving via route Q and route D was cleared to Glen Cove, where the minimum altitude was 3500 feet for holding Since it was no longer necessary for arriving aircraft from route D to cross the Scotland marker at the minimum altitude because of the increased route distance to the clearance limit, this traffic was routed over the Idlewild range at 5000 feet or higher. Traffic arriving at Glen Cove from route Q could descend to 3500 feet to enter the Glen Cove Pattern Figure 9 indicates these routes

The same type of radar-vectoring technique is employed as is used when aircraft land to the northwest and the northeast course of the LaGuardia ILS localizer is used as final-approach guidance for the pilots.

LaGuardia Airport Without Radar.

1 Operating Positions

Whenever the surveillance radar became inoperative at LaGuardia Airport, one of the sector radar controllers was immediately designated as an approach controller and a primary stack was established at the Dodger intersection. The approach controller handled the aircraft in this stack The other radar sector controller began controlling the secondary holding patterns at the Jersey and Idlewild holding fixes and began feeding the primary holding pattern at the top altitude from these holding points. The duties of the third controller were the same as those described previously

2 Arrival-Control Procedures During Northeast Landings.

During periods when LaGuardia radar was inoperative, a primary holding pattern was formed at the Dodger intersection at altitudes of 2000, 3000, 4000, and 5000 feet. Standard procedures were then employed for timed approaches from the Dodger holding pattern. The minimum altitudes at the Jersey intersection and at the Jamaica pattern were raised to 6000 feet The Dodger stack was then fed from these two secondary holding fixes

As soon as possible after the radar failure, the ARTC Center required all en route aircraft using the northeast and southwest courses of the LaGuardia range to fly at altitudes of 6000 feet and above. This was to be accomplished before the 5000-foot level could be used at the Dodger intersection.

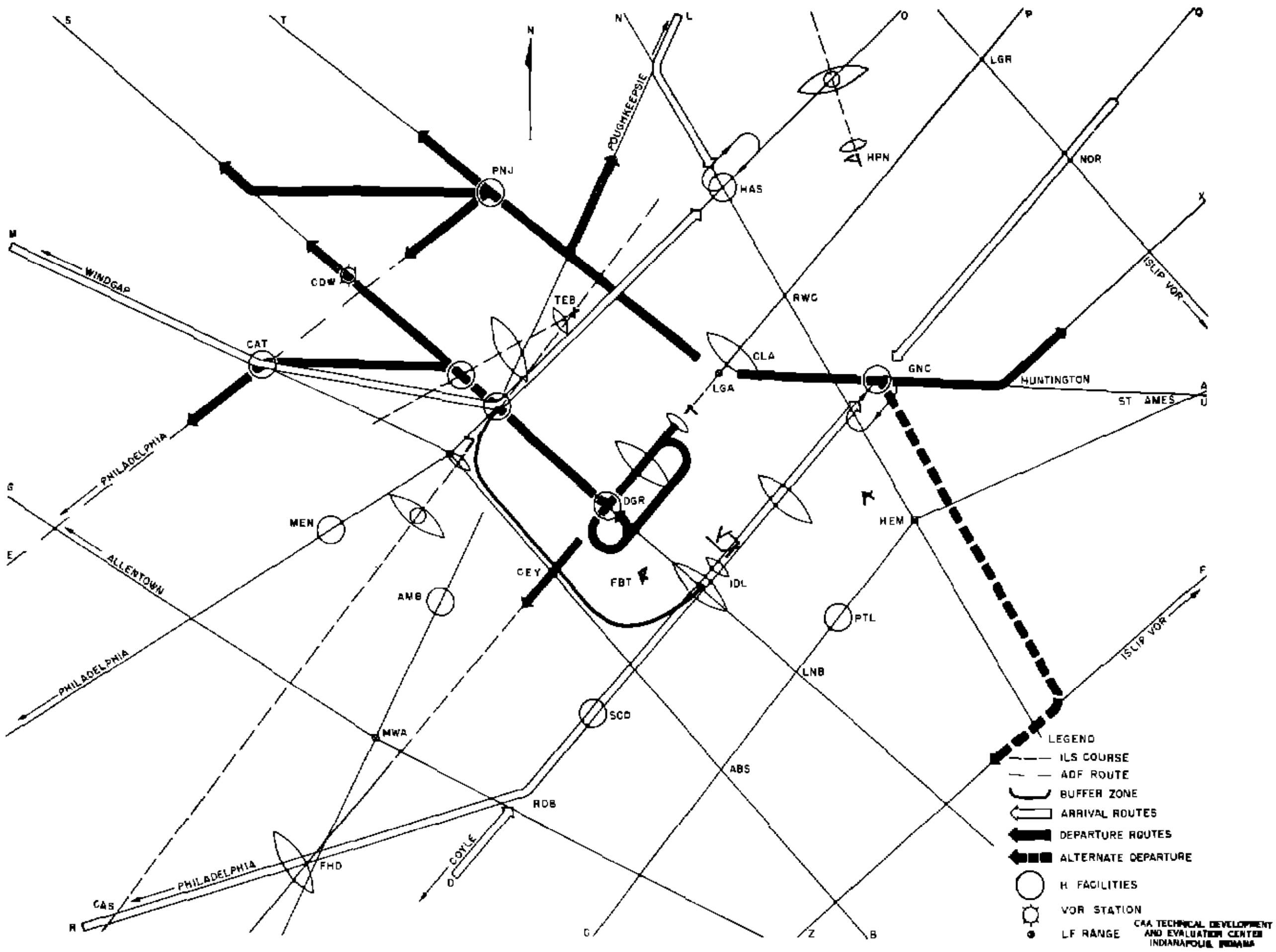

Fig. 9 Arrival and Departure Routes, LaGuardia Airport (Landing Southwest)

3 Arrival-Control Procedures During Southwest Landings

During periods when the wind required that landings be made to the southwest and the radar was inoperative, arrivals were cleared to the Hastings and the Glen Cove intersections. A primary stack was formed at the Clason Point fan marker at altitudes of 2000, 3000, 4000, and 5000 feet One of the radar sector controllers became the approach controller, and the other controlled the arrivals in the secondary patterns at Hastings and at Glen Cove. Before the 5000-foot level could be utilized at the Clason Point fan marker, the traffic using the airway over the area northeast and southwest of the LaGuardia Airport was required to fly at altitudes of 6000 feet and higher The minimum altitude at Hastings and at Glen Cove was 6000 feet

LaGuardia Airport Departure Procedures

The departure routes for aircraft departing LaGuardia Airport are shown in Figs 8 and 9 Aircraft routed from the area to the west were normally cleared via route T to cross the Paterson H-facility at 5000 feet or below From this point, aircraft en route to Philadelphia were routed via route E at altitudes of 6000 feet or below from Paterson until past the Belle Mead intersection (BMD) Since the bulk of LaGuardia departure traffic is to the west and the southwest, it was thought probable that the radar departure position should concentrate on these departures Using an offset radar presentation, this controller would be capable of tracking aircraft to a point near the Branchville intersection It was assumed that this controller would use a block of altitudes available at this intersection exclusively for LaGuardia westbound departures. An additional route to the west is provided from the Paterson H-facility by requesting an aircraft to track from the Paterson H-facility westward until it intercepts the northwest course of the Idlewild range (route S) and then to proceed to the northwest over Bushkill, and so forth This route was designated as a primary westbound departure route for aircraft from Newark, but it was the opinion of controllers that during some periods Newark traffic would not be using all the altitudes on this airway and the route could be shared by LaGuardia departures

Traffic departing northeast from LaGuardia Airport was cleared via route U to the Huntington intersection, then northeast via route X These departures normally crossed Glen Cove at 2000 and 3000 feet An alternate route to the north or northeast is the northeast course of the LaGuardia range which crosses the New Rochelle intersection at 2000 and 3000 feet

LaGuardia departures for the south were cleared to the northeast on the northeast course of the LaGuardia range in order to climb to an altitude of 5000 feet or above, then to reverse course and proceed southwest over Matawan range station This procedure necessitates the sharing of the arrival route of Newark aircraft by LaGuardia departures and requires them to pass over the Amboy holding pattern at Newark An alternate route for southbound aircraft from LaGuardia is east on route U, then south on route Z

When landings were being made to the southwest, some of the departure procedures were changed Westbound departures were requested to remain south of the west course of the LaGuardia range until past the Englewood intersection Since arrival traffic over Chatham would cross this fix at 8000 feet or above under these conditions, an additional altitude was available for use by the southwestbound departures Northeastbound aircraft proceeding via Glen Cove could cross that point at altitudes of 1500 and 2500 feet because of the Glen Cove holding pattern at 3500 feet and above

Another departure route for LaGuardia is southwest over the Dodger intersection, then west over the Jersey intersection Southbound departures would be cleared to the Dodger intersection to climb in a holding pattern to an altitude to pass over aircraft in the Amboy holding pattern and over the Matawan range station

Results and Observations of Tests at LaGuardia Airport

Delays and communications times are shown in Fig 1 Before any action based on the results of these tests is taken, it must be realized that these findings indicate what might be expected of the system providing the radar coverage is adequate, providing the radar picture is excellent, and providing the controllers and pilots are familiar with the system The recommended radar coverage is shown in Fig 10

Because of the many restrictions placed on the radar-vectoring area southwest of the LaGuardia Airport, there is little doubt that the problem of radar tracking and of identification will be a difficult one In order to reduce the controller workload, only three aircraft should be away from their respective clearance limits at one time The ideal arrangement would be for the first aircraft to be near the outer marker on final approach, the second aircraft to be entering its final-approach course properly separated in distance behind the first aircraft, and the third aircraft to be leaving the holding pattern on the base leg Such a condition is illustrated in Fig 11.

The radar-guided turn to final-approach course may at times be complicated by other radar targets en route on the southwest course of the LaGuardia range at 5000 feet or above Experience indicates that since these targets will be traveling in nearly opposite directions the merging of targets is for a very short time and need not cause loss of identification or a poor turn on to the final-approach course

During certain weather conditions such as visual-flight-rule (VFR) conditions either beneath an overcast or on top of an overcast, it is possible that aircraft operating in the metropolitan area will complicate the radar picture in this critical area If such a situation should become serious, it may be desirable to request all traffic not landing in the New York area to by-pass the entire area between Teterboro Airport and Mitchel Air Force Base

Some types of aircraft proceeding over Chatham and destined for LaGuardia may experience difficulty in descending to cross the Jersey intersection at 4000 feet In such cases the aircraft can be requested to reduce speed, or, if the radar coverage is excellent in the area near Chatham, the radar controller can assist the pilot to arrive over Jersey at 4000 feet by providing radar separation while the aircraft crosses Chatham and descends Since aircraft are

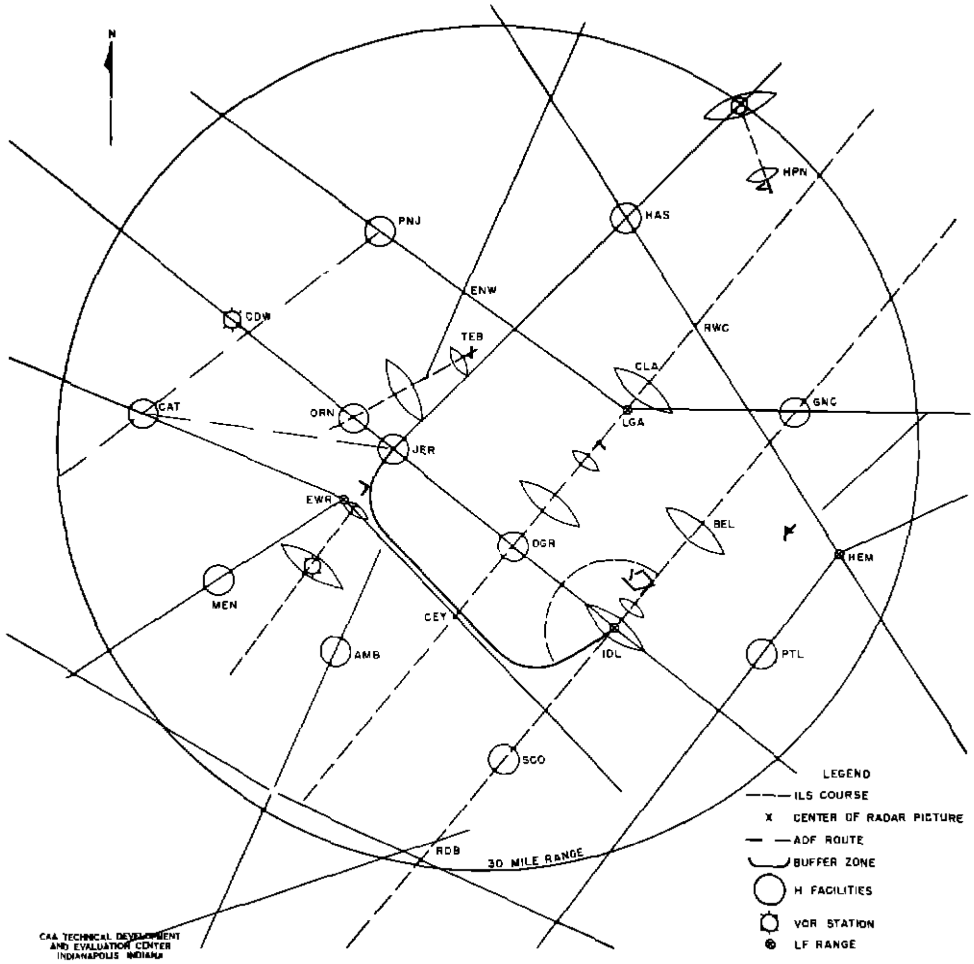

Fig. 10 Desired Radar Coverage for the Modified System, LaGuardia Airport

restricted to a minimum altitude of 3500 feet and 4000 feet in the respective holding patterns of Jamaica and Jersey, all aircraft should leave these fixes at approach speeds in order to insure their reaching the minimum altitude on the ILS course before reaching the ILS outer marker

When wind conditions require a change from northeast landings to southwest landings, the arrivals will be interrupted while the ARTC Center reroutes traffic that may previously have been using route N After the ARTC Center indicates that all traffic has ceased using this airway, the two sector controllers can begin using the Hastings and the Glen Cove H-facilities for holding purposes During the time that these two fixes are used for LaGuardia clearance limits, traffic which is arriving at or departing from the Idlewild area and which would normally use route N will be routed on airways farther north

The provision of completely independent departure routes for LaGuardia Airport does not appear to be practicable without the addition of much route mileage to departures or without the blocking of certain altitudes It is considered problematic whether there is any advantage in releasing aircraft when it is known that the routing will add an additional 30 to 50 miles to the route or whether it is better to delay the aircraft on the ground to proceed at a later time via a shorter route For the purpose of these tests, it was assumed that it was not advantageous to add route mileage to departures The use of blocked altitudes is desirable only when traffic demand is sufficient to keep these altitudes in constant use

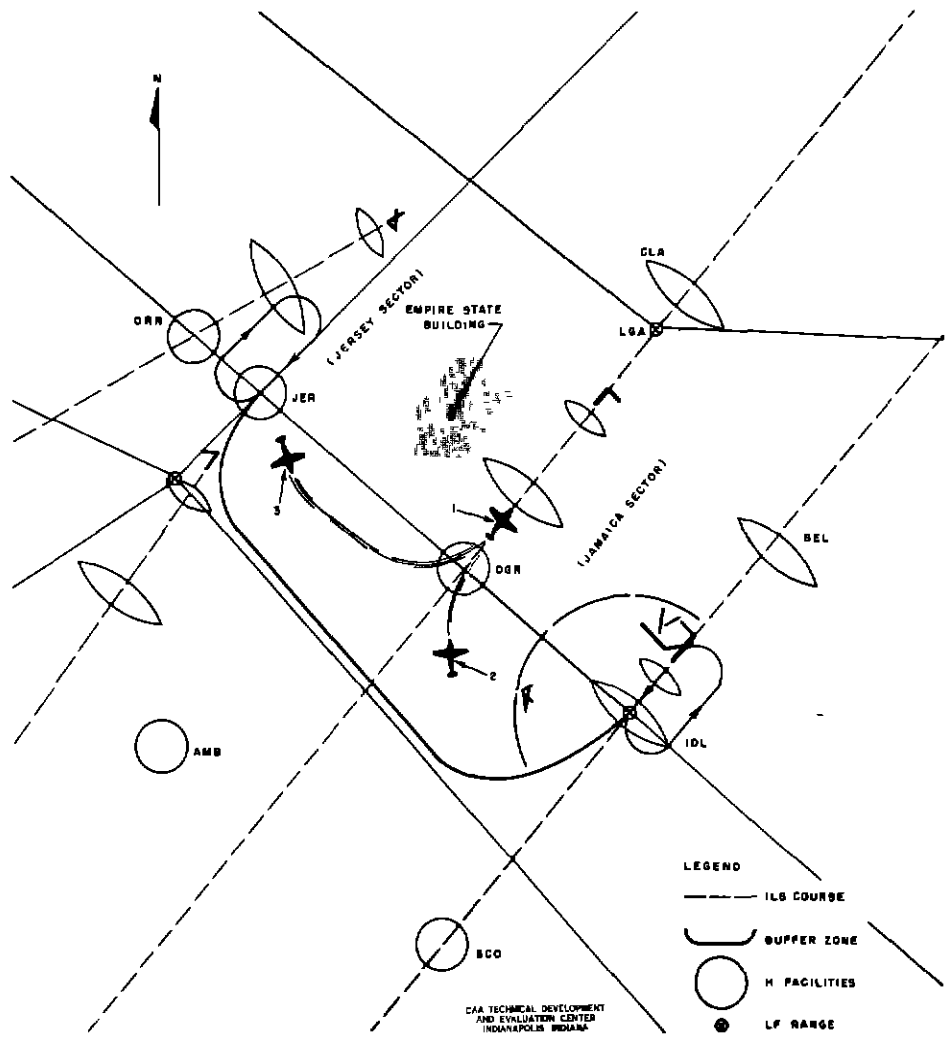

Fig 11 Optimum Placement of Aircraft in the LaGuardia Radar-Vectoring System

The results shown in Figs 1, 2, and 3 are for arrival aircraft only It was assumed that the LaGuardia Airport was provided with adequate turn-off points for landing aircraft and that in most cases departures would take off on a runway other than the landing runway

It is believed that if this system of routing the traffic into the New York area should be adopted, arrival traffic could approach the runway at LaGuardia at such a rate that it would restrict departures It may be desirable to control traffic at this airport on a one-on, one-off basis and to use the same runway in most instances It is believed that this system would operate efficiently without the use of radar It is also believed that the new routes would aid ARTC controllers in assigning lower altitudes than those now possible to aircraft at clearance limits

Newark-Teterboro Area

With Radar

1 Operating Positions.

During this phase of simulation, two radar sector controllers, each using a separate single-channel simplex frequency, were used One of these controllers handled arrivals

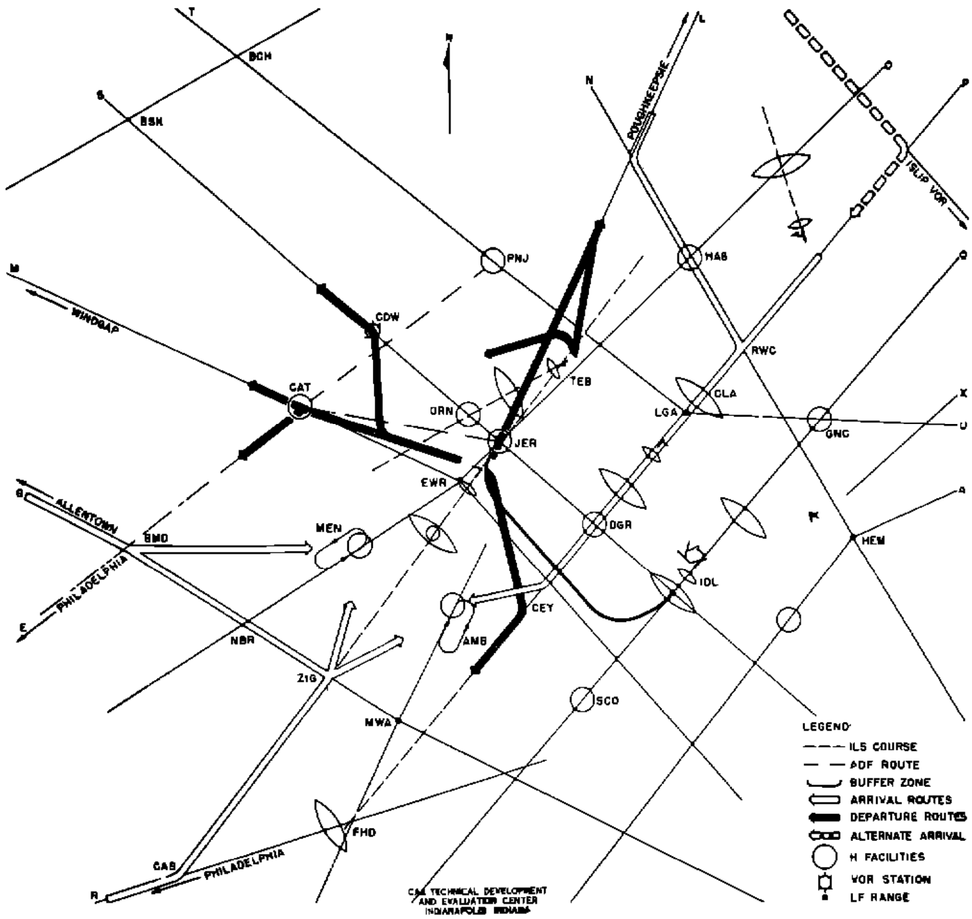

Fig 12 Arrival and Departure Routes, Newark and Teterboro Airports

cleared to Menlo Park in an area, west of the approach-course extension, which was called the Menlo Sector This controller vectored aircraft from this clearance limit to the final-approach extension The other sector controller handled arrivals which used the Amboy H-facility as a clearance limit This area was called the Amboy Sector The latter controller vectored aircraft from this fix to the final-approach extension

A third position of operation, that of a terminal-area controller, was used as in the LaGuardia tests The function of this position was the same as that described in the section dealing with LaGuardia

2 Arrival-Control Procedures During Northeast Landings

Arrivals destined for Newark and Teterboro Airports on route G, Fig 12, were restricted to cross the Belle Mead intersection at 7000 feet and to retain that altitude until past conflicting traffic on route E unless radar identification could be accomplished and radar separation effected prior to this intersection From Belle Mead, the inbound aircraft were cleared either by way of a direct route to the Menlo Park holding pattern or, if desired, to the Amboy holding pattern by way of the Ziegfield intersection and then direct to Amboy

Arrivals from the south and the southwest were routed to either the Menlo Park or the Amboy patterns from the Cassville intersection by way of the Ziegfield intersection at altitudes of 2500 feet or above This routing is predicated upon reliable reception of the front course of the Newark ILS localizer at altitudes of 3500 feet and above at Cassville If reception of this nature does not exist, the present inbound route over New Brunswick can be utilized.

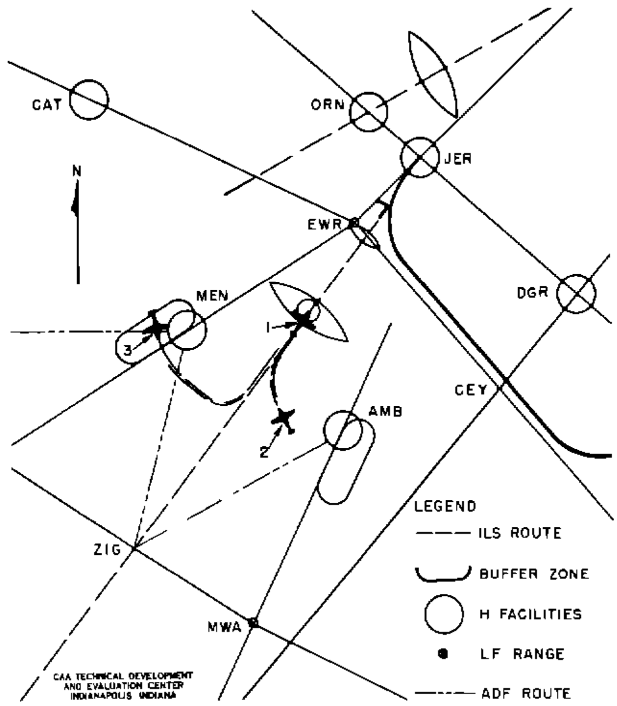

Fig. 13 Optimum Placement of Aircraft in the Newark Radar Vectoring System

Arrivals from the north and the northeast were routed on routes N and P to the New Rochelle intersection, then southwestward to the Coney Island intersection, then to the Amboy holding pattern at altitudes of 5000 feet and above until past the Coney Island intersection

Primary holding was accomplished at the Amboy and the Menlo Park holding patterns at altitudes of 2500 feet and above Secondary holding was accomplished at the Ziegfield intersection and at the Belle Mead intersection at altitudes consistent with the requirements for those routes Secondary holding for arrivals from the northeast was accomplished at the LaGuardia middle marker of the ILS or at the LaGuardia range at altitudes of 5000 feet and above

Aircraft landing at Newark were directed by means of radar from the Menlo Park and the Amboy patterns to the final-approach course at 1500 feet Aircraft destined for the Teterboro airport also used the Menlo Park or Amboy patterns as clearance limits, were directed by radar to the H-facility at the Orange intersection at 2500 feet, and were vectored to the Teterboro ILS course These aircraft were assumed to remain on Newark radar frequency until landing was assured at Teterboro

Aircraft destined for Teterboro Airport were cleared to proceed from the Newark outer marker direct to the Orange H-facility after reaching 2500 feet in the primary stack These aircraft would descend to 1500 feet after reaching Orange and would proceed northeastward on the Teterboro ILS course

3 Arrival-Control Procedures During Southwest Landings

A preliminary investigation was made as to the possibility of providing a method whereby arrival aircraft could be vectored by radar to the northeast course of the Newark ILS course for an approach to the southwest This was contingent upon the removal of the Calco stack at some future time It was determined that a primary holding stack could be formed at the Teterboro ILS outer marker at altitudes of 2500, 3500, and 4500 feet The secondary holding stacks were considered to be at the Menlo Park and the Amboy H-facilities at altitudes of 4500 feet and above

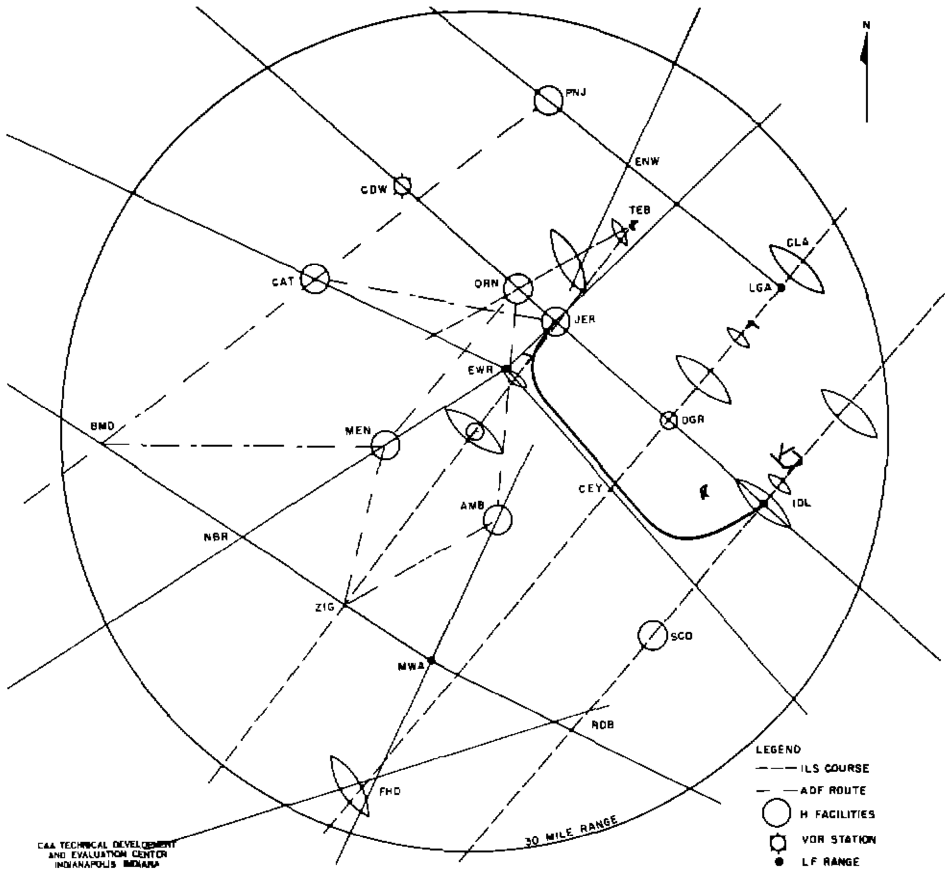

Fig 14 Desired Radar Coverage for the Modified System, Newark Airport

One of the sector controllers guided aircraft from the Orange H-marker on a downwind course and turned them to the final-approach course, as indicated in Fig 18 The other sector controller fed the final-approach stack from the secondary holding fixes at the 4500-foot altitude This procedure worked smoothly with the aid of radar

It was not considered practicable to provide Teterboro with facilities for approaches on the northeast course of their ILS course since any such approach would interfere with west-bound departures from LaGuardia Airport In addition, even a circling approach at Teterboro would mean that at least the minimum altitude on route T must be blocked during this maneuver

Newark-Teterboro Area Without Radar

1 Operating Positions

During tests of this phase without radar, three positions of operation were manned Each position used a separate single-channel simplex frequency One of the radar sector controllers was designated as the approach controller and handled traffic holding in a primary stack at the Newark outer marker, using standard timed-approach procedures The other sector controller controlled traffic arriving at the secondary holding patterns at the Menlo Park and Amboy H-facilities This controller fed the primary stack from the secondary stacks The third position functioned as in the tests of this phase using radar

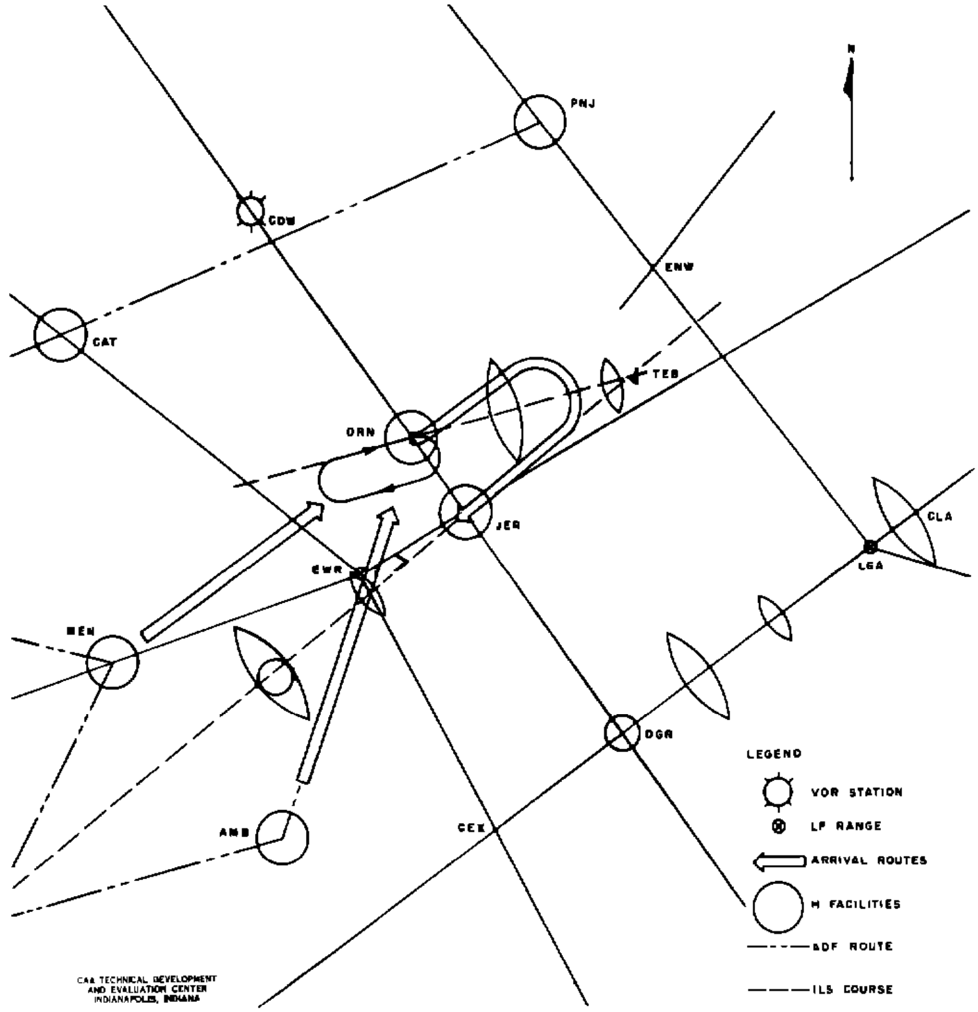

Fig 15 Radar Approach System, Runway 22, Newark Airport

2 Arrival-Control Procedures During Northeast Landings

The control without the use of radar of arriving aircraft destined for Newark or Teterboro Airports used standard timed-approach procedures from a primary holding and approach fix located at the Newark ILS outer marker The altitudes used at the outer marker for primary holding were 1500, 2500, 3500, and 4500 feet This stack was fed with aircraft from the secondary stacks at Menlo and Amboy, and the minimum altitude at the secondary holding fixes was 5500 feet Supplementary holding was accomplished at the Ziegfield intersection at altitudes of 2500 feet and above and at the Belle Mead intersection at altitudes of 7000 feet and above

3 Arrival-Control Procedures During Southwest Landings

Until the Calco stack is removed, it will continue to be necessary for Newark arrivals to circle the airport for a landing to the southwest However, with the aid of adequate surveillance radar, it should be possible to provide a steadier flow of traffic to runway 22 than is now obtained

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Newark-Teterboro Area Departure Procedures

Departure routes for aircraft departing the Newark and Teterboro airports are shown in Fig 12 Aircraft departing to the west were routed via route S over Caldwell range and Bushkill Low-level flights west from Chatham to the Windgap intersection and from Belle Mead to Allentown could use altitudes to 6000 feet Southwestbound aircraft shared route E over Chatham and over the Belle Mead intersection with LaGuardia departures Northbound traffic used route L

Southbound departures from Newark used the present procedure of maintaining 1500 feet to Coney Island, then traveling south over the Matawan range station No departure tests were conducted at this airport It appears that present departure problems will exist for this area as long as the LaGuardia Airport is at peak operation A small degree of independent operation may be had by blocking one or two altitudes at the conflicting point for the exclusive use of Newark-Teterboro departure traffic

Results and Observations of Tests on Newark-Teterboro Area

Delays and communications times are shown graphically in Fig 2 This modified system provides several advantages over the present system One of the most obvious is the possibility of providing lower entry altitudes for arrivals from the south and the west

The two primary clearance limits, Menlo Park and Amboy, give the ARTC Center a dual set of altitudes to be used for arriving aircraft This should provide the ARTC Center with additional altitudes on the feeder airways Although the amount of traffic using Teterboro and Newark airports at present may not justify the use of two clearance limits, the resulting effects on airway traffic will help provide a more flexible system of traffic flow for the New York area

The arrangement of the primary holding fixes near the ILS outer marker provides symmetrical feeder stacks for operation both with and without radar The location of these fixes is such that not more than two aircraft should depart the holding patterns at one time en route to the outer marker The ideal arrangement would be to have one aircraft over the outer marker on approach, the second aircraft turning onto the final-approach course and properly spaced behind the first aircraft, and a third aircraft preparing to leave one of the holding patterns on a heading toward the final-approach course as shown in Fig 13

In order to keep the radar picture as uncluttered as possible in the vicinity of the Newark outer marker, aircraft destined for Teterboro Airport were directed to proceed to their assigned clearance limit and from that point were guided directly to the Newark range station and then to the Orange H-facility By using this procedure, the radar targets of these aircraft did not cause confusion and possible misidentification of other targets in the area normally used to space arrivals destined for Newark airport

During this phase, an experiment was conducted to determine the practicability of vectoring LaGuardia traffic arriving at the Jersey and Jamaica patterns to the Menlo Park and Amboy patterns for eventual landings at the Newark Airport With radar coverage as shown in Fig 14, this procedure presented no difficult problems and indicated what could be accomplished should weather close the LaGuardia Airport

It is possible to provide one stack at the Teterboro outer marker to be used by Newark arrivals when landings are being made to the southwest at Newark Airport, as shown in Fig 15 The formation of this stack would eliminate a westbound departure route through this area from the LaGuardia Airport as previously described

Idlewild Area

With Radar

This system considers the area which encompasses the Mitchel Air Force Base, the Floyd Bennett Naval Air Station, and the Idlewild Airport as one control area which is under the jurisdiction of Idlewild approach control

I Operating Positions

During this phase of the simulation, one radar controller was used to control aircraft from a common clearance limit to the final-approach course for certain runways at all three airports During these tests, the normal landing direction for Idlewild Airport was runway 4 The normal landing runway at Mitchel Air Force Base was runway 5, and at Floyd Bennett Naval Air Station it was runway 1

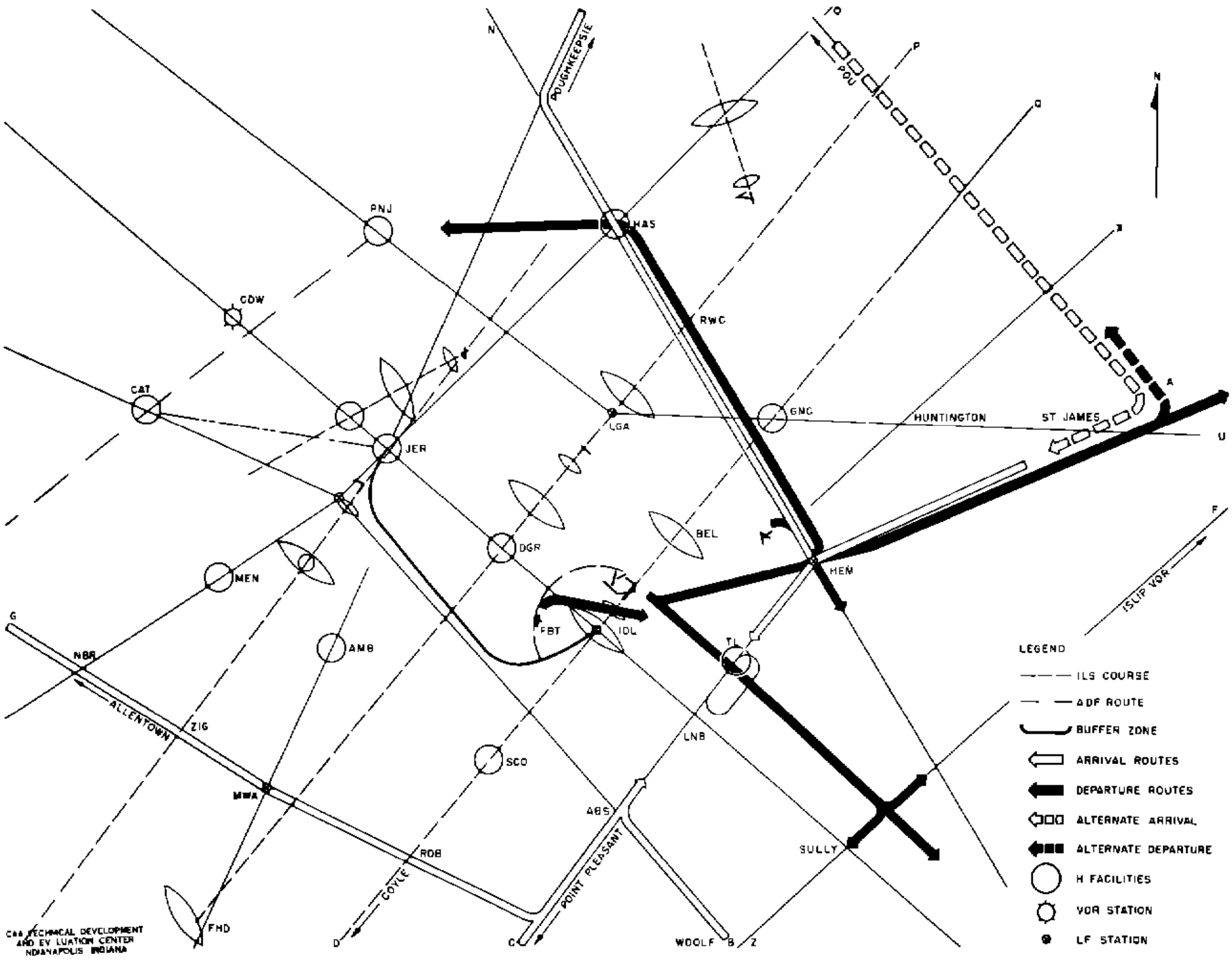

Fig 16 Arrival and Departure Routes Idlewild, Mitchel Air Force Base, and Floyd Bennett Naval Air Station

Another position, that of a terminal-area controller, was established as described in the LaGuardia Airport tests, and the function of this position was the same

2 Arrival-Control Procedures During Northeast Landings

Arrivals destined for these airports on routes G and C, Fig 16, generally were at high altitudes until they crossed the Red Bank intersection and were cleared to the Point Lookout H-facility Arrivals on route C were expected to arrive at Point Lookout at optimum altitudes inasmuch as these aircraft leave Red airway 92 (route F) at the Point Pleasant intersection Arrivals entering the area on route B would enter the area at random altitudes since this traffic must cross route F at the Woolf intersection and must join other arrival traffic at the Ambrose intersection Arrivals from the north and the northwest used route N and crossed Glen Cove at 6000 feet or above Arrivals from the northeast on route X and on route A would normally be expected to enter the area at altitudes of 6000 feet or higher and to retain that altitude until past conflicting traffic departing or by-passing the area

Primary holding was accomplished at the Point Lookout H-facility at 3500 feet and above Traffic being guided by radar would normally leave the holding pattern on a southwesterly heading and would maintain 3500 feet until crossing the east course of the Idlewild range station Traffic being guided to runway 5 at Mitchel Air Force Base would leave the holding pattern in the same manner as if landing at Idlewild but would descend only to 2500 feet At the appropriate place, these aircraft would be turned onto the final-approach-course extension of runway 5 at Mitchel Air Force Base and would become the responsibility of the Mitchel precision-approach-radar controllers when the aircraft were approximately ten miles from Mitchel This procedure provided time for co-ordination between the arrival and the departure controllers concerning the Mitchel arrival traffic, and it interrupted the departures momentarily as the departure controller observed the progress of the flight on radar

Traffic destined for Floyd Bennett Naval Air Station was cleared from the holding pattern in the normal manner and was turned onto the final-approach course of runway 1 The control of these aircraft was turned over to Floyd Bennett precision-approach-radar controllers when the aircraft were approximately ten miles from the airport

Ambrose intersection and the Mitchel range station were used as secondary holding fixes

3 Arrival-Control Procedures During Southwest Landings.

During periods when the wind necessitated landings in a southwesterly direction at the three airports in the Idlewild area, no changes in the arrival procedures were required During this time the traffic holding at Point Lookout would leave the holding pattern on a downwind course and would be guided by radar instructions to the northeast course of the Idlewild ILS localizer while they descended to 1500 feet Traffic destined for the Floyd Bennett Naval Air Station would follow the same course as the traffic destined for Idlewild and would be turned to the final-approach course for runways 24 or 19 Traffic destined for Mitchel Air Force Base would be guided from the holding fix on a northeasterly course and would become the responsibility of Mitchel precision-approach-radar controllers when turned onto the final-approach course for runway 23

Idlewild Area Without Radar

1 Operating Positions

The same operating positions were used for this area with or without the use of radar as a control aid

2 Arrival-Control Procedures During Northeast Landings

During periods when radar was inoperative at Idlewild, a primary holding pattern was formed at the Scotland radio beacon at altitudes of 1500, 2500, 3500, and 4500 feet

Traffic destined for Mitchel Air Force Base was cleared to the Mitchel range to hold, and, when cleared for approach, the aircraft would execute an ADF approach to runway 30 or would make a GCA approach with the use of Mitchel radar facilities Traffic destined for Floyd Bennett Naval Air Station was cleared to the Scotland holding pattern and was turned over to Floyd Bennett GCA upon reaching the minimum altitude in the Scotland pattern These procedures are similar to the procedures in use today, the difference being that a small primary stack at Scotland must be kept full at the 4500-foot level from secondary holding points at Point Lookout and at the Ambrose intersection Before the 3500- and 4500-foot levels are used in this procedure, the LaGuardia arrivals using the southwest course of the Idlewild range at 3500 feet and above must be recleared at 5500 feet and above

3 Arrival-Control Procedures During Southwest Landings

When radar becomes inoperative at the Idlewild tower during periods when landings are being made to the southwest, nonradar operations could be made from the Belmont fan marker In all probability LaGuardia Airport would also be landing aircraft to the southwest, and a stack of their aircraft would be using the Glen Cove intersection at 3500 feet and above It would be possible for the Idlewild controllers to establish a holding pattern at the Belmont fan marker at two altitudes, 1500 and 2500 feet, from which to control timed approaches to the airport One problem with this procedure is that this stack must be kept filled with aircraft from secondary stacks located at the Mitchel Air Force Base range station and at the Point Lookout H-facility It is doubtful if the primary stack could be kept full of aircraft from these secondary points without radar, and the approach controller would continuously run out of aircraft

With some weather conditions, circling approaches from Scotland to runway 22 at Idlewild might prove more expeditious than approaches from Belmont Figure 17 indicates two other possible solutions to this problem through use of a properly located TVOR station Either of

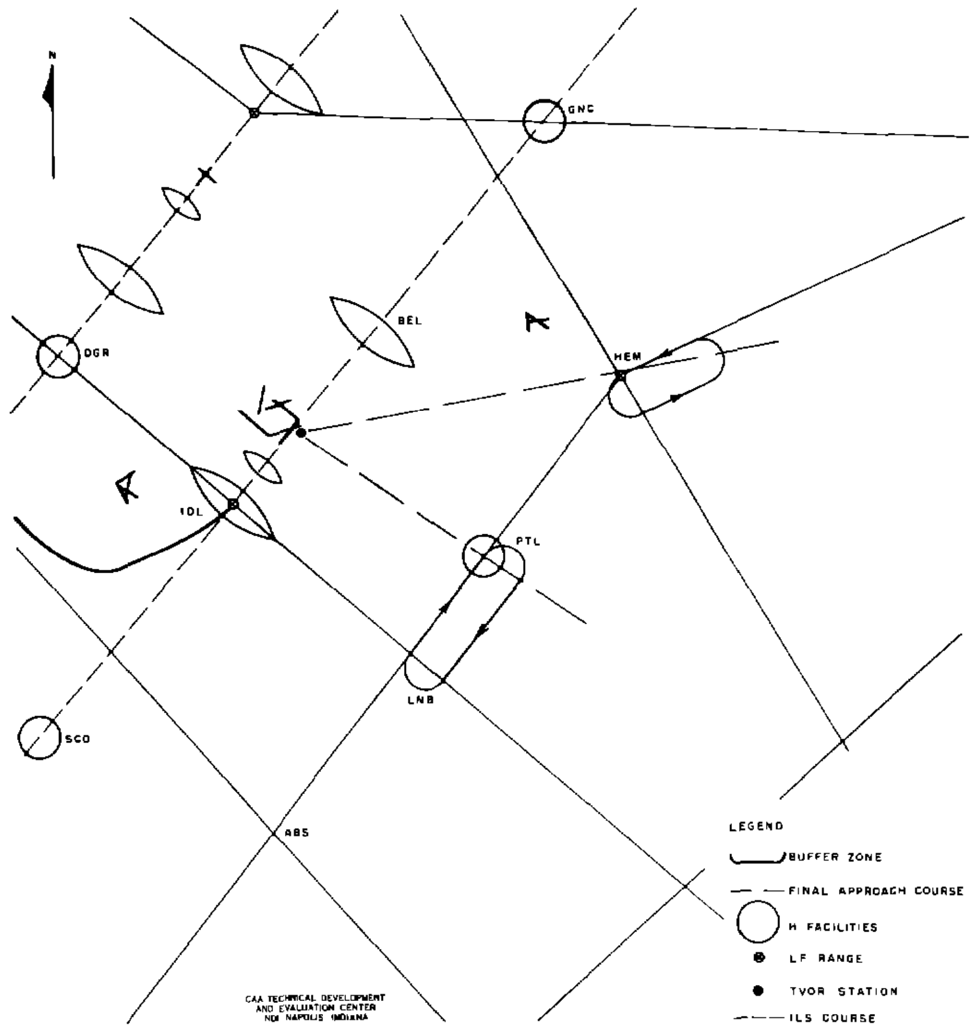

Fig 17 Use of TVOR for Nonradar Operation at Idlewild Airport, Runways 25 and 31

these two methods appear to be more desirable than the circle-approach method or the two-altitude stack on the northeast course of the Idlewild ILS course

A properly located VOR would provide course guidance from the Mitchel range station to runway 25L at the Idlewild airport It would be possible for aircraft equipped to receive VOR signals to hold on the northeast course of the Mitchel range and to use timed approaches to runway 25 at Idlewild Mitchel Air Force Base traffic would also hold in the same pattern and, when first in sequence for an approach, would be changed to Mitchel GCA for an approach to runway 23 or would make an ADF approach from the range station to runway 30 at Mitchel Field Traffic destined for the Floyd Bennett Naval Air Station would be held at the Idlewild range station or at the Scotland marker at 2500 feet until cleared for approach to Floyd Bennett under direction of the Floyd Bennett GCA controllers

A properly located VOR would provide course guidance from the Point Lookout holding pattern to runway 31R at Idlewild under proper wind conditions It would then be possible for aircraft equipped to receive VOR signals to hold at the Point Lookout marker and for controllers to employ timed-approach procedures from that point to runway 31R at Idlewild Airport Aircraft destined for Mitchel Field would also hold at the Point Lookout marker and, when first in sequence to approach, would become the responsibility of Mitchel GCA controllers for an approach to runway 30

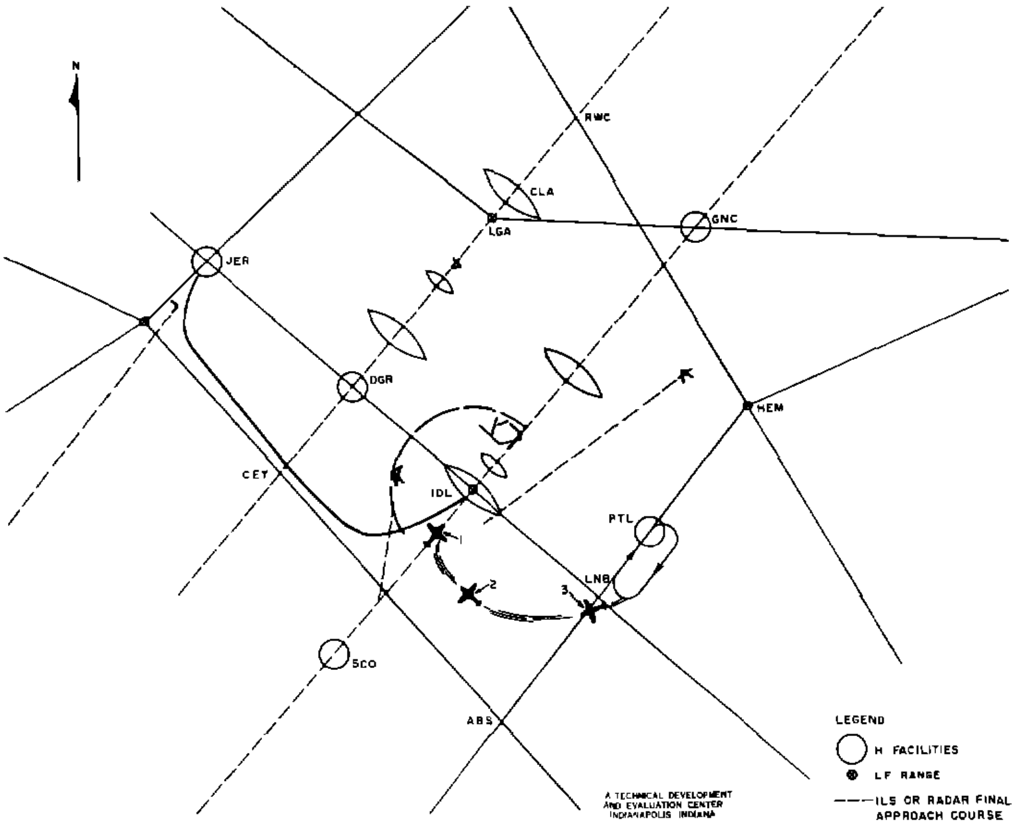

Fig 18 Optimum Placement of Aircraft in the Idlewild Radar-Vectoring System

Aircraft destined for Floyd Bennett Naval Air Station would be held at the Idlewild range or at the Scotland marker at 2500 feet, and the first aircraft for an approach would become the responsibility of Floyd Bennett GCA controllers

Idlewild Area Departure Procedures

1 Landing Northeast

Departure routes for aircraft departing this control area are shown in Fig 16 By the restriction of arriving aircraft to 3500 feet until south of the east course of the Idlewild range station, the altitudes of 1500 and 2500 feet were available to the radar departure controller to use for aircraft departing via route F At this point, these aircraft could proceed north or south as cleared In addition, aircraft proceeding north could be cleared over the Mitchel range and along the northeast course of Mitchel range station to route F Aircraft departing the area northwestbound were normally routed via route N Westbound departures were routed via route N to Hastings, direct to Paterson

2 Landing Southwest

When landings to the southwest are required for all the major airports in the New York area, the departure routes and procedures for the Idlewild area would be changed from those described previously During this period the departure controller would use the altitudes of 1500 feet and 2500 feet under the holding pattern to tunnel departures out to route F, after which the traffic would proceed northeast or southwest as cleared

Since LaGuardia traffic would be using Glen Cove as a primary holding point during this period, route N would no longer be used as a departure route As often as possible, traffic

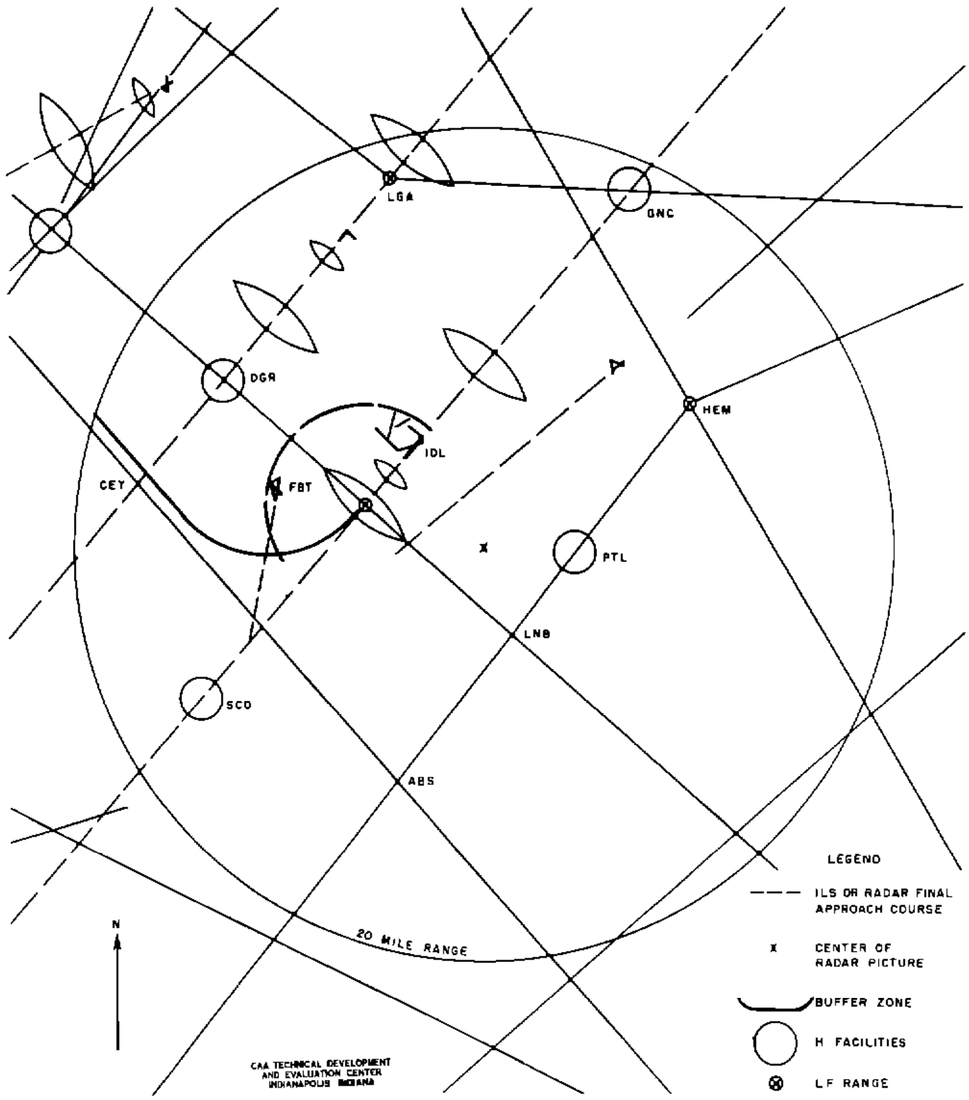

Fig 19 Desired Radar Coverage for the Modified System, Idlewild Airport

desiring to proceed to the north and the northwest would be guided around the Point Lookout holding pattern and to route U or X in order to proceed northeastward Since, during these conditions, the LaGuardia arrivals using route D would be routed into the area at altitudes of 5500 feet or higher until passing the Idlewild range station, it would be possible to use route D as a departure route at lower altitudes

3 Results and Observations of Tests on Idlewild Area

Delays and communications times are shown graphically in Fig 3 The system described for this area was decided upon after consultation with control personnel familiar with the problems of the New York area Since the number of aircraft landing and departing Mitchel Field during IFR conditions is much less than the number of aircraft using Idlewild under the same conditions, it was decided to take advantage of this fact and to make better use of the available airspace on a 24-hour basis by placing the entire area under the jurisdiction of Idlewild controllers

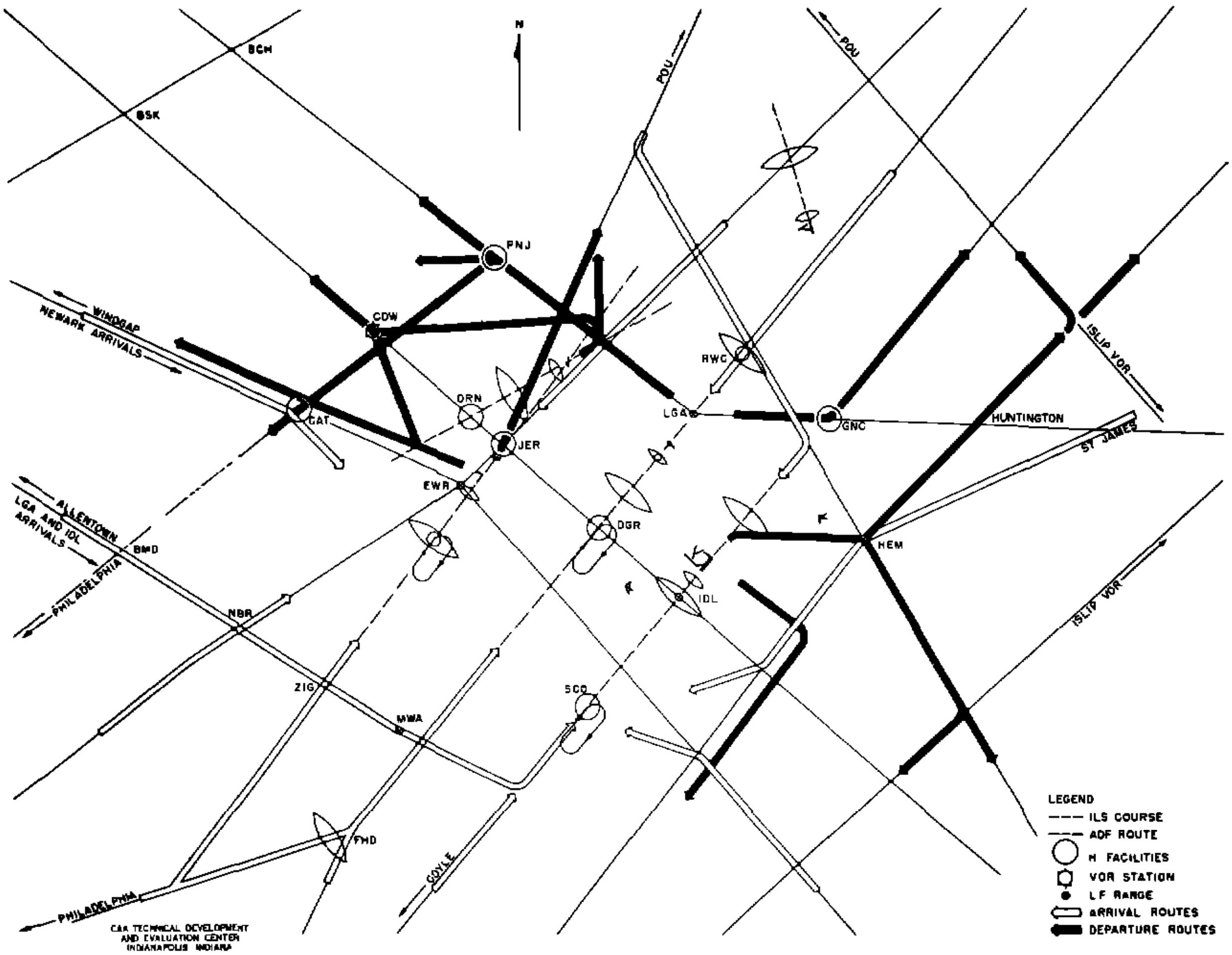

Fig 20 A Possible Use of Modified System of Routes to be Used During a Transition Period to a Full Radar-Control System

It will be noted that only one holding point is utilized as a primary stack There is room in this area to provide two primary holding stacks, but, unfortunately, much of the area is water, and it would be impractical to place radio aids in desirable locations The Point Lookout holding pattern is in a desirable position, and approach to the southwest or to the northeast can be expedited with the use of radar with little change in basic routing except for departing traffic By placing the holding fix offset from the final approach, aircraft identification and proper spacing can be accomplished before the turn to final-approach course, as shown in Fig 18

The recommended area of radar coverage is shown in Fig 19 By placing this area under the control of one agency, it is probable that the co-ordination time between the three towers would be reduced to a minimum. This area is not readily adapted to timed-approach procedures in event of radar failure unless the VOR system is available

In order to make Red airway 92 (route F) a completed airway and for several years an airway with low-frequency radio aids, it might be possible to increase the power of the radio beacon at Fire Island to at least 50 watts and to operate it on a continuous basis This change is important because much of this system depends on routing the by-pass and most of the departure traffic via Red airway 92

When approaches to the southwest are being made at all the airports, departing aircraft desiring to proceed north or northwest from the Idlewild area must necessarily be routed via a longer route to by-pass the Glen Cove area

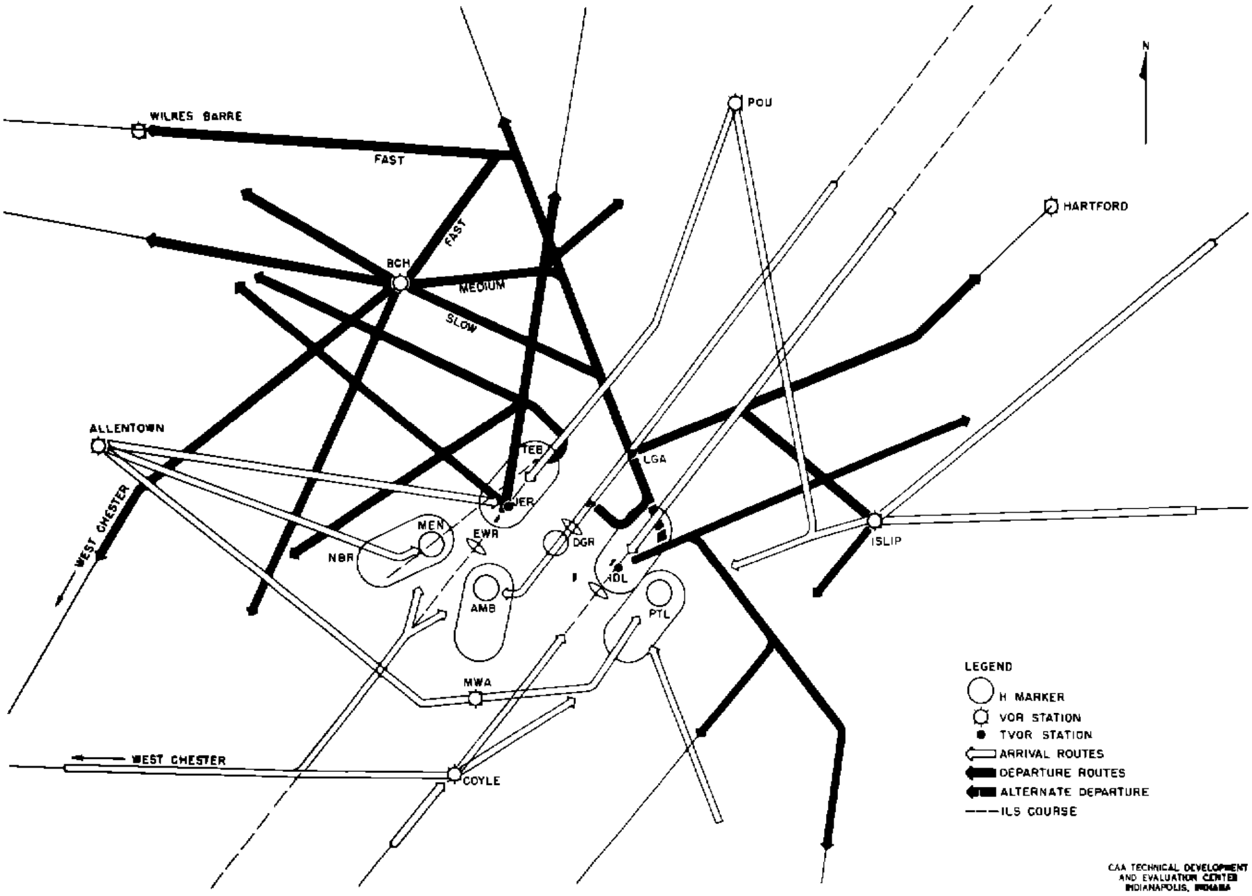

Fig 21 A Proposed System Using Omniranges to Control Traffic Flow in the New York Metropolitan Area

If, in the future, LaGuardia should become a less important airport, more of the space devoted to its operation in this system can be used to improve the approach and departure routes for the Idlewild area, as shown in Fig 6

The locations of the Ambrose and Point Lookout patterns are such that, when the arrival rate is much greater than the acceptance rate, these two points could be used as primary fixes by the radar controller

CONCLUSIONS

1 Simulation tests indicate that the acceptance rate of the New York metropolitan area can be increased substantially by the use of radar-control procedures However, unless certain changes are made in the arrangement of navigational facilities in this area, the resulting system will continue to be difficult to operate
2 The configuration described as the "Modified" system in this report is one system that should improve the manner in which arriving aircraft enter their respective approach-control areas
3 The new system should provide a more flexible use of the available airspace by control agencies if operating procedures similar to those used in this evaluation are adopted
4 The system provides ARTC with more routes to be used by departing aircraft

5 There is no apparent solution to the problem of providing completely independent routes for each of the airports in this area without resorting to a system with blocked altitudes

6 Since this system of operation does not provide independent operations from each of the airports, much co-ordination between agencies is necessary to insure a safe and orderly flow of traffic in the area By dividing the area into three approach-control areas, the co-ordination is localized within four agencies The control of arriving traffic in each approach-control area would be an independent operation for the three areas The routes for departing traffic would not be independent Because of this fact, it was assumed that ARTC would be the co-ordinating agency for departure traffic

7 It is believed that these procedures could be implemented and operated to advantage on the basis of nonradar operations as described in this report An alternate use of the modified system without radar is shown in Fig 20

8 A sudden wind shift which would require a change in landing direction may result in much loss of time before full-scale approaches can be resumed This delay could be minimized if accurate weather forecasts were available and if traffic movements were planned in advance

9 No evaluation tests were conducted of a system using VOR facilities in the New York metropolitan area Figure 21 indicates one possible compatible VOR system However, at the date of this report, insufficient criteria for VOR operations were available regarding airspace requirements Upon receipt of this information, more complete tests will be planned and conducted The results will be published in a later report

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