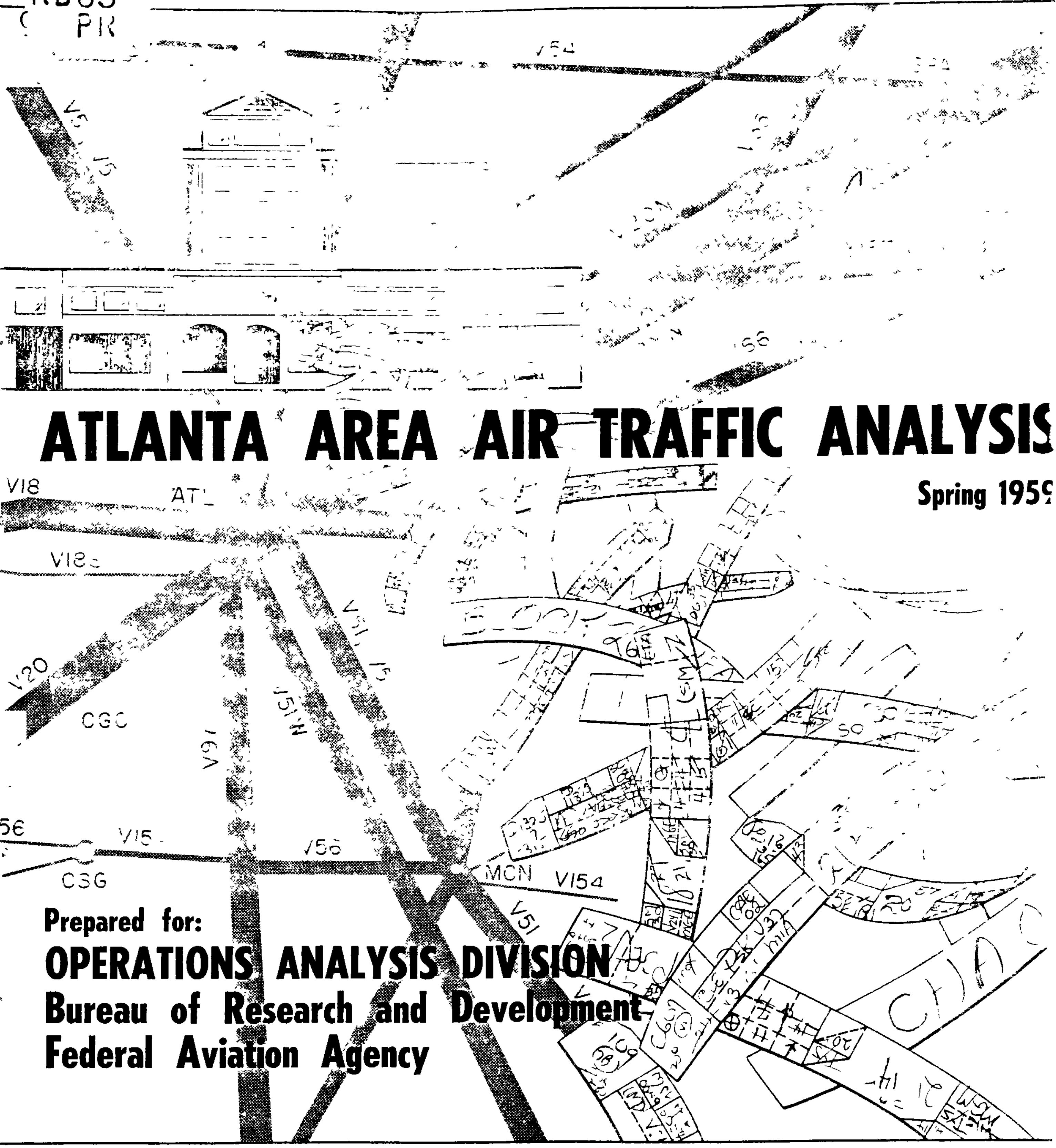
VOLUME I



ATLANTA AREA AIR TRAFFIC ANALYSIS

Spring 1959

Prepared for:

OPERATIONS ANALYSIS DIVISION
Bureau of Research and Development
Federal Aviation Agency

By

THE FRANKLIN INSTITUTE & **PHILCO CORPORATION**

LABORATORIES FOR RESEARCH AND DEVELOPMENT — GOVERNMENT AND INDUSTRIAL DIVISION

ATLANTA AREA FLOW AND DELAY ANALYSIS

VOLUME I

(of 3 Volumes)

SUMMARY AND ANALYSIS

By

The Franklin Institute

Laboratories for Research and Development

and

Philco Corporation

Government and Industrial Division

Philadelphia, Pa.

Prepared for

Operations Analysis Division

Bureau of Research and Development

Federal Aviation Agency

October 15, 1959

Under

Contract FAA/BRD-63

CHANGE SHEET NO. 1
ATLANTA AREA AIR TRAFFIC ANALYSIS - 1959
FAA/BRD-63

VOLUME I (Final Report)

Page iii a. After "Cliff Rosacrans" change ATCO to ACTD
b. Change Falkner to Faulkner

Page 2 a. Change title of Figure 4 to read: Typical Ownership Distribution for IFR Traffic on Sundays.
b. Change title of Figure 5 to read: Typical Ownership Distribution for IFR Traffic on Weekdays.

Page 21 a. Airways - General, change 245 fixes, second line, to read: 322 fixes.

Page 22 a. Restricted and Prohibited Areas, Change Dawonville to Dawsonville.

Page 27 a. Table B - Under March 29-30, General Aviation, Change 66% to read: 6%

Page 30 a. Add title to Figure 4 to read: Typical Ownership Distribution for IFR Traffic on Sundays.
b. Add title to Figure 5 to read: Typical Ownership Distribution for IFR Traffic on Weekdays.

Page 33 a. Table 3(A,B,C,D), change title to read: Minutes of delay listed by hour and fix.
b. Table 6(A,B,C,D), change title to read: Atlanta Departure Delays.
c. Table 7, change to read: Table 7(A,B,C,D), Dobbins AFB and Fulton County Departure Delays.
d. Add Table No. 8(A,B) - Total number and minutes of ground delays per hour at Atlanta terminal airports.

Page 48 a. Table R - Add titles in heading boxes, left to right: Landing a/c; a/c Grd Traffic; No clearance; Vehicular Traffic; Scheduled Stop; Unusual (others)

VOLUME II (Final Report)

Appendix A a. Page A-13 (B. Findings), first line, change Table 37 to read: Table 1.
b. Figures A-40, A-41a, A-41b, A-42, A-43a, A-43b, A-44b, label range rings 1 nm, 2 nm, 3 nm, 4 nm, 5 nm.

Appendix D a. Change ordinates to read: 10, 20, 30, 40, 50, 60, 70

Appendix E a. Page E-1, change title of Table 9 to read: Scheduled operations and delays.

FOREWORD

The Operations Analysis Division, Bureau of Research and Development, Federal Aviation Agency, specified a need for a complete traffic survey in the Atlanta, Georgia, Control Area in order to determine traffic flow, air route usage, and terminal facility use and capacity.

The prime contract was awarded to the Franklin Institute Laboratories (FIL) under Contract FAA/BRD-63, with authorization to subcontract the "ground movement" portion of the analyses (tasks 4, 6, and 10) to the Philco Corporation. Preliminary "dry run" analyses started on 9 February 1959.

The project readily lent itself to division into two parts, namely, (1) airborne traffic (enroute), and (2) surface movements. Work on the enroute portion was performed by The Franklin Institute, and the surface analyses, including the radar recording studies, were made by the Government and Industrial (G & I) Division of the Philco Corporation.

ACKNOWLEDGEMENTS

The assistance of the following persons contributed greatly to the completion of this entire survey. Without their willing co-operation, it would have been exceedingly difficult, if not impossible, to collect the necessary data and carry out the various project tasks:

Norman R. Smith, Atlanta Contract Project Manager, FAA Bureau of R & D.
R. G. Tuttle, Operations Analysis Div., FAA Bureau of R & D
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Dick Cosgrove; FAA Atlanta Tower

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John L. Smith, FAA Atlanta ARTCC

John Nance, FAA Atlanta Tower

H. W. Calloway, FAA Atlanta Maintenance and Equipment Chief

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P. Boatman, FAA Region 2 Headquarters, Chief of ATC Branch

G. Owen Fulton County Airport, FAA Tower Chief

Capt. J. Biggerstaff, Operations Chief, Dobbins AFB, Marietta, Ga.

J. Hardin, Chief, Ramp Control, Eastern Air Lines

W. McGuire, Chief, Ramp Control, Delta Air Lines

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Personnel - U. S. Weather Bureau: Washington; LaGrange, Ga., Atlanta, Ga., and Asheville, N.C.

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<u>Synopsis</u>

The purpose of the Atlanta Air Traffic Analysis was to provide complete and accurate quantitative analyses of aircraft movements in flight in the Atlanta Air Route Traffic Control Area and on the ground at the Atlanta Airport. These analyses were intended to show the nature, volume, and flow of Air Traffic both in the air and on the airport surface. Data were collected and analyzed for four high-activity 24-hour IFR periods in the enroute division of the project and four 8-hour VFR periods for the airport surface movement.

This report consists of three volumes. Volume I describes the highlights of the analysis, with conclusions and recommendations; Volume II contains detailed supporting data used in the analysis but not required for proper understanding of Volume I; and Volume III contains a tabulation of the enroute and surface data recorded on punched cards.

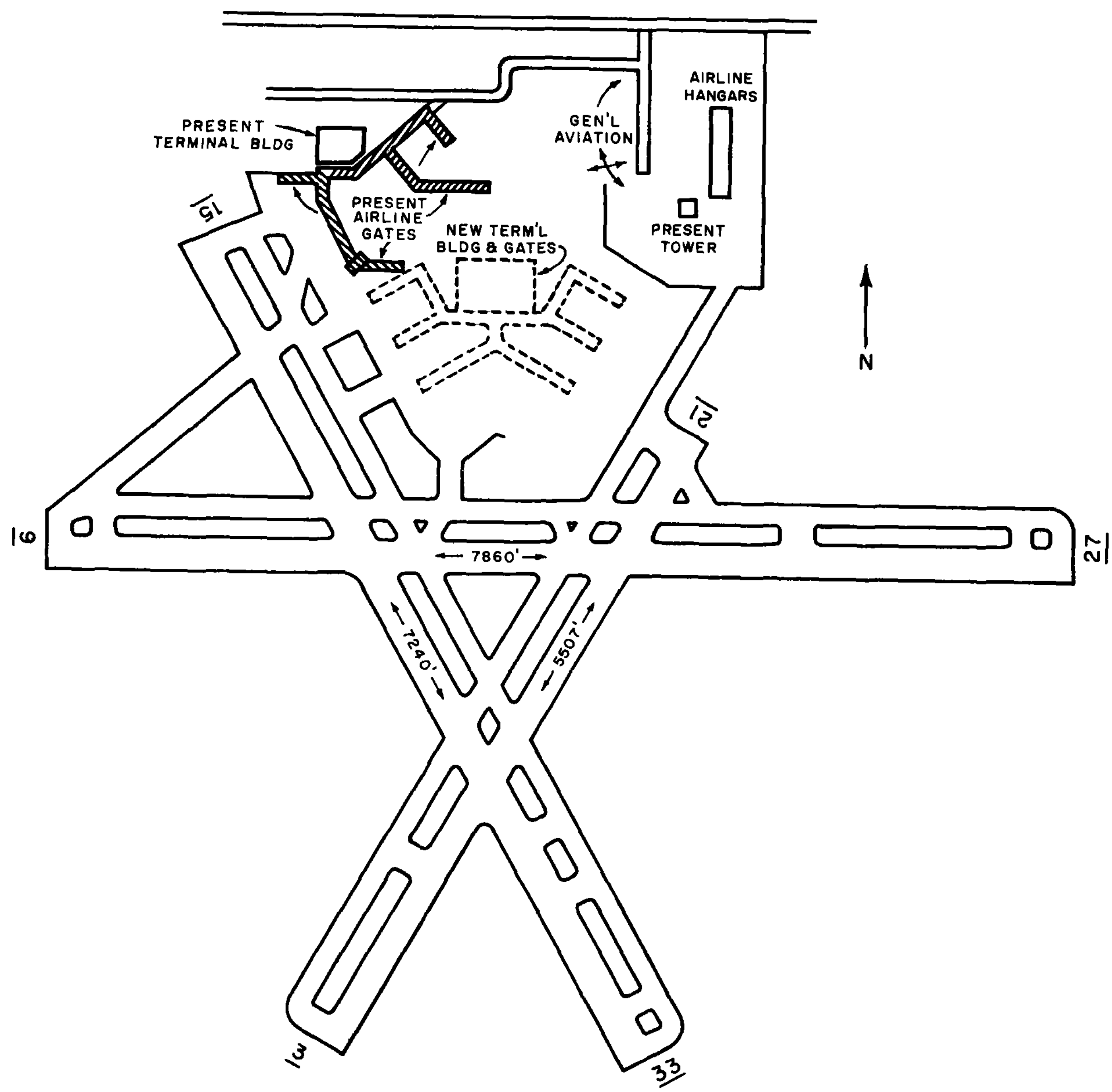
The conclusions and recommendations stated herein are based upon, (1) the actual measurements made on the surface and enroute, (2) the observations of airport operations during the data gathering process, and (3) a careful study of the actual facilities.

The following discussion is based upon both actual measurements and observed data, and includes detailed comments on the airport traffic loading and operations. The Atlanta airport with present and projected facilities is shown in Figure 1.

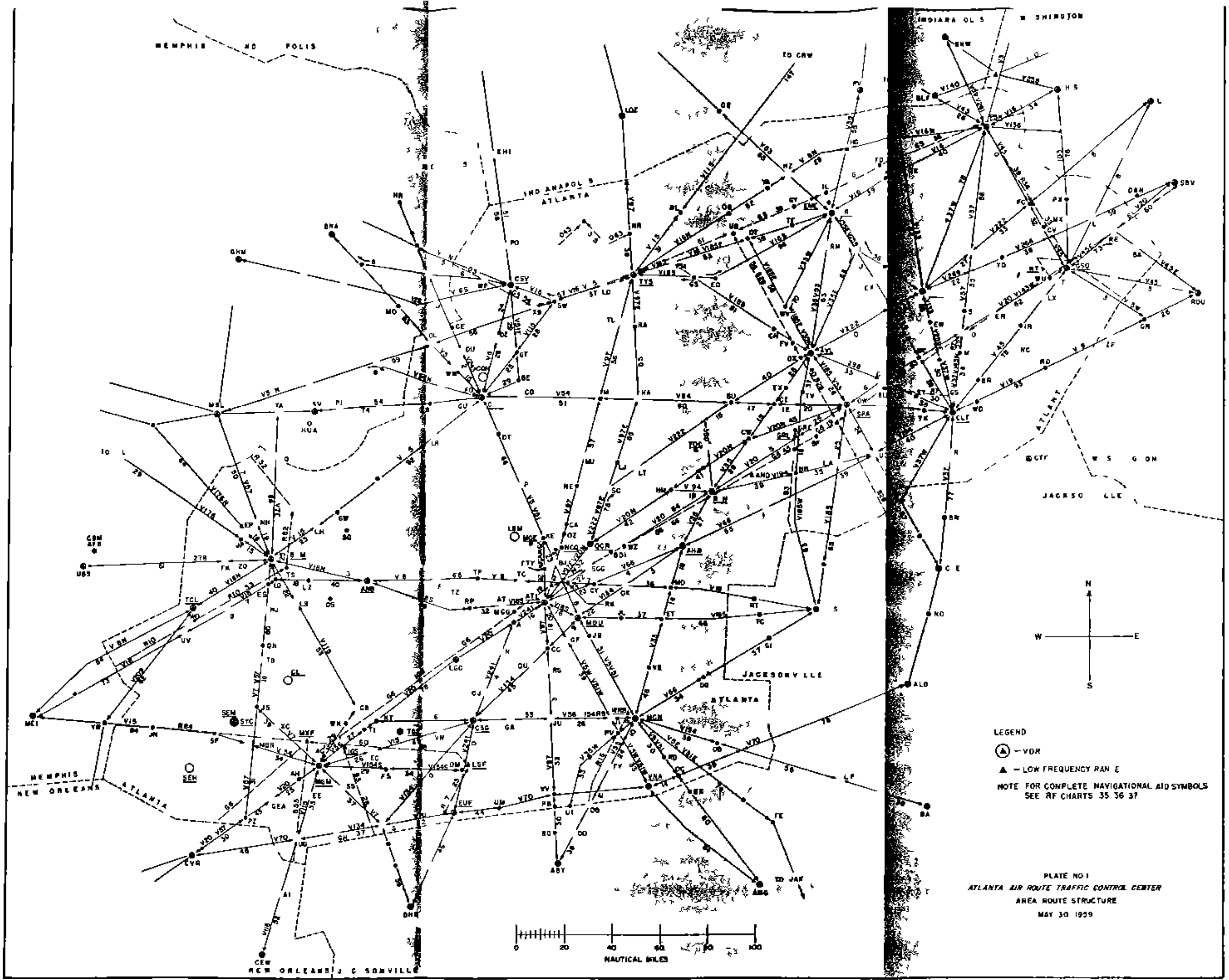
<u>Enroute Analysis</u>

The enroute analysis was based on data collected for four 24-hour high-activity IFR periods as follows

Friday,	20 March 1959	(beginning 1000 EST)
Sunday,	29 March 1959	(beginning 0800 EST)
Monday,	13 April 1959	(0000 to 2400 EST)
Friday,	22 May 1959	(0000 to 2400 EST)



ATLANTA AIRPORT
Figure 1


LEGEND
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NOTE FOR COMPLETE NAVIGATIONAL AID SYMBOLS SEE RF CHARTS 35 36 37
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ATLANTA AIR ROUTE TRAFFIC CONTROL CENTER
AREA ROUTE STRUCTURE
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NAUTICAL MILES
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JACKSONVILLE
ATLANTA
MEMPHIS
NEW ORLEANS
INDIANAPOLIS
ATLANTA

Figure 2

This portion of the study included the entire Atlanta Air Route Traffic Control Area. Raw data consisted of actual flight strips used during the selected periods.

The Atlanta Air Route Traffic Control Center has jurisdiction over an area about 500 miles long and 200 miles wide extending southwest from Greensboro, N. C. and Pulaski, Va. to some distance beyond Montgomery and Birmingham, Alabama.

The area contains 12,695 miles of Victor airways, 2,902 miles of Low Frequency airways, 33 airports, and 15 FAA-operated towers. Figure 2 is a map of the Atlanta Air Route Traffic Control Center Area and airway configuration.

The daily IFR traffic in this area ranged from 1,298 flights on March 29 to 1,582 flights on March 20, with an average for the four periods surveyed of 1,413 flights.

The hourly distribution of traffic establishes two sharp peaks; one at midday and the other in the late afternoon, with a rather shallow dip between. Figure 3 shows, for the periods surveyed, a typical weekday's traffic pattern. Figures 4 and 5 show typical makeup of traffic by ownership class for weekday and Sunday IFR periods.

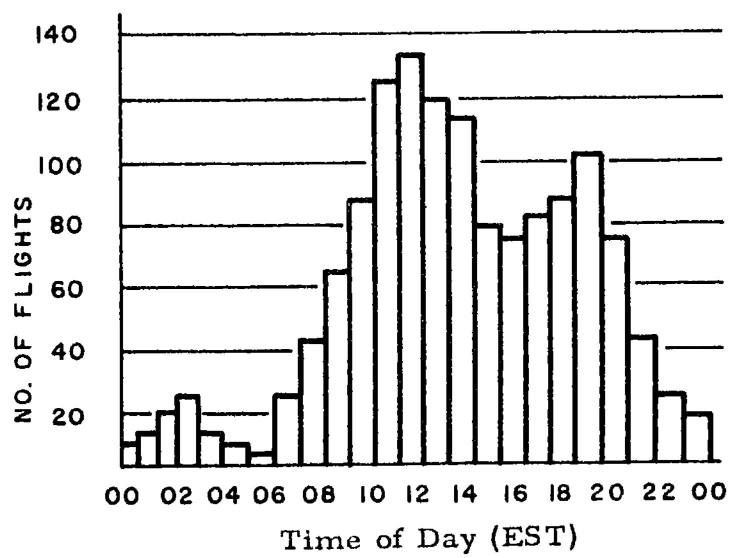


Figure 3 Typical Traffic Pattern for IFR Day

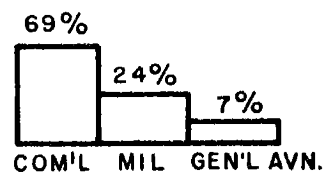


Figure 4 Typical Ownership Distribution for IFR Traffic on Weekdays.

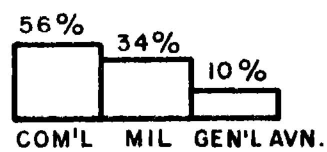


Figure 5 Typical Ownership Distribution for IFR Traffic on Sundays

In 1958, the Atlanta Air Route Traffic Control Center handled 275,722 aircraft movements with a total of 1,553,244 fix postings, ranking sixth in the number of fix postings recorded in 39 centers.

Examination of the enroute traffic in the Atlanta area has not revealed any weaknesses or chronic trouble spots in the route structure. With the tools at hand, there is no way to tell how close an airway or intersection is to saturation, since no measuring or loading index is available at present.

Delays to aircraft in the enroute area were relatively few, both in number and duration. The great bulk of delays occur at the Atlanta Airport and are directly attributable to the terminal area capacity and bunching of schedules by the commercial airlines. An accumulated total of 103 hours delay in a 24-hour period results from this "built-in delay."

Very little information is obtainable for a comprehensive listing of effects on traffic due to weather. A great deal of vital information must come from PIREPS--pilots' reports. PIREPS were found to be very few, and for long periods they are non-existent. Observations indicate that controller workload often prevents delivery of PIREPS to the weather station for transmission on the weather sequence circuit.

One important aspect of the weather problem is the effects of thunderstorms. Since very little seems to be known about thunderstorm patterns in the Atlanta area, it is felt that a large sample of pertinent data would point to optimum route configuration and locations of holding fixes in order to minimize the effects of such storms. A much-needed aid in spotting thunderstorms is some form of display that will make this storm activity immediately available to the controller. One suggestion for such a device is periodic display (say at intervals of several minutes) on the ARSR radar scope for perhaps two sweeps. Some other display media may also be effective.

Since weather is an important factor in traffic movement, it is suggested that consideration be given the integration of one or more weather specialists into the Air Route Traffic Control Center Staff.

Detailed Comments on Atlanta Airport Surface Analysis

The surface analysis part of the project was based upon data collected on four 8-hour, high-activity VFR periods as follows:

Friday,	13 March 1959	(beginning about 1200 EST)
Tuesday,	7 April 1959	(beginning about 1200 EST)
Thursday	23 April 1959	(beginning about 1200 EST)
Sunday	17 May 1959	(beginning about 1200 EST)

Data for the analysis were recorded by observers stationed at key points on the airport. These recorded data were supplemented by observation of the airport operations and facilities and discussion with senior personnel.

The following paragraphs summarize the results of the actual measurements and include detailed comments on these findings and on-the-spot observations.

(1) The peak combined landing and take-off rate recorded on the four VFR survey days, using two intersecting-diverging runways (9 & 15, or 21 & 27), was 65 operations per hour; the peak half-hour period recorded was 35 operations, a rate of 70 per hour. On other than the 4 days surveyed, using 2 runways (9 & 15), the tower recorded 67, 72, and 58 operations in 3 consecutive VFR hours.

The peak combined landing and take-off rate recorded in VFR, using a single runway (27), was 61 per hour; the peak half-hour period recorded was 31 operations, a rate of 62 per hour.

Considering the airport configuration and the separation and runway occupancy rules, this is close to maximum theoretical capacity.

No scheduled turbojet transports were operating at Atlanta Airport during this survey period. Delta started their first DC-8 operations during September 1959.

(2) The combined landing and take-off maximum capacity during IFR is about 40 to 44 operations per hour.

(3) There are 2 "peak" VFR traffic periods: one from about 1130 to 1400 and the other from 1700 to 1930 EST.

(4) According to timetables of the "survey" period, there were 65 operations (25 landings and 40 take-offs) scheduled during the 60-minute period from 1156 to 1255 EST. During the 30-minute period from 1156 to 1225 EST, 37 operations (21 landings and 16 take-offs) are scheduled,

a rate of 74 per hour. During a 16-minute period from 1200 to 1215 EST, 29 operations (16 landings and 13 take-offs) are scheduled: this is a rate of 109 per hour. These rates will go up shortly when Northwest Airlines start their scheduled operations at Atlanta.

Analysis at Atlanta Airport shows that during IFR, other-than-scheduled operations amount to about another 10% of scheduled operations; and during VFR it is about 35%. Table A summarizes the peak traffic demand rates of all landings and take-offs during IFR and VFR, based on the above

Table A - Peak IFR and VFR Traffic Demand Rates

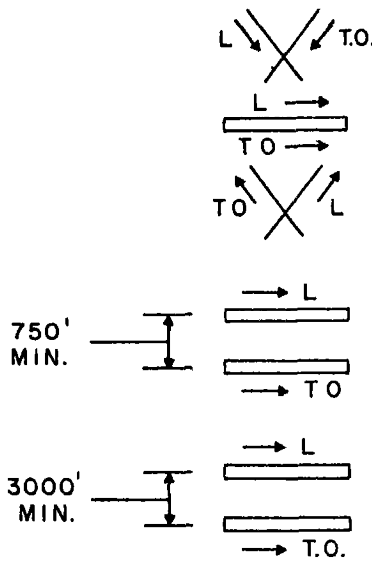
Period From, EST	Total Time, Mins.	Scheduled Operations plus 10%	Total IFR Traffic Demand Rate per hour	Approx. Max* IFR Capacity Opers./hour	Total IFR Traffic Loading = Demand x 100 / Capacity
1156-1255	60	72	72	44	164%
1156-1225	30	41	82	44	186%
1200-1215	16	32	120	44	272%

Period From, EST	Total Time, Mins.	Scheduled Operations plus 35%	Total VFR Traffic Demand Rate per hour	Assumed Max. VFR Capacity Opers. /hour	Total IFR Traffic Loading = Demand x 100 / Capacity
1156-1255	60	88	88	65	135%
1156-1225	30	50	100	65	154%
1200-1215	16	39	146	65	224%

* It should be noted that this assumed 44 per hour maximum capacity in IFR was not "officially recorded" during the four airport survey days (which were conducted on clear VFR days), but was obtained from tower records.

(5) The above item 4 shows that even during unrestricted VFR conditions, "bunched" traffic scheduling is one of the major causes of delays. Of course, during IFR it is much worse. An obvious conclusion is reached that the airport capacity is the major limiting bottleneck. Even without the coming improvements in airspace allocation, route structure, radar control, communications, displays, data transfer, data processing, etc., the present outmoded system of enroute and terminal area ATC is still sufficient to oversaturate the present Atlanta Airport, even in VFR.

(6) As a matter of convenient record, the Curtis Report* to the President states that the ". . . .forecast of the future IFR runways equipped with high-speed (60-knot) turnoffs is . . . . . ." as shown below for several runway configurations:



55/hr.

50/hr.

70/hr. Note: This configuration approximates that of Atlanta's runways 9 & 15.

75/hr. Note. In VFR operations, these runways can be operated somewhat independently at an estimated rate of about 90 to 100 per hour.

100/hr. Note. In this configuration, landing and take-off operations are considered to be practically independent, with little or no coordination between controllers.

The Curtis Report further states ". . . . . an airport should be developed to its maximum capacity with parallel runways before a second airport is constructed. The recommended spacing between high density airports is on the order of 16 miles . . . . ."

*Modernizing the National System of Aviation Facilities, May 1957.

According to information obtained from the Atlanta Airport Manager's office, a dual parallel runway 9-27, 3000 feet south of the present runway 9-27, was contemplated several years ago. The recent build-up of the residential area approaching this dual parallel runway at the westerly approach to runway 9 and the location of the planned expressway pretty much puts this out of the picture.

From the standpoint of economics, it appears to be cheaper now to build another airport. From the standpoint of anticipated traffic demand * and near-future jets, immediate planning for a supplemental airport should be undertaken: this supplemental airport should be of a high-performance type design in which, among other sophisticated features, taxiways will permit uninterrupted taxi routings and provision is made for approximate by-pass taxiways or by-pass areas leading directly to the take-off positions. A typical new jet transport has an operating cost of about 30 dollars per minute and it will burn about 1,000 lbs. of fuel in only four minutes of taxiing.

(7) With regard to the airport proper, there are 42 airline gates (Eastern, Delta, Capital, TWA, and Southern) presently available, 23 of which are allocated to Eastern Air Lines. The city's master plan calls for construction of a new terminal building with 6 "fingers" having a capacity of 52, 160-foot diameter, airline gates by late 1960. Separate cargo loading areas will also be available.

During VFR operations, there were many occasions (sustained periods of up to one-half hour) when we counted 50 to 54 airline "gates" occupied. Double and triple parking was used, a very hazardous and undesirable conditions; and during these and lesser peak periods, there were often several arrival aircraft delayed because of unavailability of gates and/or ramp congestion.

The average number of airline gates occupied during peak hours was about 45.

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* As an example of anticipated traffic demand, FAA's Bureau of Air Traffic Management Report for Calendar Year 1958, entitled, "Terminal Locations for Planning Purposes." shows that by 1965 Atlanta Airport instrument approaches are expected to increase by about 71%.

(8) With regard to the above-mentioned 52 near-future airline gates (planned to be 160-foot diameter), no provision is made for accommodating the 203-foot diameter gates tentatively prescribed for airline jets.

It is recommended that provisions be made by 1960 for at least 10 special "jet" gates and their appropriate blast fences. In addition, it appears that 52 airline gates (ultimately planned to total 60) will be inadequate to meet the anticipated peak hourly demands. A total number of at least 75 gates (including the 10 jet gates) appears to be a better number for near-future planning purposes.

(9) The longest runway is 7860 feet (instrument runway 9-27), and its elevation is 1024 feet above sea level and the effective gradient is 0.73%. CAA's TSO-N6b of 3 October 1958 calls for a runway length at continental airports of 7500 feet plus 7% for each 1000 feet above sea level. This Atlanta requirement then figures out to be about 8025 feet. Another 20% is required for each 1% of gradient, making the total about 9200 feet in order for ATL to be rated as a continental airport. At such times as longer runways become available, the runway occupancy rule (no two aircraft allowed on or over the runway at the same time) may reduce runway efficiency. It is probably not too early to begin devising safe and effective procedures for rapidly clearing the runway when it is used by aircraft requiring only a short landing or take-off space.

There are no near-future implementation plans to extend the present runway 9-27, although the city's 1958 Master Plan shows that an additional 800-foot extension at the west end and a 900-foot extension at the eastern end had been considered as a future possibility.

(10) TSO-N6b also calls for taxiway widths of 75 feet. The Atlanta Airport Master Plans show taxiway widths to be 75 feet. However, it is believed that even 75 feet is inadequate for the larger transports, both those presently in operation and those of the near future.

(11) No high-speed turn-off's are provided on any of the runways, nor are any planned at present. Present exits on 7860-foot long runway 9 are located at about 2510 feet, 2920 feet, 4110 feet, 4460 feet, 5760 feet from the threshold.

For runway 27, these exits are therefore about 2100 feet, 3400 feet, 3750 feet, 4940 feet, 5300 feet, and 7500 feet from the threshold.

The average runway occupancy time (threshold to runway exit) for landings on runway 9 or 27 during "dry" VFR operations was about 48 seconds. As a matter of convenient comparison, the average occupancy time of runways 18 and 36 at the smaller Washington National Airport, measured a year or so ago by the CAA, was about 38 seconds.*

There appear to be 3 major reasons for the significantly lower occupancy times at WNA; (1) At Atlanta, the average touchdown point on runways 9 and 27 was about 1200 feet, and at WNA it was about 1000 feet; (2) better spaced and angled runway exits at WNA (and it should be noted that prior to pouring the concrete for several new angled exits on WNA runway 18-36, the average runway occupancy time in VFR was measured to be 48 seconds); and (3) pilots decelerated more rapidly on the shorter runways at WNA to permit them to use the most direct route to their gates. It should be mentioned, however, that the new terminal building at Atlanta will be centrally located with respect to runway 9-27.

(12) During the four VFR test days, the largest number of aircraft observed in the actual take-off "queue" was 11. However, on other than the four recorded VFR test days, there were several occasions observed during peak VFR operations where 15 to 18 aircraft were in the take-off queue. Unfortunately, it is not known how many additional aircraft stayed at their airline gates during these periods, not bothering to start their engines and taxi out because of the known congestion. Their failure to depart consequently resulted in the lack of gate space for arrival aircraft.

(13) Some of the take-off queues mentioned above were caused by lack of taxiway and warmup pad by-pass areas. On many occasions, the first take-off aircraft was ready to go but did not have his enroute clearance. The #2, #3, etc. take-off aircraft could not by-pass #1 and were therefore delayed. Sometimes a chain reaction followed where, after several minutes delay, the #1 aircraft finally got his clearance and took off. Subsequently, the #4 aircraft finally got to be #1 in line and his clearance didn't come through. This then triggered-off further delays to subsequent aircraft in the take-off queue.

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* CAA Office of Airports Report dated April 1958, "The Provision of Exit Taxiways at Washington National Airport and Their Effect on Runway Occupancy Time of Landing Aircraft."

(14) The number and delays of VFR arrival aircraft becomes so great that they often stretch out way beyond the visual range of the local controller. The controller cannot possibly schedule or plan ahead for more than a few minutes, and then only in a rather coarse manner. Sequencing is also a problem, and it would be helpful if the ASR-3 radar could be used for controlling and separating the VFR approaches. Theory shows that for a VFR hourly demand rate of 88 mixed operations, the average delay for all 88 operations is about 13 minutes, or a total of about 19 hours delay for this one peak hour alone.

Further to the above, a simple data transfer and a local situation and aircraft identity display should also be very helpful to the local and ground controllers.

(15) The flow of traffic into and out of Atlanta Airport usually occurs in sudden peak 1-hour bursts of landings and then bursts of their subsequent take-offs for a period of about 1 to 1 1/2 hours. This occurs twice a day. With regard to item 14 above, it is unavoidable in VFR for long sequences of landings to occur, while the occasional take-offs (during the landing peaks) have to wait until gaps in landing times occur to get off. It would be much more efficient overall if a few judiciously selected landing intervals could be stretched out to allow "sandwiching" of the occasional departure before the subsequent take-off peaks occur.

Conclusions

The foregoing discussion may be summarized briefly in the following conclusions:

(1) A major limiting bottleneck is airport capacity.

(2) With the present terminal and airport configuration at Atlanta, both VFR and IFR opertions are close to maximum theoretical capacity as stated in the "Curtis Report".

(3) One major cause of delays is "bunched" airline scheduling.

(4) There are usually two combined landing and take-off traffic peaks every day· one from about 1130 to 1400 and the second from about 1700 to 1930 EST.

(5) Present methods for displaying traffic in towers and centers are obsolete.

(6) There was no indication from measured delays that the route structure in the enroute area is inadequate.

(7) About 80% of the enroute delays were attributable to Atlanta terminal saturation.

(8) Traffic inbound to the area, traffic outbound from the area, traffic overflying the area and traffic with origin and destination within the area (local) is made up as follows in IFR:

Inbound	26%
Outbound	28%
Overflights	29%
Local	17%

(9) Delays separated by class, total numbers and accumulated time for March 20, 1959, the busiest IFR day surveyed, are listed below:

Class	No. of Delays	Accumulated Time
Enroute - overflights	45	9 hours
Inbound to ARTCC Area	137	31 hours
Departure - ground	128	12 hours

(10) Postings were made for 167 fixes during the survey. There are 322 fixes in the area -- 34 with three-letter identifiers and 288 with two-letter identifiers.

(11) The highest and lowest number of fix postings and ownership proportions for the four 24-hour survey periods in IFR were:

Friday March 20, Beginning 0800 EST. 6904 postings

Commercial	52%
Military	36%
General Aviation	12%

Sunday, March 29, beginning 1000 EST. 4744 postings

Commercial	69%
Military	25%
General Aviation	6%

(12) The highest and lowest number of daily postings for the 12 busiest fixes in the area were:

Atlanta VOR (ATL) 661 postings on May 22 - 0001 to 2400 EST

Spartanburg 85 " " Mar 29-30 -1000 to 1000 EST

The greatest number of postings per hour was Atlanta VOR (1300 to 1400 EST), 68 postings.

(13) In the search for cancellations and diversions due to actual or forecast delays in the area, the data source specified was airline companies' records. Two airline operators responded to our questionnaire with the information that no such cancellations or diversions were experienced. It should be noted that negative answers from some operators and no answers from the balance is not a guarantee, per se, that no trouble existed. Only actual data results can be recorded.

(14) The average number of flight progress strips prepared per flight for each traffic class were:

Traffic Class	Average strips prepared per flight
Inbound - to ATL area	4
Outbound - from ATL area	4
Overflight	5
Local-Flight within the area	4

(15) The average number of hidden delays in the two-hour peak periods in each of the IFR days surveyed were:

Due to rerouting	8
Due to altitude changes	16

Except for several unusual cases, the average hidden delay approximated 2 minutes.

(16) The maximum number of ETA updates was 303 at 1600Z while the minimum was 8 at 1200Z. For altitude updates, the maximum was 554 at 1600Z and the minimum was 6 at 1100Z. The average number of ETA changes per strip is 0.50 and the average number of altitude updates per strip is 0.80. The Atlanta (omni) strips have, by far, more updates than any other fix, presumably because this is a feeder fix. (This information derived from April 13, 1959 data)

(17) Communications, in the overall analysis, yield very little in total results. They are useful in certain delay investigations and sometimes uncover delays that would not otherwise have been found. The use of these recordings is extremely expensive. Had all channels, center and approach control, been recorded and completely examined, the listening time alone for this entire survey would have been 3,744 hours.

Recommendations

On the basis of both the measurements and observations made during the Atlanta Air Traffic Analysis, the contractor recommends that the following specific actions for improvement of operations in the Atlanta Area be considered.

The first group of these recommendations is based upon the data recording and measurements program.

(1) Several features should be designed into the present Atlanta Airport ground environment as follows:

   (a) Multiple warm-up pads
   (b) Taxiway by-passes
   (c) Taxiway widening
   (d) High speed turnoffs, judiciously located

(2) To meet TS0-N6b for continental airports, runway lengths must be extended.

(3) The airlines should be encouraged to eliminate bunching by rescheduling in the interest of economy of their own

operations. Also, a mathematical analysis should be made of the decrease in delays, and their economic implications, by various degrees of re-scheduling.

(4) In addition to recommendation (1) above, plans for a supplemental airport (of the high performance type) should be considered seriously by cognizant Atlanta authorities.

(5) By 1960, provision should be made for a total of at least 75 gates, of which 10 should be special jet gates with their appropriate blast fences.

(6) Studies should be made to determine the width of taxiways needed for safe and efficient large transport operations.

(7) It is recommended that the airway route structure be reviewed with respect to the number of fixes, since our survey showed that only 167 fixes were in active use out of a total of 322 fixes in the ares.

The following recommendations submitted for consideration are based upon discussions between contractor and operational personnel.

(1) The strobe line lights and the attendant control system generate problems because of individual pilot preference for varying degrees of brightness. Atlanta Tower reports that an extra controller must often be used just to handle the controls. This situation requires study and analysis to determine if optimum compromises can be achieved. Possibly a control system governed by ceiliometer and transmissometer outputs could result in acceptable strobe line lighting.

(2) To relieve congestion at Charlotte during IFR, an ASR radar is recommended.

(3) The ARSR radar planned for Middlesboro, Ky, should be relocated at Etowah, Tenn.

(4) An ARSR radar is recommended between Birmingham and Chattanooga for both jet coverage and terminal coverage at these locations.

(5) As soon as available, beacon equipment should be provided for the center and the Tower.

(6) The Tower should be provided with a scan-converted drop on the Center ARSR-1 Radar.

(7) Additional discrete telephone lines to Washington, Jacksonville, and Memphis are needed.

(8) Atlanta Center currently needs one additional outbound and one additional over traffic frequency.

(9) Atlanta Center needs a peripheral frequency at Hickory to take care of Charlotte's low altitude traffic.

(10) The frequency needs of Atlanta Center should be rechecked after some operational experience with jets has been acquired.

(11) Traffic handling in the terminal area could be both eased and expedited in IFR if exclusive inbound, outbound, and over routes can be provided in all four quadrants surrounding the terminal area.

(12) VOR's are needed east of Atlanta and northeast of Birmingham to replace ILS airways.

(13) VOR's are needed at Jasper, Ga., Clemson, S.C., and Eutaw, Alabama as gap fillers.

(14) Experimentation with closed circuit TV should be conducted between the center and the tower IFR room, and also between the tower cab and tower IFR room.

(15) The center and tower should be provided with a single IFR room for common control to cover a 50-mile radius with a definite altitude ceiling.

(16) Atlanta facilities should have 24-hour maintenance available, and provisions should be made to conduct preventive maintenance during off-peak periods.

(17) It is felt that the Oklahoma City controller training school could be very helpful in supplying needed personnel if there were some upgrading of the criteria used in selecting, grading, and screening of trainees.

(18) Improved displays and procedures should be developed to facilitate collection and transmission of pertinent weather information.

(19) Consideration should be given to supplementing the air traffic control staff with weather specialists.

(20) A coordinated effort by the airlines and FAA should be made to analyze the economic and operational impacts of re-scheduling during the serious "noon" and evening peaks.

SECTION I

INTRODUCTION

Objective and Scope of The Project

The basic objective of this project, as originally outlined in Article I, Section A of the contract is to: "Provide complete and accurate quantitative analysis of aircraft movements in flight in the Atlanta Air Route Traffic Control Area and on the ground at the Atlanta Airport. These analyses must show the nature, volume and flow of air traffic both in the air and on the airport surfaces. In addition, the analyses must establish the distribution, magnitude and causes of delays that occur during periods of heavy demand upon the air traffic control system. This must be determined for aircraft on the designated airport surfaces and in the air under the control of the Atlanta Air Route Traffic Control Center, the Atlanta Tower and the Atlanta Naval Air Station (DeKalb-Peachtree) Tower".

Data were collected and analyzed for four high activity 24-hour IFR periods in the enroute division of the project, and four 8-hour VFR periods for the airport surface movements. No two periods were concurrent, since each had to meet a different set of requirements. The surface studies specified 4 eight-hour Visual Flight Rule (VFR) "test days" which had to be selected in advance. Requirements for the enroute portion were Instrument Flight Rules (IFR) on 4 twenty-four hour days of high density traffic. These periods were specified as "after the fact", based on IFR weather conditions in the Control Center Area and high activity traffic. Following are the periods selected for this survey:

Enroute

(1)	24 hours beginning 1000 E. S. T.	March 20, 1959
(2)	24 hours beginning 0800 E. S. T.	March 29, 1959
(3)	24 hours beginning 0001 E. S. T.	April 13, 1959
(4)	24 hours beginning 0001 E. ST.	May 22, 1959

Atlanta Airport Surface

(1) - 8 hours beginning approx.	1200 E. S. T.	March 13, 1959
(2) - 8 hours beginning approx.	1200 E. S. T.	April 7, 1959
(3) - 8 hours beginning approx.	1200 E. S. T.	April 23, 1959
(4) - 8 hours beginning approx.	1200 E. S. T.	May 17, 1959 (Included Task 10 data taken at Fulton County, Dobbins AFB and DeKalb-Peachtree)

The project was divided into 12 tasks, each detailing requirements for a certain phase of the work. Listed below are the general heading and company responsibilities for each task:

Task 1 - (FIL) Determine the nature, volume and distribution of air traffic on 4 high activity IFR test days.

Task 2 - (FIL) Determine the number and distribution of air traffic delays in IFR.

Task 3 - (FIL) Determine the number of flights cancelled or diverted because of delays in IFR.

Task 4 - (PHILCO) Photo record the radar scopes for the same 4 IFR test days of Task 1. Identify and plot certain periods of traffic appearing in radar scope photographs.

Task 5 - (FIL) Determine the number of flight progress strips prepared for each aircraft in IFR.

Task 6 - (PHILCO) Determine the nature, volume and distribution of aircraft movements on the surface of Atlanta Airport for 4 VFR test days.

Task 7 - (FIL) Determine the number of aircraft diverted or delayed because of weather in IFR.

Task 8 - (FIL) Hidden delays in IFR.

Task 9 - (FIL) Flight strip up-dating in IFR

Task 10 - (PHILCO) Tabulate arrivals and departures at 4 Atlanta area airports during one of the Task 6 VFR test days.

Task 11 - (FIL) Voice recording equipment.

Task 12 - (FIL & PHILCO) Over-all Recommendations, based on both observations and quantitative data.

Historic Sketch of Atlanta Airport

Atlanta has been, since prior to the Civil War, a leading transportation center in the South. During the growth of aviation the pattern continued in much the same manner as that established by the railroads during the early development of the area.

By 1925 the need for airport facilities to handle aviation was recognized, and the present site was selected by a committee composed of members of Atlanta's governing body and private citizens following consultation with the Army and commercial aviation interests. The site then consisted of 287 acres of land, leased from what was known as the Candler Estate and, for some time after the airport became operational, was known as Candler Field.

In 1927 two 1500 ft. landing strips were laid. The first two operators on the field were Doug Davis and Beeler Blevins. Also, for a few months, beginning in May, 1927, a company known as the Florida Airways Company operated Atlanta's first air mail service utilizing a German Junkers Aircraft. This was between Atlanta and Miami.

On May 1, 1928, Pitcairn Aviation Company inaugurated mail service between Atlanta and New York. This, together with other commercial operations, gave Atlanta its first Air Traffic Control. It has been said that air traffic control became a necessity the moment two or more airplanes took to the air. The traffic control system, when it was inaugurated, according to the present Tower Chief, Ben Faulkner, was entirely operated by Ben traversing the runways, transmitting instructions to arriving and departing pilots by means of two hand flags. All control activities were administered by the airport authorities.

It was not until the winter of 1938-39 that Ben Faulkner and his associates were able to furl their flags and perform all control functions in the shelter of the newly-built tower cab. In 1941 the Civil Aeronautics Administration took over the operation of all air traffic control and transferred all personnel from the municipal pay-roll. The present Tower complement is 57 which includes controllers, administrative, and clerical personnel.

The Atlanta Airport today covers 1414 acres and has 3 runways: 9-27, 7860 feet long with instrument landing system (ILS); 33-15, 7240 feet long; and 3-21, 5507 feet long.

In October, 1939, the Atlanta Air Route Traffic Control Center was established by the Civil Aeronautics Administration, operating one sector. Gradual expansion has increased its control jurisdiction to include its present area and 15 sectors, With controllers, administrative, and clerical forces, the present Center complement is 310.

In addition to the above operating forces, the office of the ATCD Area Supervisor is located in Atlanta.

Description of the Present System

The Atlanta Air Route Traffic Control Area, as shown in Figure 2, has an irregular boundary but is roughly oblong in shape, measuring about 200 x 500 nautical miles and encloses an area of about 100,000 square miles. The long dimension lies in a northeast-southwest direction between Pulaski, Va., and Montgomery, Ala., and the narrow dimension near the middle of the area is between Macon, Ga., and Chattanooga, Tenn. The lower two-thirds of the area is relatively free of mountainous terrain and other operational hazards where elevations generally do not exceed 2,000 feet. The upper third includes the Great Smoky Mountains and southern portion of the Appalachians with two elevations of nearly 7,000 feet. Elevation of Atlanta Airport is 1,024 feet.

The ARTC Center operating facilities are located in Atlanta, about 60 miles southwest of the area's geographical center.

A ring of population centers near the border, each accommodating from 8 to 11 converging airways, consists of:

Pulaski, Virginia
Greensboro, North Carolina
Charlotte, North Carolina
Macon, Georgia
Montgomery, Alabama
Birmingham, Alabama
Chattanooga, Tennessee
Knoxville, Tennessee
Tri-City(Bristol), Tennessee

ARTC Center areas bounding this center are:

Washington
Jacksonville
New Orleans
Memphis
Indianapolis

Airways - General The area contains 12,695 miles of Victor airways with 28 VOR's (11 with Distance Measuring Equipment), 245 fixes, 2,902 miles of Low Frequency (colored airways), 14 Low/Medium Frequency Ranges and 10 Radio Beacons. The main concentration of airways is along the above mentioned northeast-southwest axis, generated by a line of omniranges at Greensboro, Spartanburg, Charlotte, Greenville, Royston, Athens, Atlanta, McDonough, Columbus and Montgomery.

Airports, Towers and Facilities There are 33 airports, 1 FAA-operated ASR-PAR radar (at Atlanta Airport) and 9 Instrument Landing Systems in the area: Birmingham (BHM), Montgomery (MGM), Atlanta (ATL), Columbus-Muscogee (CSG), Charlotte (CLT), Greensboro (GSO), Winston-Salem (INT), Greenville (GRL), Macon (MCN).

Also there are 15 FAA-operated towers classified by FAA as:

2 - (L) Large
3 - (M) Medium
9 - (S) Small
1 - (N) Non-Hub

The area also contains 4 military-operated towers. The ARTC Center is equipped with 31 radio frequencies, and the Atlanta tower has 21 available frequencies.

Center Operations In 1958 the Atlanta center handled 275,722 aircraft movements with a total 1,553,244 fix postings, ranking 6th in the number of fix postings recorded in the list of 39 centers, published in "FAA AIR TRAFFIC ACTIVITY, CALENDAR YEAR 1958". The peak day, to the present, was on March 20, 1959, with flights totalling 1,582, peak hour fix postings were 584 (at hour 1600Z), and total postings for the day 6904.

Traffic Distribution

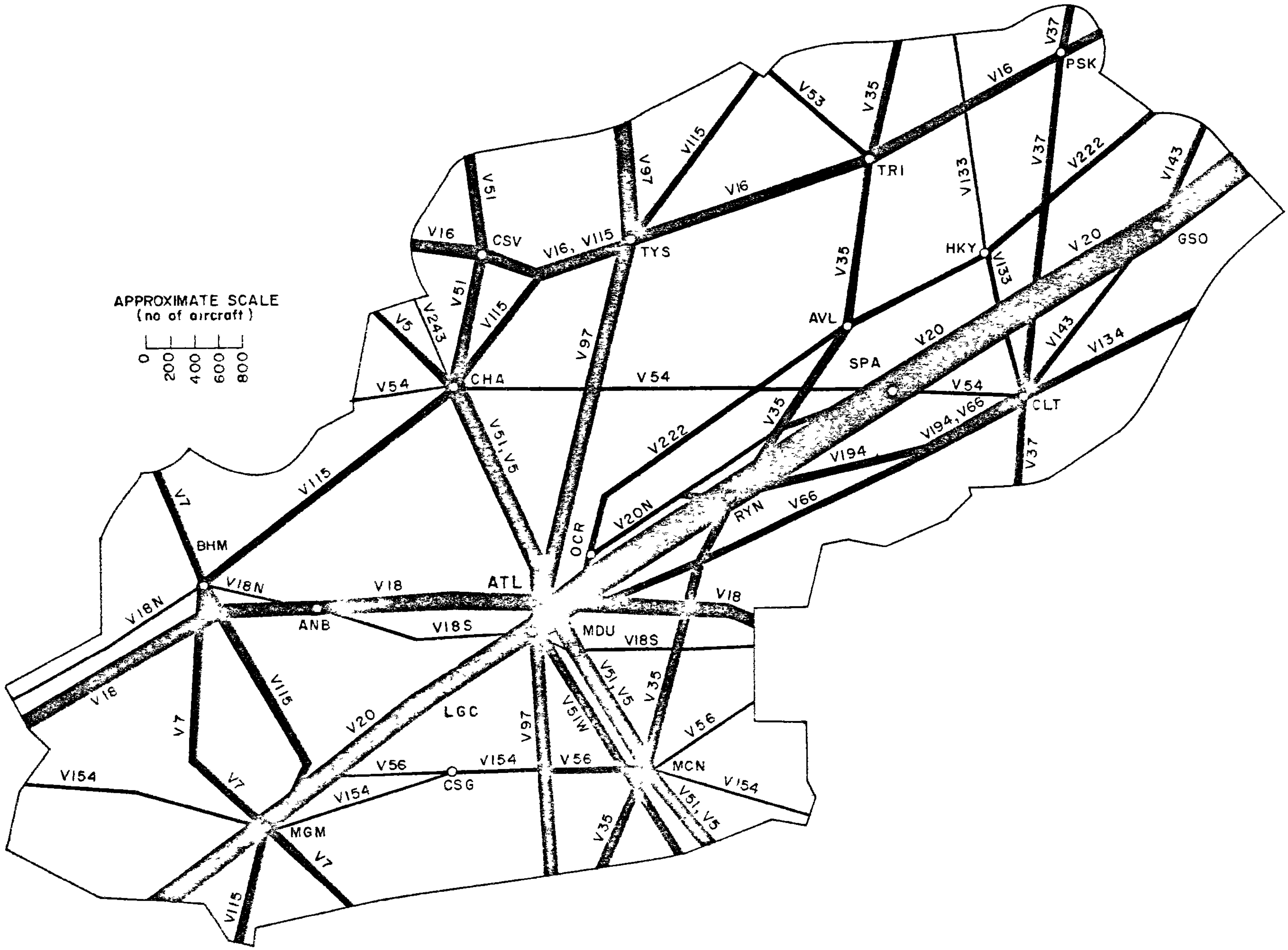
Commercial Traffic is not very well distributed with respect to time. There are two serious "bunching" peaks during the day; the highest during the hours 1600, 1700 and 1800Z and a secondary peak almost as severe at hours 2200, 2300, 0000, and 0100Z. This results in periods of complete saturation and accounts for a high volume of delays, mostly in the Atlanta Terminal Area.

Restricted and Prohibited Areas Restricted areas, as published in Radio Facilities Chart US RF 35 include Fort Benning, Fort McClellan and Dawonville. The Clinton Engineering Works near Knoxville, Tennessee, is designated as a Prohibited Area.

Atlanta Airport A sketch of the Atlanta Airport was shown on Figure 1, in the SUMMARY. The most widely used runways are the 150-foot wide instrument runway 9-27 (7860 feet long) and 15-33 (7240 feet long). Field elevation is 1024 feet, and the airport is classified as "Continental". It should be mentioned that, during the data collection phase, considerable construction work on new ramp, gate and terminal building facilities was in progress.

Area Map The Atlanta ARTCC Area and airway configurations are shown in Figure 2 (also in the SUMMARY). Figure 6 shows the traffic density on the routes in the Atlanta area, and Figure 7 shows the central and sector boundaries of the Atlanta ARTCC. Figures 8, 9, and 10 show the Atlanta holding patterns and departure routes.

Administration Control of air traffic in the Atlanta area is under the over-all authority of the Atlanta Air Route Traffic Control Center located at the Atlanta Airport. At the time this report was written, an enroute radar (ARSR-1) and scan conversion displays were undergoing commissioning tests. The Atlanta Center, under the administrative control of FAA's Region 2, has complete operational control of controlled air traffic in its area, with the exception of some operational authority delegated to certain towers. Transfer of jurisdiction between Center and Tower is applied to appropriate traffic about 25 miles from the airport. Specific control and communication points established along the airway structure are used as "hand-off" fixes or "release" points between the Center and



AIR ROUTES DENSITY
(ONLY ROUTES WITH 25 OR MORE AIRCRAFT PER DAY ARE SHOWN)

Figure 6

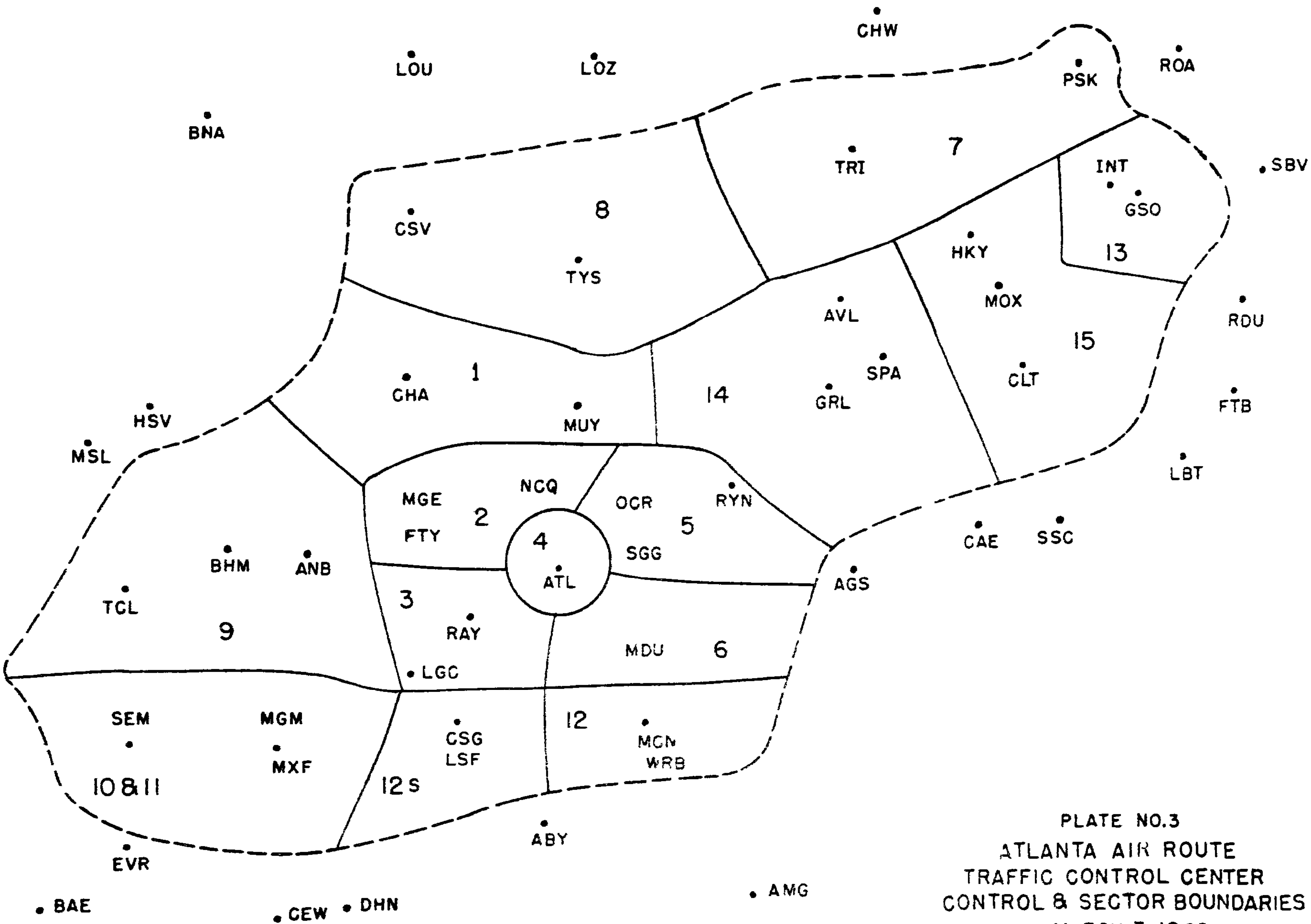
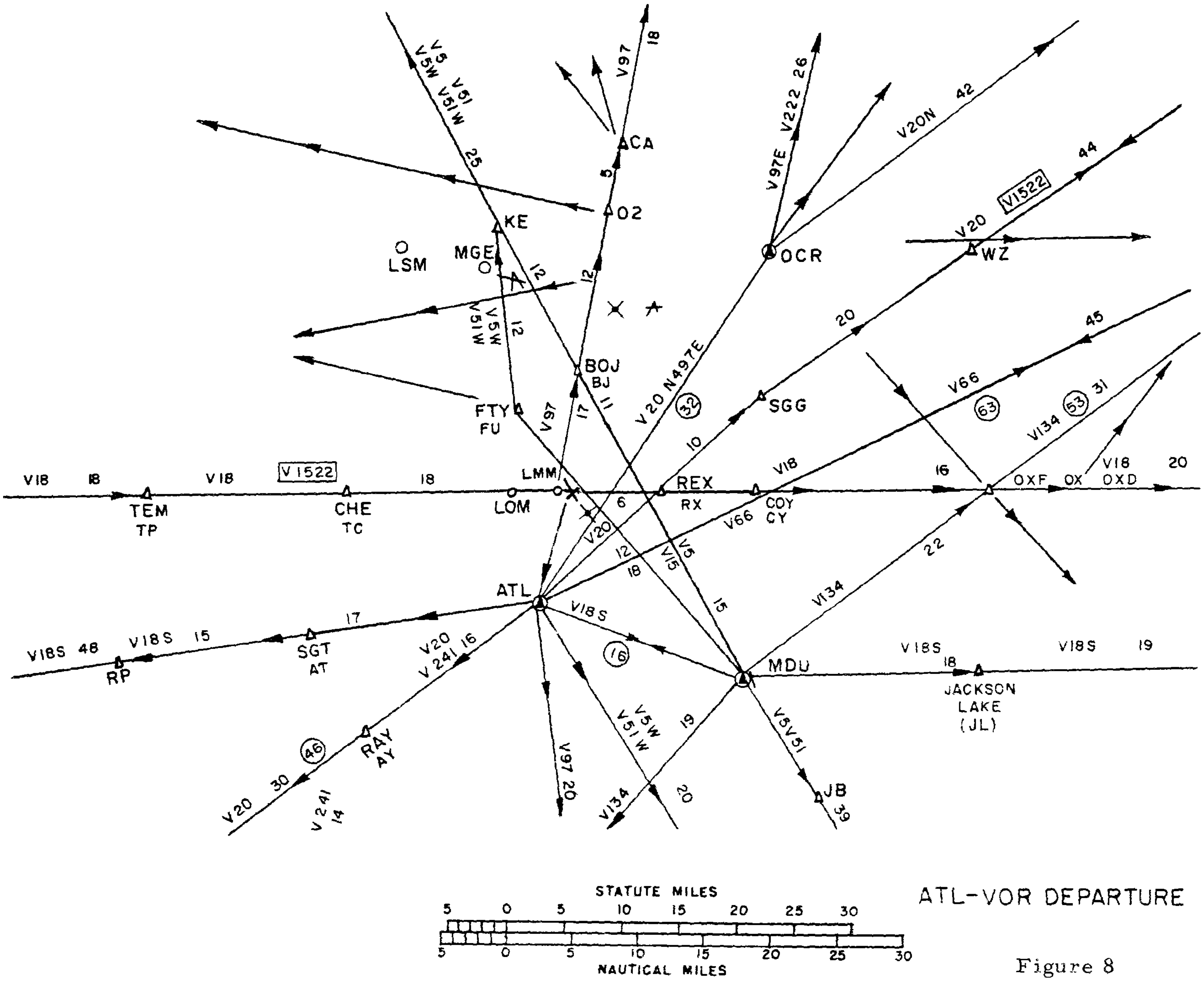


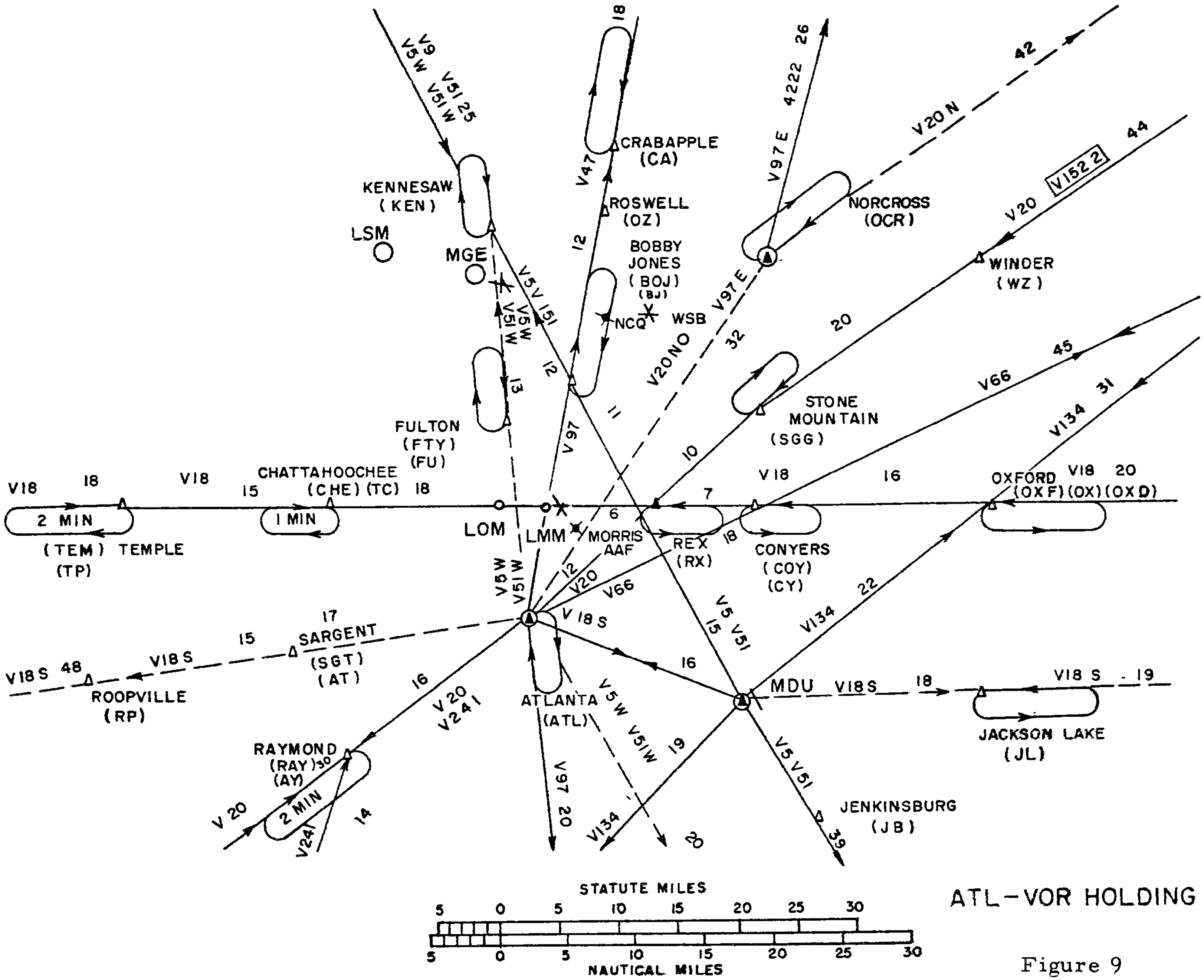
PLATE NO. 3
ATLANTA AIR ROUTE
TRAFFIC CONTROL CENTER
CONTROL & SECTOR BOUNDARIES
MARCH 3, 1959

Figure 7



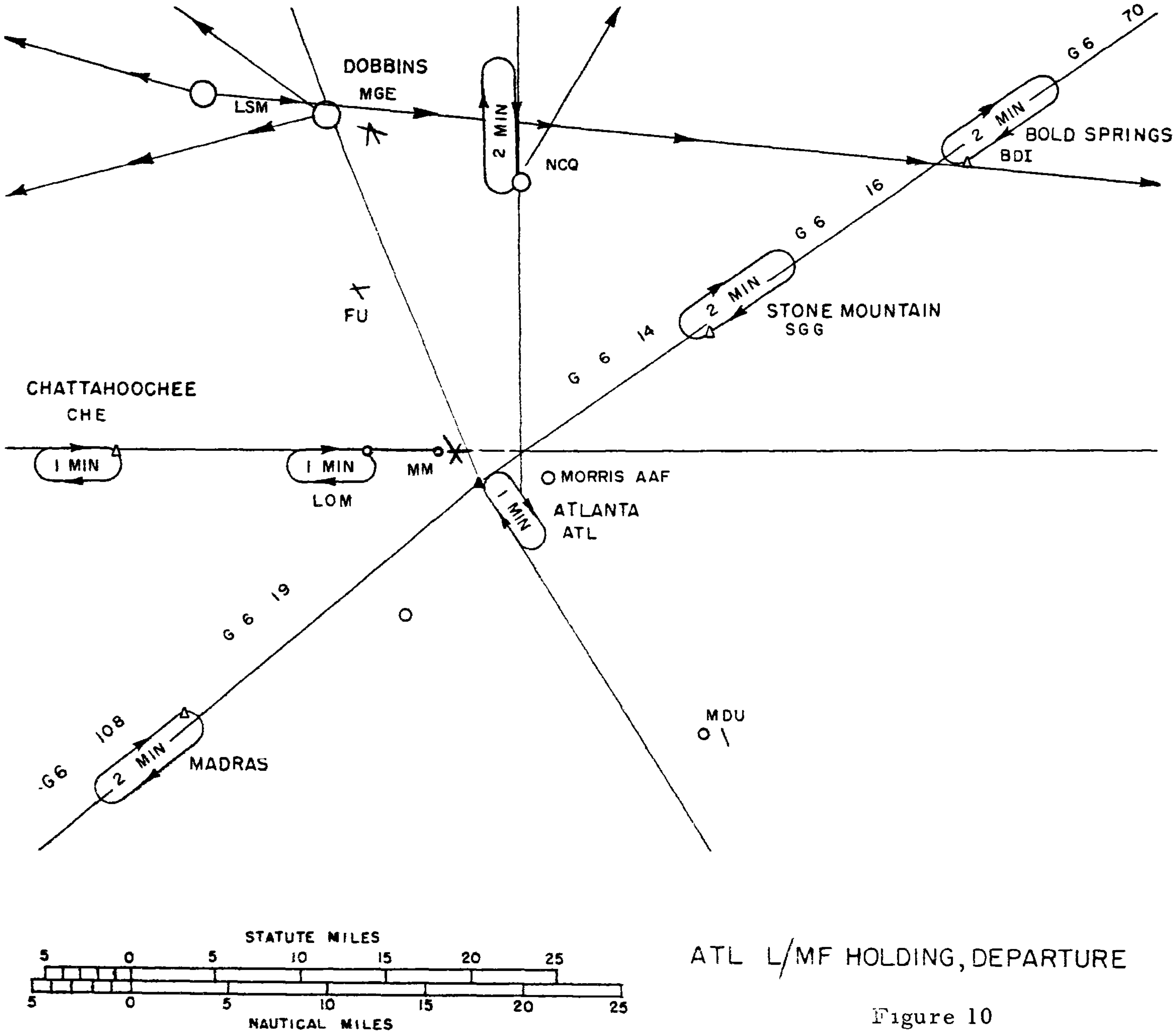
ATL-VOR DEPARTURE

Figure 8



KENNESAW (KEN)
LSM
MGE
CRABAPPLE (CA)
ROSWELL (OZ)
BOBBY JONES (BOJ) (BJ)
NCQ
WSB
NORCROSS (OCR)
WINDER (WZ)
STONE MOUNTAIN (SGG)
FULTON (FTY) (FU)
CHATTAHOOCHEE (CHE) (TC)
OXFORD (OXF) (OX) (OXD)
LOM
LMM
MORRIS AAF
REX (RX)
CONYERS (COY) (CY)
(TEM) TEMPLE (TP)
2 MIN
1 MIN
SARGENT (SGT) (AT)
ROOPVILLE (RP)
ATLANTA (ATL)
MDU
JACKSON LAKE (JL)
RAYMOND (RAY) (AY)
JENKINSBURG (JB)
V152 2
STATUTE MILES
NAUTICAL MILES
ATL-VOR HOLDING

Figure 9



ATL L/MF HOLDING, DEPARTURE

Figure 10

approach controllers. Approach control radar is used in the Terminal Area to provide separation and for necessary vectoring. More detailed descriptions of the individual Tasks 1-12 and related highlights of the results follow in the main body of the text.

SECTION II

DISCUSSION OF ANALYSIS

AND

COMPILATION OF DATA BY SPECIFIC TASKS

General Direction and Findings of Analysis

One of the main objectives of air traffic control is to expedite traffic and eliminate delays. First, we must find where the delays occur. If aircraft are held enroute because of saturated intersections or airways, then an obvious (but perhaps not always practical) solution is similar to that of providing relief in a congested communications trunk group: provide more VOR's and by-pass airways. If the delays are the result of terminal congestion, relief lies in improvement of the time sharing system, or, as often expressed by at least one member of FAA Operations Analysis Division, "by pouring more concrete."

In the Atlanta Area, the Atlanta terminal is the focal point of delays. An additional runway parallel to runway 9-27 or more taxi strips could improve the condition significantly in VFR. However, this is not recommended as a long-term measure because of the near-prohibitive cost and land acquisition problems. One of the major problems in the Atlanta terminal is one of unrealistic airline time sharing. There could be sufficient facilities to handle a significant percentage of the present traffic demand if only all that demand were not made at the same time.

Enroute delays actually recorded in IRF in the Air Route Traffic Control Center Area were relatively few.* On the busiest day surveyed, there were 45 enroute delays totalling 9 hours; i.e., overflights, or delays to other aircraft not destined for Atlanta Airport. On the same day there were 265 delays totalling 43 hours to aircraft arriving and departing Atlanta.

The daily traffic pattern in the Atlanta Terminal Area shows two sharp peaks: one at mid-day (1100 to 1400 EST) and the other in the afternoon (1630 to 1930 EST). These 6 hours carry 70 per cent of the

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* It should be pointed out, however, that at the time these data were recorded, there were no scheduled jet operations.

day's terminal traffic and, since the traffic is mostly commercial, these peaks and consequent system overloads are largely created by airline scheduling. Simply stated, there are too many scheduled aircraft bunched in too short a period of time. With present IFR traffic demand under the present system, there would be an estimated accumulation of 104 hours of scheduled delays in a 24-hour IFR period. This is a "built-in delay", and while simple enough to state, unraveling these traffic snarls is an extremely complex problem.

With the airport operating capacity being limited and with scheduled traffic peaks at their present level, it is evident that little significant relief from the delay problem could be expected by increasing the "airborne" capacity of the present control system. Immediate relief, then, lies in attacking the problem from the other end: i. e., REALISTICALLY OVERHAUL THE ENTIRE AIRLINE SCHEDULING STRUCTURE!

The airlines themselves are well aware of this situation. "AVIATION WEEK", in its issue of May 18, 1959, in reporting a meeting of Eastern Air Lines' Advisory and Junior Board had this to say:

"George Roerig, assistant to the senior vice president, warned against over-scheduling of flights by the entire industry. He told the group that unless the airlines agreed to cooperate among themselves by limiting the volume of flights to airport acceptance rates, the Federal Aviation Agency very likely may step in and regulate schedules for the industry".

Roerig said that many airports are now bogged down by such heavy frequencies of flights that delays in landing and takeoff are inevitable. He doubted, however, that the industry would voluntarily make any cuts in the present pattern because of the keen competition between airlines".

In order to emphasize the effect of scheduling, there is assembled in Table 9, Volume II, Appendix E, a detailed tabulation and summary of calculated scheduled delays in IFR at the Atlanta Airport as of May, 1959. This table was compiled by personnel of the FAA Atlanta Air Route Traffic Control Center.

The Atlanta traffic pattern and problems were quite different from those revealed in a recent survey of the New York area. In New York, the terminal traffic is shared by 3 airports, while Atlanta has only a single major airport area. New York experienced considerable difficulty in a part of their airway configuration, mostly centered around Coyle intersection of routes Victor 1 and 16, where even through traffic was delayed at times.

Survey of the Atlanta area route structure has not shown any serious or chronic enroute trouble spots*. The few delays found outside the Atlanta terminal area were sporadic in nature and were the result of random build-ups which followed no established pattern, with the exception of occasional congestion at Chattanooga (CHA). Relief for this area is proposed and outlined in the section entitled Conclusions and Recommendations.

The sub-sections which follow describe each of the task requirements, the data sources, the method of analysis, and results for a specific task or sub-division of the project.

TASK 1 - NATURE, VOLUME, AND DISTRIBUTION OF IFR TRAFFIC ON FOUR TEST DAYS

Task 1 required determination of the nature, volume and distribution of air traffic operating on instrument flight plans under the control of the Atlanta Air Route Traffic Control Center, the Atlanta Airport Tower and the Atlanta Naval Air Station (DeKalb-Peachtree) Tower.

The data source for this task was flight progress strips. Postings were made at 167 fixes, with the indentifier and location of each fix listed in Table 1 of Appendix D, Volume II. Strips were prepared for all (34) three-letter fixes and for 133 two-letter fixes. There is a total of 288 two-letter fixes in the area; there are listed in Table 2, Appendix D, Volume II.

Total Traffic - Fix Postings

A quantitative listing of traffic in each of the 24 hour periods is shown in Table 4(A, B, C, D), Appendix D, Volume II. These tables separate the traffic by owner category (commercial, military, general aviation), list traffic at each fix, and list the number of delays. A delay shown at a fix when no posting is shown is at an intersection or little-used fix for which no strip was prepared; the delay was found through communications recordings or other strip information.

* It should be stated again, however, that scheduled jet operations had not yet started in the Atlanta area.

All traffic counts to determine route or fix density are derived from fix postings. Table B below lists the total fix postings, separated by owner category, for the four test periods:

Table B - Total Fix Postings, by Owner Category, for Four Test Periods

Owner Category	Fix Postings and Percent of Total			
	March 20-21 1000-1000 EST	March 29-30 0800-0800 EST	April 13 0001-2400 EST	May 22 0001-2400 EST
Commercial	3534 (52%)	3260 (69%)	3447 (56%)	3615 (53%)
Military	2582 (36%)	1163 (25%)	2056 (33%)	2832 (41%)
General Aviation	788 (12%)	321 (6%)	598 (11%)	418 (6%)
Total	6904	4744	6101	6865

Hourly Traffic Distribution by Fix.

Table 6 (A, B, C, D) App. D, Vol. II titled "Hourly Fix Postings" lists traffic at all used fixes by hours. Totals are shown for each fix and each hour. The heaviest-loaded fix by far is Atlanta VOR, with as many as 68 postings in an hour. Twenty-four hour totals for the busiest fixes are shown in Table C.

Table C - Traffic at Busiest Fixes, 24-hour Totals

		March 20	March 29	April 13	May 22
Atlanta	(ATL)	642	517	612	661
Birmingham	(BHM)	227	157	203	242
Chattanooga	(CHA)	236	200	242	236
Charlotte	(CLT)	273	174	231	204
Greensboro	(GSO)	210	130	213	250
Macon	(MCN)	173	120	155	184
Montgomery	(MGM)	178	120	151	210
Pulaski	(PSK)	140	89	132	145
Royston	(RYN)	150	104	110	147
Spartanburg	(SPA)	179	85	143	211
Tri-City	(TRI)	145	102	141	144
Knoxville	(TYS)	191	122	182	191

The busiest hour for the Atlanta VOR fix was hour 1800Z (1:00 to 2:00 P. M. Atlanta local time) May 22, when 68 postings were made. Of these, 8 flights were inbound to Atlanta terminal, 33 were outbound from Atlanta, 14 were overflights with altitude separation, and 13 were VFR. Since the bulk of this traffic is low altitude with little room for altitude separation, the above observations indicate that the Atlanta VOR has about reached saturation.

Flights Per Hour - Center Area and ATL Tower

Tables 7(A, B), App. D, Vol. II list flights by hour, both those controlled by the Center and by the Atlanta Tower. These are separate flights. These flights are summarized in Table D below.

Table D - Summary, Total Flights per Test Day

	March 20-21 1000-1000 EST	March 29-30 0800-0800 EST	April 13 0001-2400 EST	May 22 0001-2400 EST
Center Area	1582	1298	1424	1350
ATL Tower - inbound	227	215	206	202
ATL Tower - outbound	260	224	215	213
ATL Tower - total	487	439	421	415

Hourly Distribution of Area Traffic

Figures D-7(a, b, c, d) and D-8(a, b, c, d), App. D, Vol. II, show the distribution of all traffic by hour for each of the four test days. Figure D-7 shows total traffic and Figure D-8 shows how the traffic volume is made up: Commercial, Military and General Aviation.

There are two sharp peaks - 1100 to 1300 EST and 1700 to 1900 EST (local time), but with a relatively slight dip between. If the three hours of this dip is included with the two peaks, then 60% of the day's traffic is in these 9 hours. From a study of airline schedules, these peaks appear to be typical of year-round operation.

Figure 3, shown in the Summary and repeated on the next page for convenience, shows a typical IFR day's traffic.

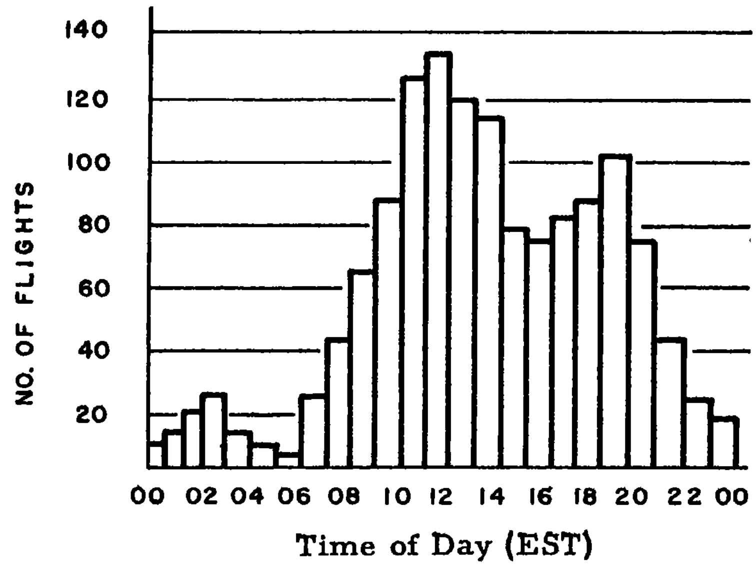


Figure 3

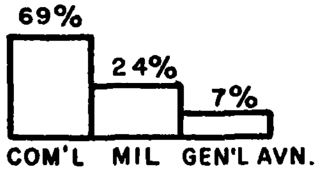
Proportionate Distribution by Owner Category

Figure D-9, Vol. II shows the traffic make-up by Commercial, Military and General Aviation for each of the four test days. The proportions are listed in Table E.

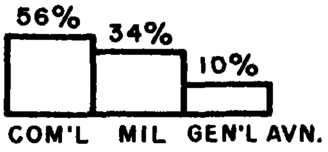
Table E - Traffic Distributions by Owner Category per Test Day

Owner Category	March 20-21 1000-1000 EST. Fri. - Sat.	March 29-30 0800-0800 EST. Sun. - Mon.	April 13 0001-2400 EST Monday	May 22 0001-2400 EST Friday
Commercial	54%	69%	56%	53%
Military	34%	24%	34%	41%
General Aviation	12%	7%	10%	6%

The traffic make-up by ownership class for a typical day is shown in Figure 4 and 5 (also repeated from the Summary).



Period includes Sunday
(March 29-30)
Figure 4



Week Day Pattern
(April 13)
Figure 5

Fix Postings by Hour and Owner Category

Table 5 (A, B, C, D), App, D, Vol. II lists fox postings by hour and owner classification - commercial, military and general aviation for each of the four test days.

Class of Traffic Distribution

Table 9, App. D, Vol. II lists flights by class-inbound to the Center Area, outbound from the Center Area, overflights (origin and distribution outside the Center Area) and local flights (origin and destination in the Center Area). The proportions shown are percent of total traffic, and remained almost constant for all test days. This distribution is shown in Table F for all four test days. The distribution for a typical day (April 13) is illustrated by Figure 11.

Table F - Traffic Distribution by Class per Test Day

Class	March 20-21 1000-1000 EST.	March 29-30 0800-0800 EST.	April 13 0001-0001 EST	May 22 0001-2400. EST
Inbound	24%	27%	26%	28%
Outbound	29%	25%	28%	28%
Over	29%	29%	29%	29%
Local	18%	19%	17%	15%

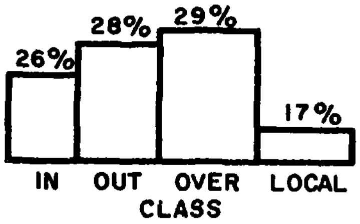
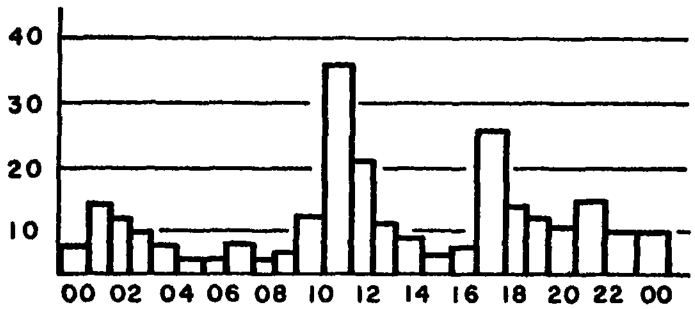


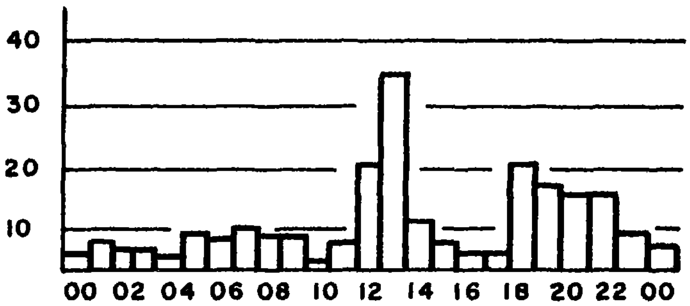
Figure 11 - Typical Distribution of Daily Traffic

Inbound and Outbound Hourly Distribution - Four ATL Terminal Airports.

The hourly distribution of inbound and outbound IFR traffic at the four terminal airports - Atlanta, Dobbins AFB, DeKalb Peachtree and Fulton County, is shown in Table 8 (A, B, C, D) of Vol. II. Figures 12 (a, b) show the inbound and outbound pattern for a typical day. The outbound peaks are nearly always an hour later than the inbounds.



Time of Day (EST)
(a) - Inbounds



Time of Day (EST)
(b) - Outbounds

Figure 12 - Hourly Distribution of Traffic Atlanta Terminal Airports

Punch Card Information

Punch card listings for the four IFR test days are bound in Volume III. These listings are shown by (1) Flight orientation, (2) Fix orientation, and (3) Route of flight. The card format and coding are shown in the first pages of each part of Volume III.

TASK 2 - NUMBER AND DISTRIBUTIONS OF DELAYS IN IFR

This task required determination of the number, distribution and nature of the air traffic delays to airborne aircraft in the Atlanta Air Route Traffic Control Area in IFR. "Departure" delays to aircraft at the Atlanta NAS, Dobbins AFB and the Atlanta and Fulton County Airports were also determined where the "proposed" take-off time for these aircraft was available. "Departure" delay is defined as the time interval between the "proposed" take-off time and the "actual" take-off time. Delays were examined in sufficient detail to permit an identification of the factors and the characteristics of the delay created, and the duration and frequency of the delays related to the events that caused them. Data sources for this task were flight strips and communications recordings. The delays found in Task 2 were considered under the following three categories:

(a) Enroute delays -- flights not destined for an Atlanta area airport.

(b) Inbound delays -- flights destined for airports in the Atlanta area.

(c) Departure (ground) delays.

The four IFR days surveyed showed similar characteristics in the matter of number and magnitude of delays. The busiest of the test days showed the following distribution of delays:

	No. of Delays	Accumulated Time
Enroute (overflights)	45	9 hours
Inbound	137	31 hours
Departure (ground)	128	12 hours

Of the airborne delays (enroute and inbound) 76% were air flights inbound to Atlanta airport .

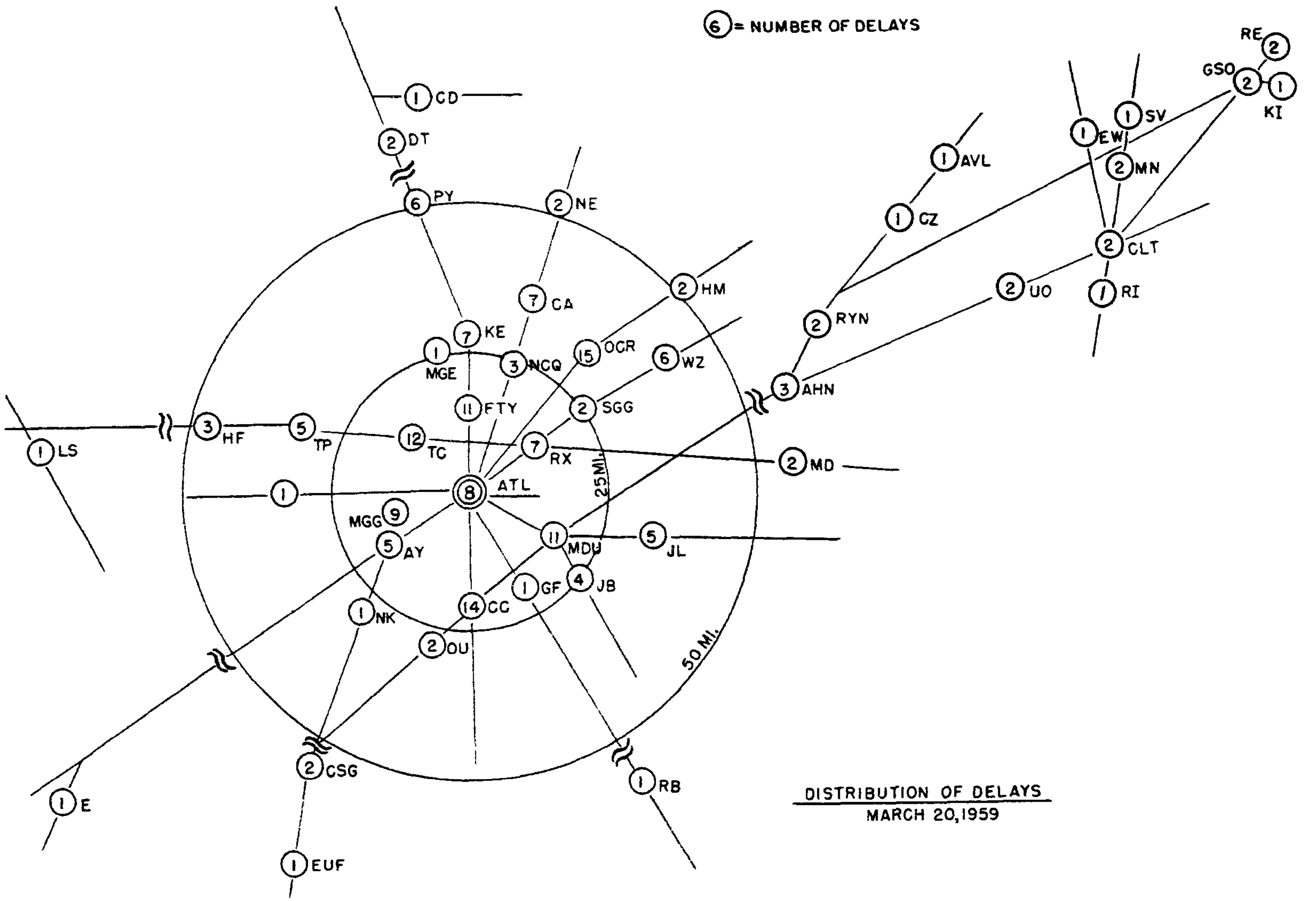
The Tables below, found in Volume II, Appendix E list delay details as shown:

Table 1(A, B, C, D) -	Delays listed by fix.
Table 2(A, B, C, D) -	Occurances of 5 delays or more listed by fix, hour and owner category -- Commercial, Military, General Aviation
Table 3(A, B, C, D) -	Minutes of listed by hour and fix.
Table 4(A, B) -	Total number and minutes of enroute delays per hour, Atlanta ARTCC.
Table 5(A, B, C, D) -	Total number of delays to aircraft inbound to the Atlanta terminal airports.
Table 6(A, B, C, D) -	Departure delays, Atlanta, Dobbins AFB and Fulton County airports.
Table 7 -	Total number and minutes of ground delays per hour at Atlanta terminal airports.
Table 9 -	Tabultation of scheduled operations and delays.

Figures 13 a, b, c, d, illustrate the distribution of delays for each of the IFR test days.

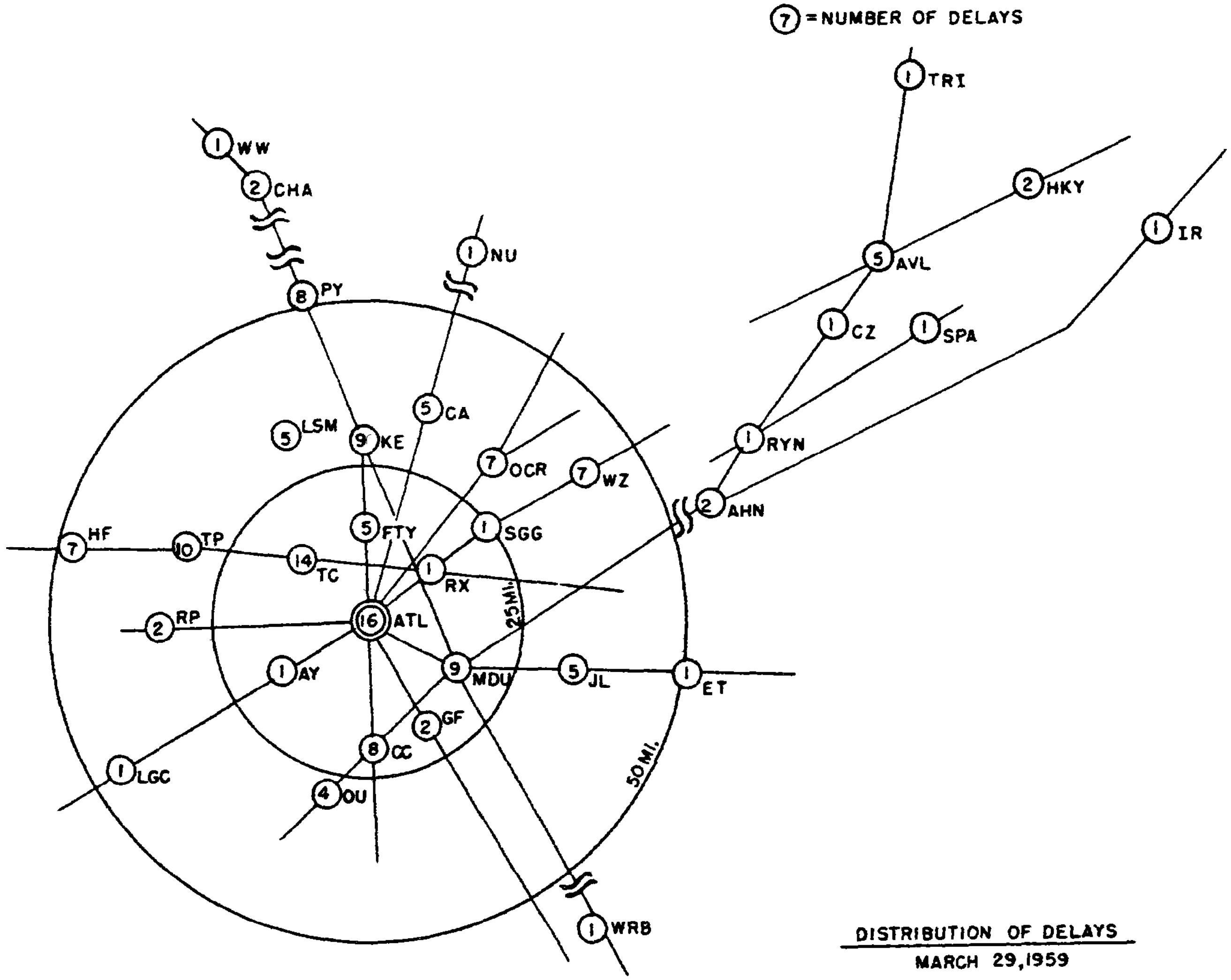
TASK 3 - NUMBER OF FLIGHTS CANCELLED OR DIVERTED BECAUSE OF DELAYS IN IFR

Task 3 was intended to include the following requirements. Determine the number of flights cancelled or diverted because of actual or forecast delays in the Atlanta Air Route Traffic Control Area. The tabulation of flight cancellations will include the type of aircraft, ownership category, proposed time of take-off, proposed departure airport and destination. Flights cancelled in the Atlanta Area, or elsewhere, as a result of equipment shortage clearly caused by actual or forecast delays



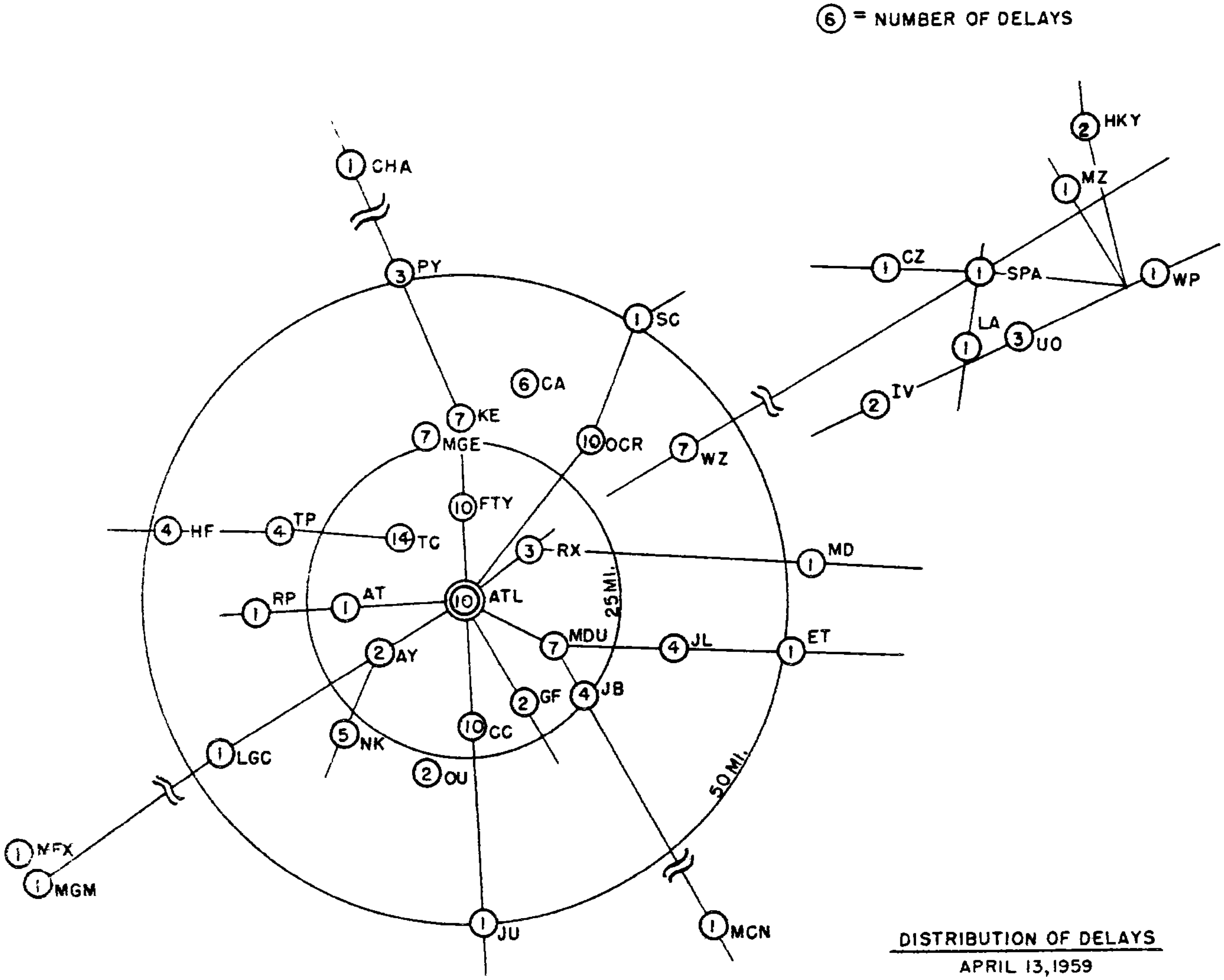
6 = NUMBER OF DELAYS
DISTRIBUTION OF DELAYS
MARCH 20,1959
25 MI.
50 MI.
ATL
PY
DT
CD
NE
CA
KE
MGE
NCQ
FTY
OCR
HM
WZ
SGG
RX
TC
TP
HF
LS
MD
MGG
AY
MDU
JL
JB
GF
CC
NK
OU
CSG
EUF
E
RB
AHN
RYN
CZ
AVL
UO
CLT
RI
EW
SV
MN
GSO
RE
KI

Figure 13a



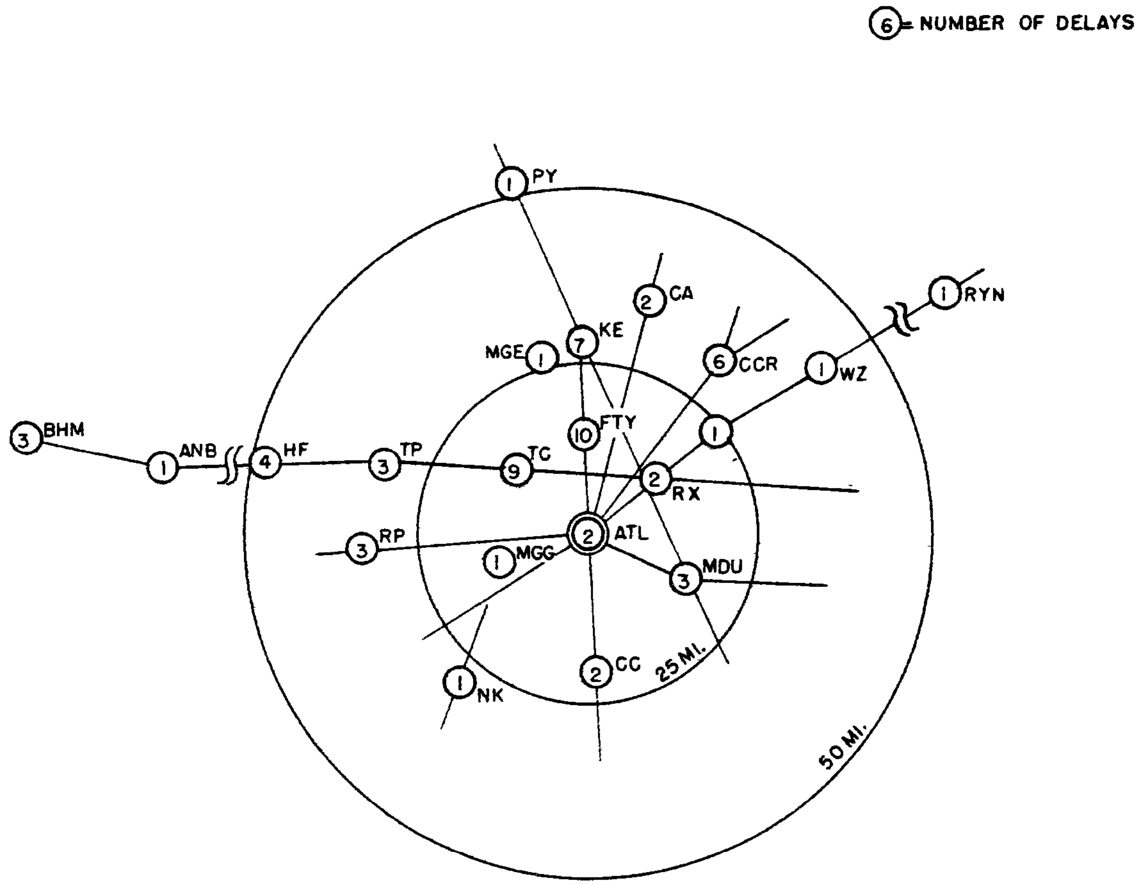
7 = NUMBER OF DELAYS
1 TRI
1 WW
2 CHA
2 HKY
1 IR
1 NU
5 AVL
8 PY
1 CZ
1 SPA
5 CA
5 LSM
9 KE
1 RYN
7 OCR
7 WZ
2 AHN
5 FTY
1 SGG
7 HF
10 TP
14 TC
1 RX
25 MI.
2 RP
16 ATL
1 AY
9 MDU
5 JL
1 ET
2 GF
8 CC
50 MI.
1 LGC
4 OU
1 WRB
DISTRIBUTION OF DELAYS
MARCH 29, 1959

Figure 13b



DISTRIBUTION OF DELAYS
APRIL 13, 1959

Figure 13c



DISTRIBUTION OF DELAYS
MAY 22, 1959

Figure 13d

in the Atlanta Area will be included. The tabulation of flight diversions shall include the type of aircraft and ownership category, airport and time of departure, aircraft position and time when flight was diverted and time and airport at which flight landed. For each cancelled or diverted flight, the initiating and subsequent events leading to the cancellation or diversion was established.

The data sources for this task were the airline companies' records. Five major operators in the Atlanta Area were solicited for information: Eastern, Delta, American, Northwest-Orient and Southern. Two responded -- Eastern and Southern -- with the information that no diversions or cancellations on the days in question were made because of delays in the area.

TASK 4 - RADAR SCOPE PHOTOGRAPHY

A 16 mm movie camera and associated mount-hood-timer-clock assembly was fabricated and installed on the repeater scope of the Atlanta Tower's ASR-3 radar receiver, using a photographic rate of 2 frames per minute. Radar scope photography was conducted during all forecasted IFR weather conditions, using a 50-mile range. A similar type 16 mm camera installation was fabricated and mounted on the Center's ARSR-1 repeater scope. However, no useful data were recorded since the ARSR-1 at the time was in a continuous state of "de-bugging" and operational acceptance tests. Appendix I-B of this Volume presents a description of the data recording and data analysis techniques used in this program.

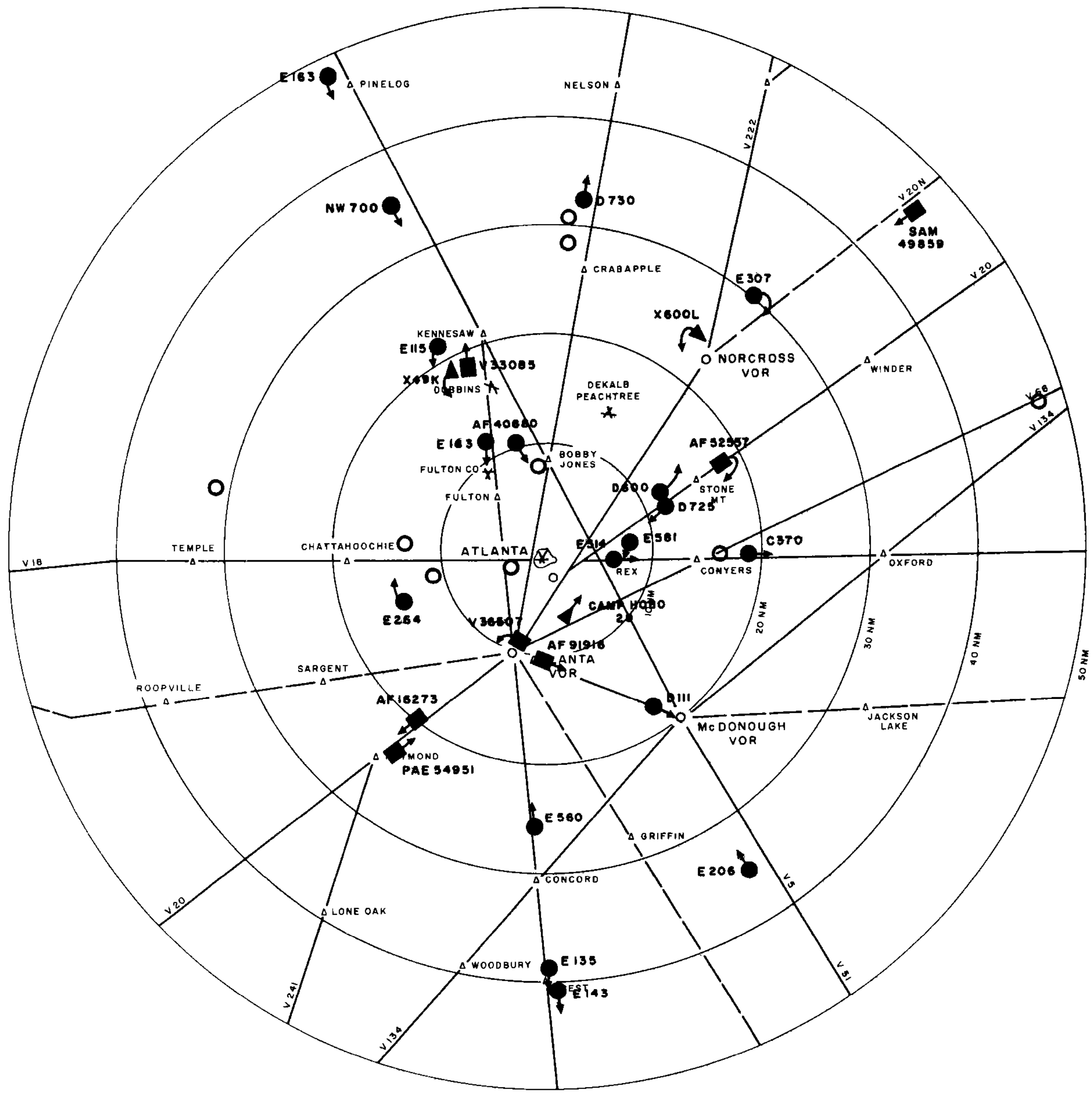
The ASR-3 radar camera data were analyzed to prepare, per contractual requirements:

a. A 16 mm motion picture film strip showing the traffic movement during the 2 peak hours of each of the four "test" days. Through the use of multiple printing of the radar scope photographs, the film strip shows air traffic movements at a rate whereby one second of viewing time represents one minute of actual flight time; i.e., a 60-to-1 speed up. This prescribed film strip was prepared and delivered to FAA.

b. Pictorial displays showing the instantaneous position of all aircraft once an hour for one (1) of the 4 IFR test days;

March 20-21, 1959. During the heaviest one (1) hour period, (1630-1730Z) displays were prepared for the intervening five (5) minute intervals also, with ownership category of each aircraft indicated by appropriate identifying symbol. These displays are shown in Volume II as Figures A-2 through A-37. For convenient reference, Figure 14 of this volume shows one of these radar plots. The maximum instantaneous count of a/c under control in the 50-mile radius was 31, at 1800Z. The next highest count was 30, at 2300Z.

c. In the case of the IFR traffic a tabulation to show, by ownership category, the actual location of an aircraft relative to a given "fix" at the time it reports being over that fix. The tabulation was supplemented by graphical displays of the distribution of the deviations found. This was done for 6 representative fixes, with a maximum of 50 aircraft per fix. Figures 15a, 15b show the gross "picture" of these deviations for the six fixes selected; Concord (CC), Fulton (FU), Kenesaw (KE), McDonough (MDU), Norcross (OCR), and Rex (RX).
Table G summarizes the analysis of the deviations according to fix; type of fix; mean of deviation (i.e., "center of gravity") per early or late, left or right (according to direction) including their maxima; and the early-late and left-right standard deviations about these means. Although Figure 15 shows a rather wide scatter of aircraft positions about their respective fixes, statistically speaking the means of these deviations are relatively small; the largest was 1.76 miles late at McDonough, a VOR station. The largest standard deviation was 3.87 miles late at Concord, a VOR intersection. Considering the size of the samples and the inaccuracies in aircraft clocks together with their synchronization with tower and center clocks, insignificant differences were found between the two types of close-in fixes analyzed (VOR stations and VOR intersections), between ranges of altitude, and between ownership categories (commercial, military, and general aviation). It should be pointed out that pilot and/or controller clock reading errors when reporting and recording to the nearest minute usually result in errors of one minute or more; and at an average ground



CODE

- IFR COMMERCIAL A/C
- IFR MILITARY A/C
- IFR GEN'L AVIATION A/C
- VFR OR UNCORRELATED TRAFFIC

Figure 14 Instantaneous Locations of Aircraft in the Atlanta Area, 1800 Z

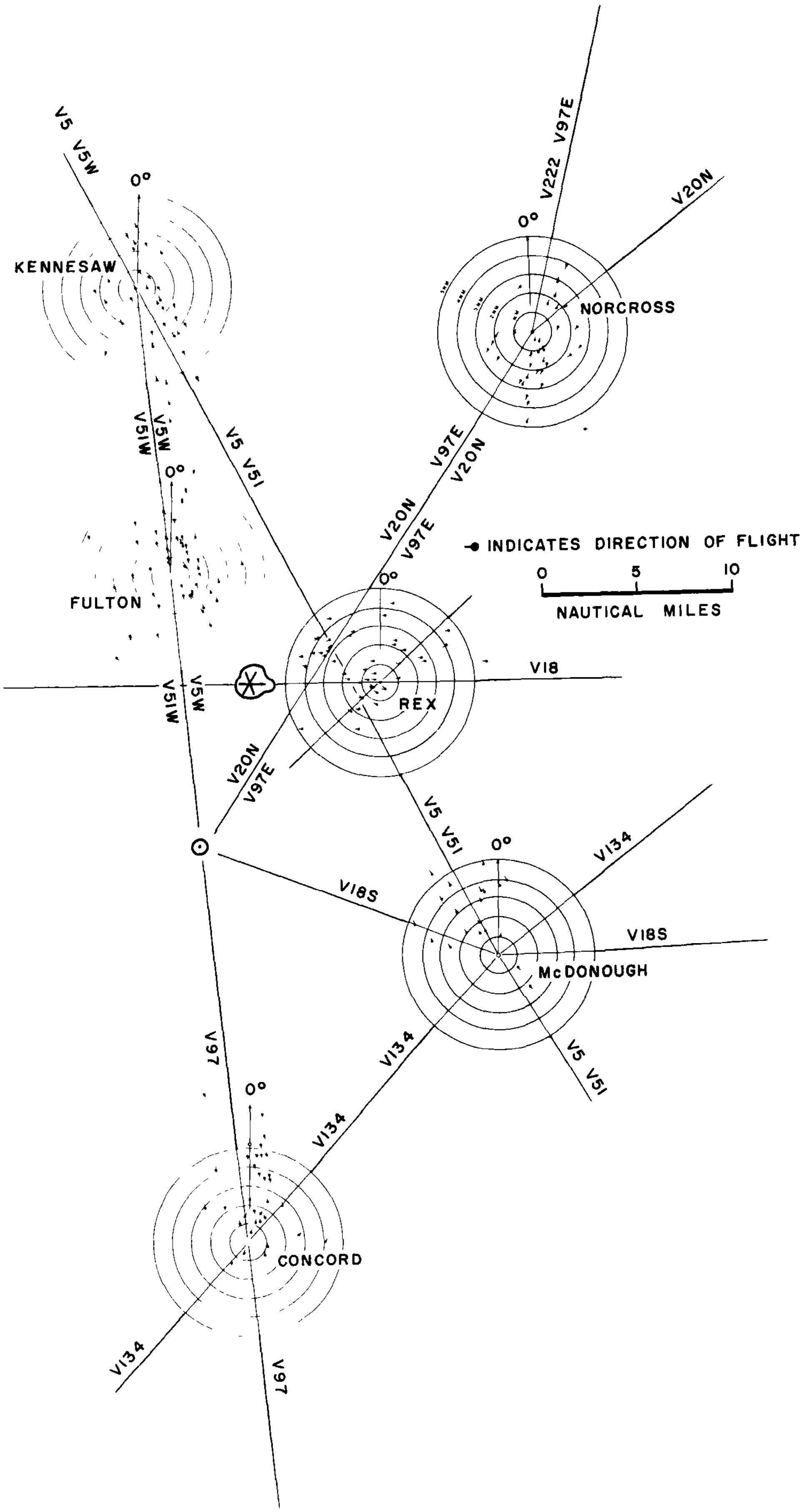


Figure 15 (a) Distributions of Deviations About Fixes (Commercial Aircraft)

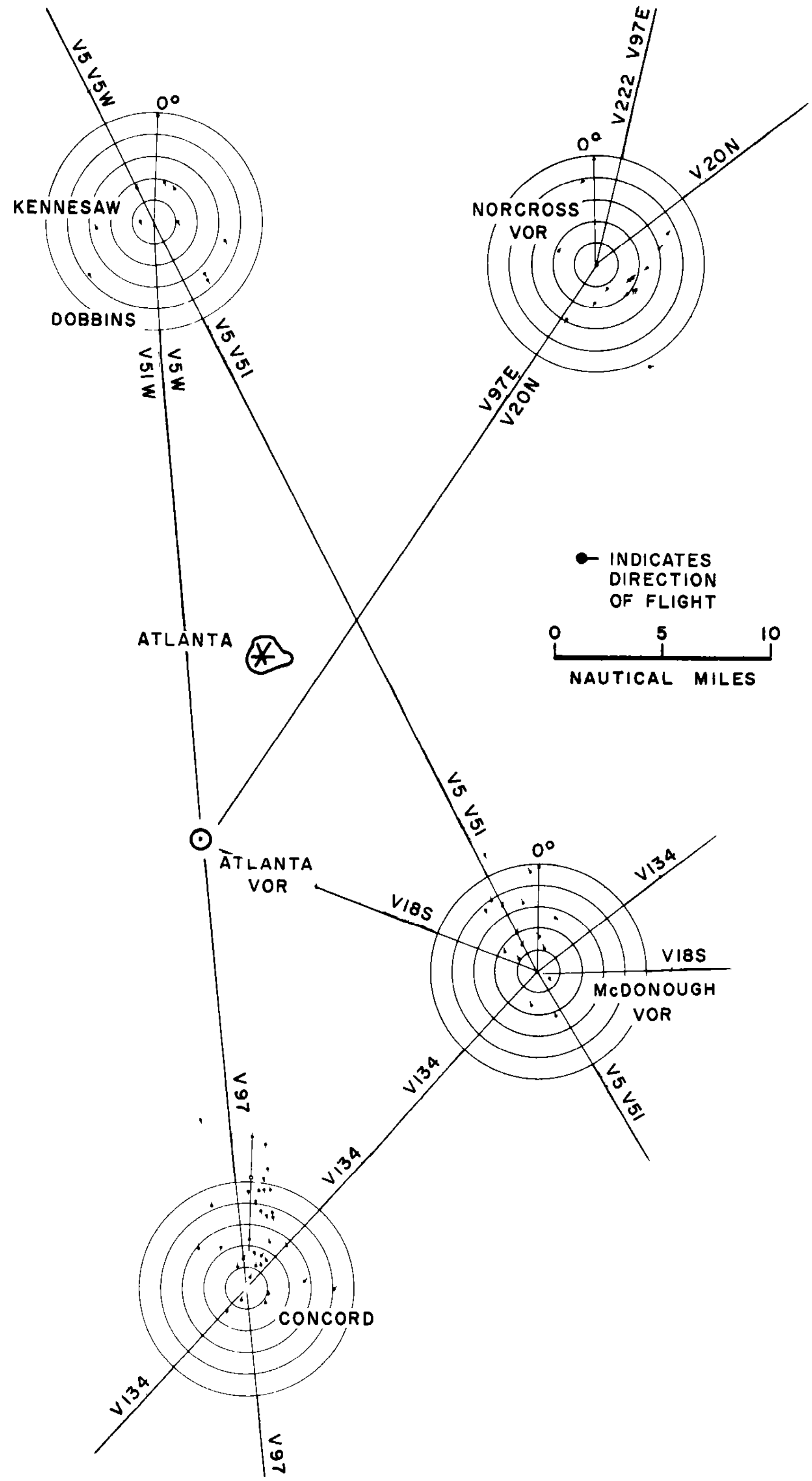


Figure 15 (b) Distributions of Deviations About Fixes (Military and General Aviation)

Fix	Type of Fix	Sample Size	Mean of Deviation-Miles				Standard Deviation*-Miles	
			Early	Late	Left	Right	Early-Late	Left-Right
Concord	VOR Inters.	48	- - - (7.75 max)	0.24 (9.75 max)	0.15 (5.00 max)	- - - (3.00 max)	3.87	1.41
Fulton	VOR Inters.	47	0.69 (5.50 max)	- - - (4.25 max)	- - - (1.75 max)	0.54 (4.00 max)	1.98	1.48
Kenesaw	VOR Inters.	47	- - - (7.00 max)	0.26 (4.00 max)	0.03 (2.50 max)	- - - (3.75 max)	2.57	1.36
Rex	VOR Inters.	50	0.32 (5.50 max)	- - - (4.50 max)	0.04 (1.50 max)	- - - (1.25 max)	1.86	0.68
McDonough	VOR Station	40	- - - (10.50 max)	1.76 (8.50 max)	- - - (3.00 max)	0.08 (2.25 max)	3.14	1.08
Norcross	VOR Station	49	- - - (4.25 max)	0.33 (3.50 max)	0.25 (2.25 max)	- - - (3.50 max)	1.79	1.39

*NOTE: The standard deviations are shown for convenient reference only; the distributions are not necessarily normal.

TABLE G

Summary of Aircraft Position Reporting Deviations speed of 240 MPH, this can result in at least 4 miles error.

TASK 5 - FLIGHT PROGRESS STRIPS PREPARED FOR EACH AIRCRAFT IN IFR

Task 5 included determination of the number of flight strips that are prepared for each aircraft during the period that it is under control of the Atlanta Air Route Traffic Control Center. A tabulation was made showing the number of strips required for each flight route flown, including:

(a) Flights between two (2) points within the Atlanta ARTC Area. (Local)

(b) Flights originating outside the area and terminating within the Atlanta ARTC Area. (In)

(c) Flights originating within the Atlanta Area and terminating outside the ARTC Area. (Out)

The data for this task were taken from flight strips after the strips were sorted into flight orientation. The strips were counted for each flight route flown under jurisdiction of the Atlanta ARTC Center. While no format was ordered, it was deemed desirable to place the information on punch cards in order ot facilitate future tabulating or sorting. The cards, together with the format and coding, are included with the route-of-flight cards. Table 1, App. F, Vol. II, is a complete listing of flight strips prepared.

The listing shows owner category (commercial, military, general aviation) traffic class ("in", "out", "over", and "local") and the number of strips prepared for each route. The average number of strips prepared per flight for each traffic class is shown in the summary below:

Traffic Class	Average Number of Strips Prepared per Flight
Inbound - to ATL area	4
Outbound - from ATL area	4
Overflight	5
Local - flight within the area	4

TASK 6 - AIRCRAFT SURFACE MOVEMENTS AT ATLANTA AIRPORT FOR 4 TEST DAYS

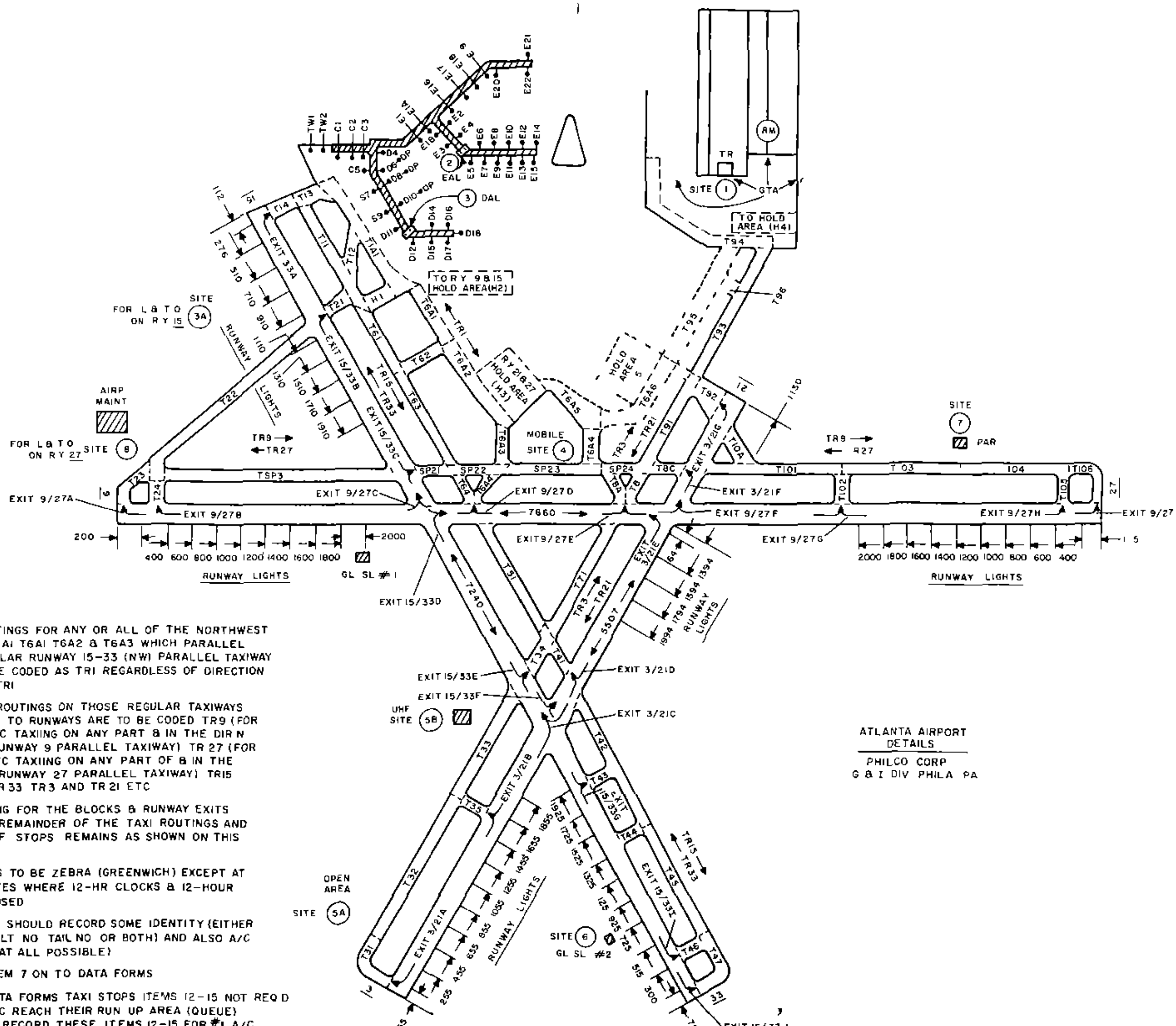
This task requires a "fine grain" determination of the nature, volume, and distribution of aircraft movements on the surface of the Atlanta Airport. Ground observations were made throughout an 8 to 8 1/2 hour period (approx. 1130 or 1200 to 2000 EST) on the four clear VFR days. A map layout (see Fig. 16) was prepared to identify all gates, parking, and run-up areas, intersections, taxi-ways, and ramp areas. Ground observers located at key positions identified each aircraft operation, and timed and recorded all of its movements to the nearest second.

Typical of the data observed and recorded for landings and take-offs were: aircraft identity and type, runway and taxi routes used, touch-down time and distance, time of, and runway exits and entrances used, runway threshold times, place and time of taxi stops and starts and their reasons, runway and gate arrival-departure occupancy times, enroute, clearance times, etc. Appendix I-C describes the data recording techniques.

Gross Operations, Schedules and Delays

Fig. (17) shows the actual count of landing and take-off operations for the 4 test days by 1/2 - hour periods. The highest number of take-offs in an hourly period was 52 (7 April 1959) during the period 1730-1830 Z, 1230-1330 EST; and the highest number of landings per hour was 43 (17 May 1959) during 1630-1730Z. The largest recorded hourly combined landing and take-off rate of 65 operations occurred on 7 April 1959 between 1700-1800Z. However, on other than the 4 "survey" days, 67, 72, and 58 combined landings and take-offs were recorded for a 3 consecutive hourly period during VFR. The number of "taxis and tows" was negligible, with a maximum of 24 during the busiest 8-1/2 hour "day", and a peak 1/2 hourly rate of 4 during 1800-1830Z.

According to airline timetables for the 4 test days, there are 65 operations (25 landings and 40 take-offs) scheduled during a 60-minute period starting around noon; and during the 1/2-hourly period starting around noon 37 operations are scheduled, 21 landings and 16 take-offs. On the average, and even during peak hours, other-than-scheduled airline operations amount to about another 35%; mostly general aviation. This also held true on the one Sunday surveyed, 17 May 1959. If, therefore, another 35% is added to the 1-hour peak airline "demand" of 65 operations, the resulting total hourly demand is 88. Similarly, if 35% is added to the 1/2-hour



NOTES

1. TAXI ROUTINGS FOR ANY OR ALL OF THE NORTHWEST BLOCKS T1A1 T6A1 T6A2 & T6A3 WHICH PARALLEL THE REGULAR RUNWAY 15-33 (NW) PARALLEL TAXIWAY ARE TO BE CODED AS TR1 REGARDLESS OF DIRECTION ON THIS TR1
2. TAXIWAY ROUTINGS ON THOSE REGULAR TAXIWAYS PARALLEL TO RUNWAYS ARE TO BE CODED TR9 (FOR THOSE A/C TAXIING ON ANY PART & IN THE DIR N OF THE RUNWAY 9 PARALLEL TAXIWAY) TR 27 (FOR THOSE A/C TAXIING ON ANY PART OF & IN THE DIR N OF RUNWAY 27 PARALLEL TAXIWAY) TR15 (DITTO) TR33 TR3 AND TR 21 ETC
3. THE CODING FOR THE BLOCKS & RUNWAY EXITS FOR THE REMAINDER OF THE TAXI ROUTINGS AND PLACES OF STOPS REMAINS AS SHOWN ON THIS MAP
4. ALL TIMES TO BE ZEBRA (GREENWICH) EXCEPT AT THOSE SITES WHERE 12-HR CLOCKS & 12-HOUR E S T IS USED
5. ALL SITES SHOULD RECORD SOME IDENTITY (EITHER AIRLINE FLT NO TAIL NO OR BOTH) AND ALSO A/C TYPE (IF AT ALL POSSIBLE)
6. ELIMIN ITEM 7 ON TO DATA FORMS
7. ON TO DATA FORMS TAXI STOPS ITEMS 12-15 NOT REQ D AFTER A/C REACH THEIR RUN UP AREA (QUEUE) HOWEVER RECORD THESE ITEMS 12-15 FOR #1 A/C READY TO T O OR #2 #3 ETC READY TO TO BUT HELD UP BY #1 NOT HAVING CLEARANCE OR NOT READY ETC

Figure 16

LANDING & TAKE-OFF TOTAL TRAFFIC-ATLANTA AIRPORT

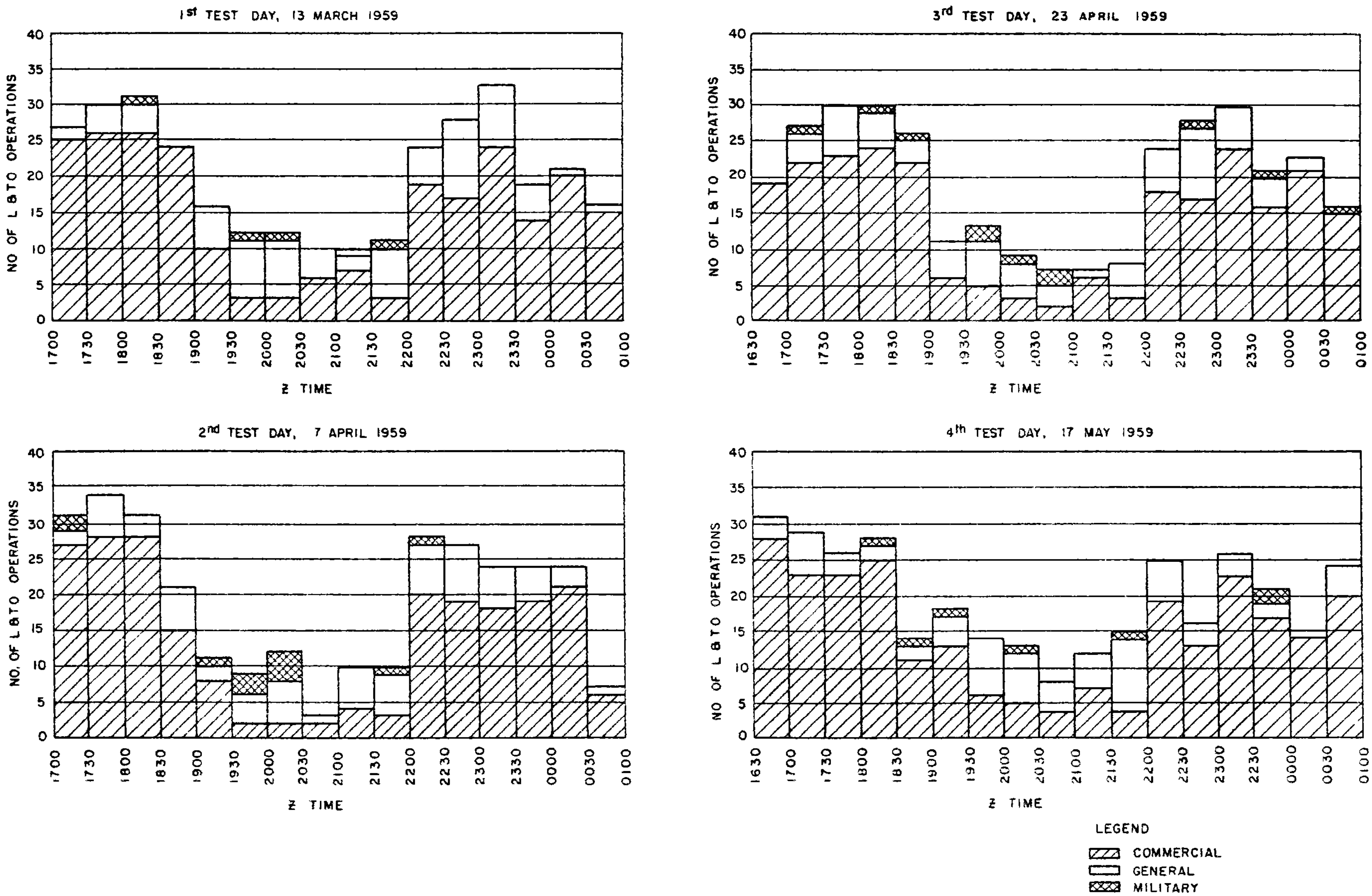


Figure 17

scheduled demand of 37, the total is 50, or 100 per hour for 1/2 hour.

As a typical example, Fig. 18 shows the total number of landings plus take-offs recorded at Atlanta on 17 May 1959 from 1630 to 0100Z time for each 1/2 hour, together with the actual count of scheduled airling operations, other than airline scheduled operations, and the scheduled number of operations (per timetables) plus 35%. Note the fast build up of "scheduled" (or "desired") demand, including the additional 35%, as compared with the actual operations rate at 1630Z (1130 EST) and at 2200 Z (1700 EST). The obvious conclusion is that many aircraft in the sudden "shockwave" demand don't get to land or take-off until subsequent time periods when the demand gets below the actual operating capacity.

Since our 4 "survey" days, 2 of the busier airlines have made a few minor "smoothing" changes in their schedules during the noon peak. Table H below shows a gross 1/2-hourly comparison between the total airline schedules of 17 May 1959 and 1 September 1959.

Table H - Airline Scheduling: 17 May 1959 vs 1 September 1959

1/2 hour period	17 May 1959			1 September 1959		
Z time	In	Out	Total	In	Out	Total
1630-1659	25	4	29	21	4	25
1700-1729 (noon EST)	18	16	34	16	17	33
1730-1759	3	24	27	5	24	29
1800-1829	4	13	17	3	12	15
1830-1859	1	7	8	1	8	9

No records were required of delays in VFR other than the apparent (not hidden) airport surface delays. However, based on transient delay theories developed and validated in several CAA Technical Development Reports*, Figure 19 shows the expected average delays in VFR for sustained

*1. CAA TDR #222, Analytical and Simulation Studies of Several Radar Vectoring Procedures in the Wash., DC Term. Area, by S. M. Berkowitz and R. R. Doering, Apr. 1954.

2. CAA TDR #251, Analytical and Simulation Studies of ATC, by S. M. Berkowitz and E. L. Fritz, May 1955.

3. CAA TDR #297, Summary of Joint FIL-TDC Simulation Activities in ATC, by S. M. Berkowitz, E. L. Fritz, and R. S. Miller, March 1957.

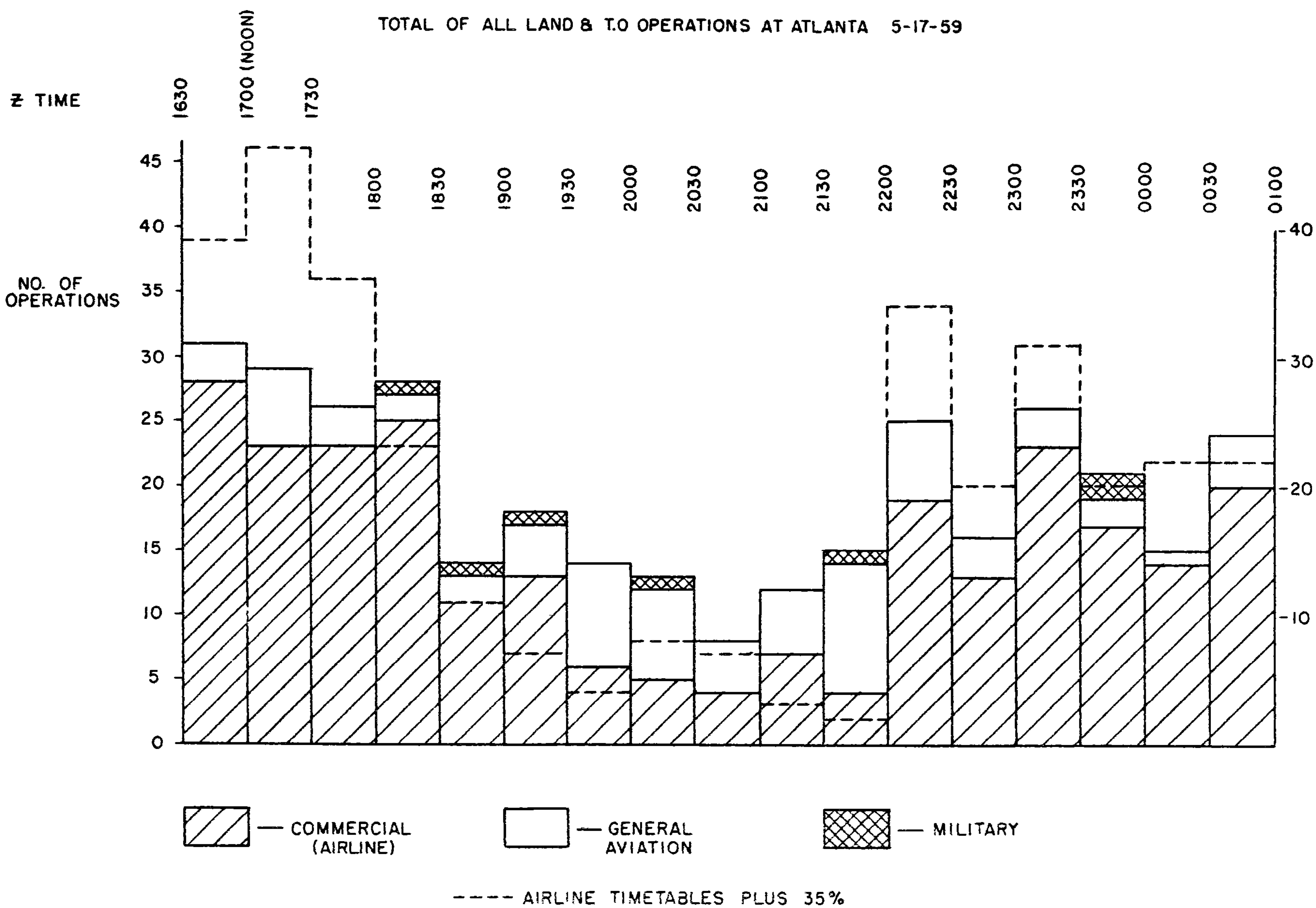
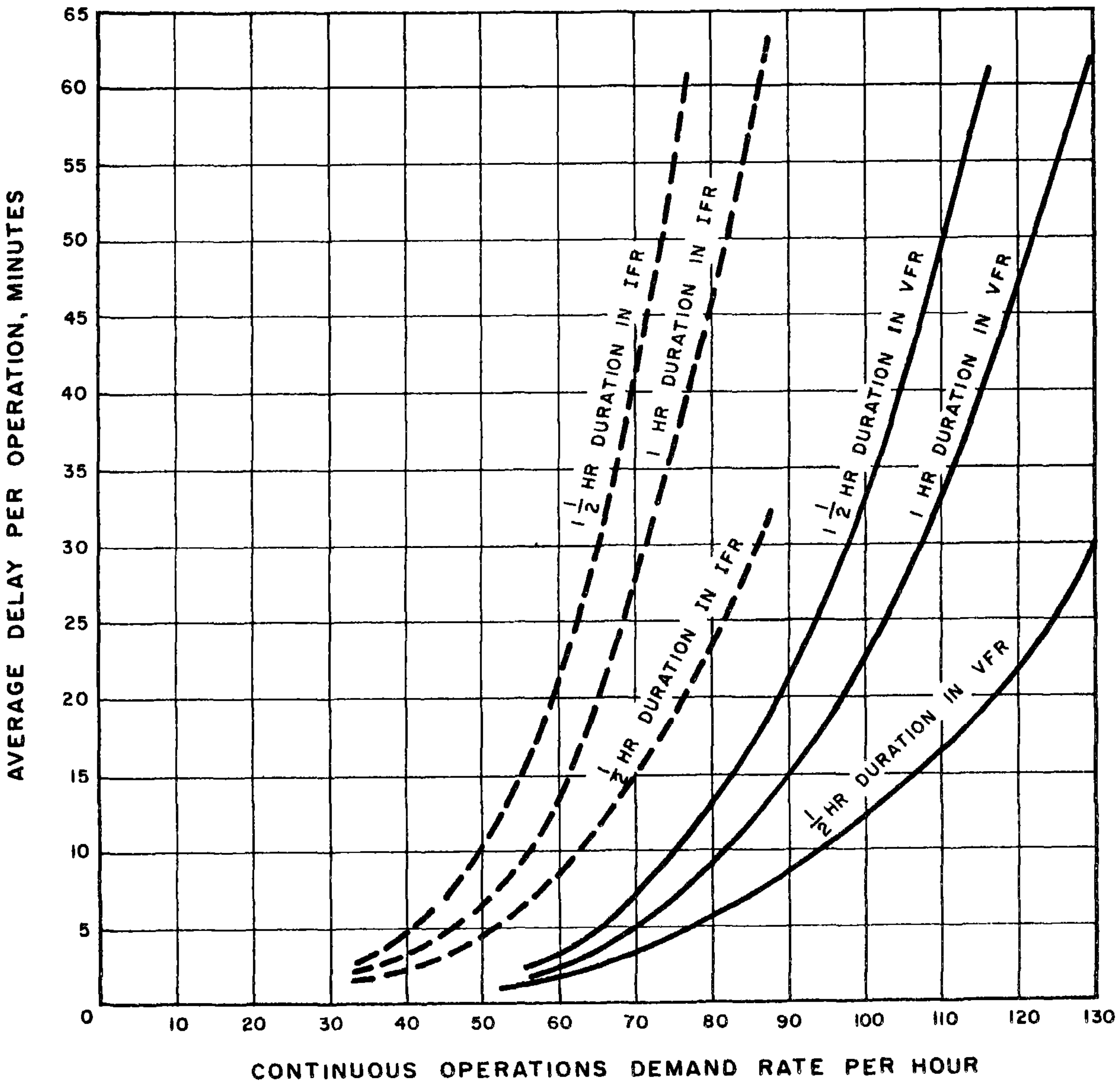

TOTAL OF ALL LAND & T.O OPERATIONS AT ATLANTA 5-17-59
Z TIME
NO. OF OPERATIONS
1630
1700 (NOON)
1730
1800
1830
1900
1930
2000
2030
2100
2130
2200
2230
2300
2330
0000
0030
0100
COMMERCIAL (AIRLINE)
GENERAL AVIATION
MILITARY
AIRLINE TIMETABLES PLUS 35%

Figure 18

NOTE. ASSUMED IFR OPERATING CAPACITY = 44 OPERATIONS / HOUR
ASSUMED VFR OPERATING CAPACITY = 66 OPERATIONS / HOUR



Theoretical Average Delays as a Function of
Demand Rate and Duration in IFR and VFR

Figure 19

1/2-hour, 1-hour, and 1 1/2-hourly periods as a function of continious demand rate, assuming a VFR capacity of 66 mixed operations per hour. Note that for a peak 1/2-hour VFR period with a continuous average demand rate of 100 per hour, the expected average delay to all aircraft in this 1/2-hourly period is about 12 minutes, a total of 600 minutes (10 hours) for the 50 aircraft; and if this 100/hr. demand rate persisted for one full hour the average delay for all 100 aircraft would increase to about 22 minutes, a total of 2200 minutes (almost 37 hours). For the 88 per-hour hourly demand rate the average delay to all aircraft is seen to be about 13 minutes, 1144 minutes total for the 88 operations.

The peak of the Atlanta Airport and Terminal Area is approximately 42 to 44 mixed operations per hour, using 2 intersecting runways; runway 9 for landings and runway 15 for take-offs. Analysis shows that during IFR, other-than-scheduled operations amount to about another 10% of scheduled operations. For the peak 1/2-hourly airline demand rate of 37 operations, the total 1/2-hourly rate of all traffic is then 41; a rate of 82 per hour. For the peak 1-hour airline damand rate of 65 operations, the total hourly demand rate works out to be about 72 per hour. Figure 19 also shows the theoretical average delays as a function of continuous demand rate, assuming an IFR capacity of 44 mixed operations per hour. Note that for the 1/2-hourly continuous demand rate of 82 operations per hour, the average delay for the 41 aircraft in the 1/2-hourly period would be about 24 minutes. Similarly for the 1-hour sustained rate of 72 per hour in IFR, the average delay to these 72 operations would be about 30 minutes, a cumulative total of 36 hours delay just for this 1-hour peak period alone.

As a matter of further interest, a cursory comparison was made between airline timetable scheduled times and the actual recorded landing and take-off times for only those airline aircraft scheduled during the 1200-1400 (EST) peak. To be somewhat realistic, 4 minutes were added to the arrive or depart times shown on the airline timetables; i.e., those scheduled aircraft whose actual touchdown or take-off roll times were later than their published arrive or depart times by more than 4 minutes are shown as "late" in the table on the next page. The average number of minutes late shown in Table I are the averages for these "late" aircraft only.

Table I - Summary of Late Arrivals and Take-Offs, Per Test Day

Noon to 2 PM Date	Landings				Take-Offs				Total L & T.O.		
	No. Sched.	No. Late	Ave. Mins. Late	Max. Mins.	No. Sched.	No. Late	Ave.. Mins. . Late	Max. Mins.	No. Sched.	No. Late	Ave. Mins. Late
3-13-59	28	13	9-3/4	22	60	19	18-1/2	64	88	32	15
4-7-59	28	9	11-1/2	23	60	20	12-1/4	44	88	29	12
4-23-59	28	11	12	34	60	21	10-3/4	23	88	32	11-1/4
5-17-59	26	8	6	12	60	17	10	50	86	10	9

Landing Aircraft*

The mean runway exit distance for 652 landing aircraft of all 4 days on the 3 major runways 9, 27, and 33 was 4,367 feet. The mean runway occupancy time (threshold to exit time) was about 47 seconds. Figure 20 shows a graphical-numerical summary of the 3 runway exit and time distributions for all landing aircraft. It should be noted that during the 4 test "days" surveyed the weather was clear and the runways "dry".

All aircraft were classified by performance class as follows:

Group I - Viscount, DC-6, DC-7, Constellation, Electra
Group II - Martin, Convair, DC-4
Group III - DC-3, and C-46
Group IV - Others, light civil aircraft, such as Twin Beech, Cessna, Apache, Aero Commander, Bonanza, Pipers, etc.

The mean runway exit distances and runway occupancy times for each performance class for the 3 runways are shown in Table J.

---

* Standard deviations as stated here and in subsequent text and tables in this Volume I and also in Volume II, are shown merely for convenient reference. In practically all cases, the distributions were skewed rather than normal.

RUNWAY 33 →
MEAN EXIT DIST = 4317'
MEAN OCCUP TIME = 47.7 SECS

	0'	340'	1390'	1890'	2480'	2880'	4420'	4780'	6190'	7240'	
NO OF A/C USING EXIT	0	0	0	5	7	13	29	10	20	1	(TOTAL = 85)
% OF TOTAL	0	0	0	5 9	8.2	15 3	34 1	11 8	23 5	1 2	
ACCUM %	0	0	0	5 9	14 1	29 4	63 5	75 3	98 8	100	
AVG RUN'Y OCCUP TIME, SECS	–	–	–	43	33	33	48	50	61	68	

RUNWAY 9 →
MEAN EXIT DIST = 4504 FEET
MEAN OCCUP TIME = 49 0 SECS

	0'	360'	2510'	2920'	4110'	4460'	5760'	7560'	7860'	
NO. OF A/C USING EXIT	0	0	0	30	104	41	50	8	2	(TOTAL = 235)
% OF TOTAL	0	0	0	12 8	44 2	17 4	21.3	3 4	0 9	
ACCUM %	0	0	0	12 8	57 0	74 4	95 7	99 1	100	
AVG RUN'Y OCCUP TIME, SECS	–	–	–	39	48	41	61	73	71	

← **RUNWAY 27**
MEAN EXIT DIST = 4268 FEET
MEAN OCCUP TIME = 46 0 SECS

	7860'	7500'	5350'	4940'	3750'	3400'	2110'	300'	0'	
(TOTAL = 332)	0	10	8	176	80	31	27	0	0	NO OF A/C USING EXIT
	0	3 1	2 4	53 0	24 1	9 3	8 1	0	0	% OF TOTAL
	100	100	96 9	94 5	41 5	17 4	8 1	0	0	ACCUM %
	–	72	49	50	40	44	32	–	–	AVG RUN'Y OCCUP TIME, SECS

Figure 20 Runway Exit and Time Distributions for All Landing A/C (Total of 4 Test Days)

Table J - Runway Exit Distances and Occupancy Times by Performance Class

Perf. Class	% of total	Mean Exit Dist-Ft.	Mean Occup. Time-Secs.
Group I	46	4740	50.8
Group II	22	4370	44.0
Group III	9	3950	45.3
Group IV	23	3460	45.6
All Groups Combined	100	4367	47.3

There were no large significant differences between runways used. The average touchdown point recorded for 645 aircraft landing on runways 9, 27, and 33 combined was 1217 feet (with a standard deviation of 536 feet*), and the average threshold-to-touchdown time was 9.2 seconds (with a standard deviation of 4.3 seconds*). The breakdown according to performance class is shown in Table K:

Table K -Average Touchdown, Distances and Threshold-to-Touchdown Times by Performance Class

Perf. Class	% of total	Touchdown Dist. Feet		Threshold to TD Time - Seconds	
		Mean	Std. Dev.	Mean	Std. Dev.
Group I	46	1191	538	7.7	2.9
Group II	22	1191	450	8.4	3.3
Group III	9	1274	542	10.7	4.8
Group IV	23	1267	591	12.2	5.5
All Groups	100	1217	536	9.2	4.3

The mean undelayed taxi times from runway exit to arrive at loading gate for all commercial aircraft is shown in Table L.

Table L - Undelayed Taxi Times, Exit to Gate, Commercial A/C

Exiting From Runway	No. of Aircraft	Mean Time Seconds	Std. Dev. Secs.
9	170	215	78
27	229	165	54
33	60	168	72

Table M is a summary of the average intervals (during peak traffic only) between successive landings which are and are not interspersed by another operation from that runway or another runway.

Table M Mean Time Intervals Between Successive Landings On a Given Runway During Peak Periods of Continuous Traffic Demand

Runway No.	Not interspersed by a T.O. from that runway or by a T.O. or landing on any other runway		Are interspersed by a T.O. from that runway, but not from another runway		Are interspersed by a T.O. or landing on another runway, but not by a T.O. from that runway	
	No. of intervals	Mean Time	No. of intervals	Mean Time	No. of intervals	Mean Time
9	20	99 secs.	4	126 secs.	15	103 secs.
27	47	80 secs.	8	170 secs.	10	100 secs.
33	8	77 secs.	1	147 secs.	--	---- ----
all runways combined	75	84 secs.	13	155 secs.	25	102 secs.

The surface taxi delays to landing aircraft are summarized in Table N by test day and reasons for taxi delays.

With regard to "lay-over" gate times of through airline aircraft (i.e. land and then take off as same flight number) an examination of airline timetables showed an average of about 33 minutes between arrive-depart time. If we conservatively allow undelayed land-to-gate taxi-times of 4 minutes for landings, this then averages out to about 29 minutes. An analysis of 263 such "through" aircraft on the 4 "days" surveyed yielded an actual gate occupancy average of about 41 minutes. An average gate

Table N - Surface Taxi Delays, Landing Aircraft

Date	LA			GT			UF			VT			GD			NC		
	No.	Avg.	Max.	No.	Avg.	Max.	No.	Avg.	Max.	No.	Avg.	Max.	No.	Avg.	Max.	No	Avg	Max.
3-13-59 (156 total land. A/C in 8 hrs.)	6	1'40"	3'32"	10	42"	1'52"	14	27"	1'51"	0	- -	- -	9	1'02"	2'57"	0	- -	- -
4-7-59 (143 total land. A/C in 8 hrs.)	0	- -	- -	17	59"	2'27"	3	22"	0'40"	2	57"	1'38"	15	2'27"	6'41"	2	12"	23"
4-23-59 (166 total land. A/C in 8-1/2 hrs.)	0	- -	- -	22	1'09"	7'45"	3	1'02"	1'44"	3	48"	1'33"	4	1'02"	2'27'	9	32"	1'41"
5-17-59 (166 total land. A/C in 8-1/2 hrs.)	0	- -	- -	15	39"	2'04"	3	1'15"	1'43"	0	- -		14	2'54"	8'50"	1	19"	- -

Reasons for Taxi Stops of Landing Aircraft -

LA - Priority to other landing A/C
GT - A/C Ground Traffic
UF - Unfamiliarity
VT - Vehicular Traffic
GD - Gate Delay
NC - No Clearance

time of 75 1/2 minutes was recorded for 107 airline aircraft that "landed" as one flight number and turned around as another flight number.

The lowest gate occupancy average for through aircraft was approximately 35 minutes (58 aircraft total) on 13 March 1959, with the highest average of about 49 1/2 minutes (for 70 aircraft) occurring on 23 April 1959. The lowest gate occupancy average for 54 total turnaround aircraft was approximately 72 minutes, on both 13 March 1959 and 7 April 1959, the highest average was approximately 82 minutes for 26 aircraft on 17 May 1959.

Take-Off Aircraft *

Mean runway occupancy time, from start of take-off roll to runway threshold, for 618 total take-offs on all runways combined (9, 15, 21, 27, & 33) was 50 1/2 seconds, with a standard deviation of 11 seconds. The breakdown by runway for all performance classes is shown in **Table O.**

Table O - Mean Runway Occupancy Time, Per Runway

Runway No.	Runway Length, Feet	Mean Occup. Time, secs.		Standard Dev. - Secs. *
		N	Time	
9	7860	53	49.0	8.8 .
27	7860	171	53.4	10.5
15	7240	178	50.5	9.9
33	7240	102	54.2	11.9
21	5507	114	44.1	7.8
Total All	----	618	50.4	11.1

This was further broken down by performance class, with mean occupancy times of 49.0 seconds for 278 Class I performance type take-offs on all 4 runways (36 take-offs on runway 9, 80 on 27, 102 on 15, 43 on 33, and 36 on runway 9), 49.6 seconds for 131 Class II take-offs on all runways (16 take-offs on runway 9, 32 on 27, 46 on 15, 22 on 33, and 15 on runway 21), 57.5 seconds for 67 Class III take-offs on all runways (1 take-off on runway 9, 20 on 27, 27 on 15, 14 on 33, and 5 on runway 21), and 50.5 seconds for 142 Class IV take-offs on all runways (0 take-offs on runway 9, 39 on 27, 3 on 15, 23 on 33, and 77 on runway 21).

* As stated previously, standard deviations are shown for convenient reference, as the distributions were, in most cases, skewed rather than normal.

For those cases where take-off aircraft entered the active runway, lined up, applied power with brakes on, and thus started from a full stop on that runway (i. e., not a "rolling" type of take-off), and where these take-off aircraft did not get onto the runway and wait while a preceding take-off or landing aircraft was clearing that same or an intersecting runway, the mean time interval between the time of arrival on that runway and the time of take-off roll for 132 such take-offs on all the runways was 16-1/2 seconds.

The mean time interval between the time of start engine run-up and start of take-off roll during "noon-time peak periods" for 204 take-offs on all runways was 5 minutes, 49 seconds. The breakdown by test-day, noon-peak periods was:

Mean time of 4 minutes, 59 seconds for 55 T. O.'s on 3-13-59

Mean time of 6 minutes, 47 seconds for 54 T. O.'s on 4-7-59

Mean time of 7 minutes, 10 seconds for 54 T. O.'s on 4-23-59

Mean time of 3 minutes, 54 seconds for 41 T. O.'s on 5-17-59

The maximum time intervals were 21 minutes, 35 seconds on 4-7-59 and 22 minutes, 56 seconds on 4-23-59.

The mean undelayed time interval between the time 317 "undelayed" airline aircraft left their gates to the time they started their engine run-ups was 3 minutes, 27 seconds. The breakdown by runway is shown in Table P"

Table P - Mean undelayed Taxi-time from Gate to Engine Run-up, Per Runway

Runway No.	N.	Mean Time
15	130	2' 38"
9	30	3' 10"
21	25	3' 27"
27	83	3' 32"
33	49	4' 59"
All	317	3' 27"

With regard to the discussed undelayed taxi-to-run-up times, there were insignificant differences between airlines and their various aircraft types (Martin, DC-3, DC-6, DC-7, Convair, Constellation, Viscount, and Electra).

The mean time intervals between the time the aircraft requested take-off clearance (which was synonomous with requesting VFR enroute flight plan clearance) and the time the Tower granted take-off clearance was 2 minutes, 19 seconds for a total of 182 take-offs during the 4 noon peak periods. During the four 1800 EST evening peaks, this averaged out to 1 minute, 46 seconds for 136 take-offs, and during the 4 afternoon lull periods (during approximately 1330 EST to 1630 EST) this averaged 54 seconds for 148 take-offs. The maximum times were 24 minutes, 8 seconds during the noon peak on 23 April 1959, and 8 minutes, 35 seconds during the 1800 peak on 23 April 1959.

Table Q is a summary of the time intervals between successive take-offs, during peak periods only, when there was a continuous demand, which are and which are not interspersed by a landing on that runway or a take-off or landing from another runway:

Table Q - Time Intervals Between Successive Take-offs, Per Runway

Runway No.	Not interspersed by a landing on that runway or a T.O. or landing on any other runway		Are interspersed by a landing on that runway but not by a T.O. or landing on any other runway		Are interspersed by a T.O. or landing on another runway but not by a landing on that runway	
	No. of intervals	Mean Time	No. of intervals	Mean Time	No. of intervals	Mean Time
9	11	71 secs.	---	--------	8	91 secs.
27	63	73 secs.	16	133 secs.	----	--------
15	38	76 secs.	---	--------	35	125 secs.
33	45	62 secs.	10	125 secs.		
21	18	83 secs.	---	--------	12	134 secs.
All runways Combined	175	72 secs.	26	130 secs.	55	122 secs.

Table R summarizes the airport surface taxi delays to take-off aircraft, by test day and reasons for delay. Engine run-up times were not recorded explicitly since in most cases it was difficult to determine what part of their delay in the total take-off queue delay was attributed to actual run-up. Some of the run-up and subsequent delay times to take-off are "buried" in the previously mentioned time intervals between start of engine run-up and start of take-off roll

Also, in many cases, "ground traffic" was recorded as the cause of delays to take-off aircraft which were number 3, 4, 5, etc. in the take-off queue However, the real cause triggering off the queue may have been either priority to a landing aircraft or no clearance to the number one take-off. It should also be mentioned that the take-off warm-up pads were too small to allow passing

Table R - Summary of Taxi Delays and Reasons For Delay, Per Test Day

Date.	No	Avg.	Max.	No.	Avg.	Max	No.	Avg	Max.	No.	Avg.	Max.	No.	Avg.	Max.	No	Avg	Max.	No.	Avg.	Max
3-13-59 (168 total TO's in 8 hr)	5	1'13"	2'5"	27	1'11"	6'5"	8	1'15"	2'45"	3	0'59"	1'25"	-	-	-	-	-		-	-	-
4-7-59 (162 total TO's in 8 hr)	-	-	-	11	1'37"	9'18"	1	0'20"	-	-	-	-	-	-	-	-	-		1	4'20"	-
4-23-59 (163 total TO's in 8-1/2 hr.)	-	-	-	25	1'7"	5'4"	4	0'31"	1'13"	1	0'30"	-	2	0'20"	0'21"	-	-		3	0'54"	1'45"
5-17-59 (170 total TO's in 8-1/2 hr)	-	-	-	14	1'12"	5'0"	2	0'20"	0'26"	-	-	-	1	0'59"	-	2	1'18"	1'50"	-	-	-

As a matter of further observation, there were a number of occasions where departing aircraft delayed their departure from their gate because of large take off queues and knowledge, therefore, that they would only further aggravate taxiway congestion and, in addition, waste their own fuel if they started up These gate delays were not recorded explicity, and further to the above, these outbound gate-holding aircraft often caused already landed aircraft to wait for a gate at an already overloaded airline ramp area.

TASK 7 - AIRCRAFT DIVERTED OR DELAYED BECAUSE OF WEATHER IN IFR

The requirements for Task 7 were as follows: Determine the number of aircraft that were delayed or diverted because of the weather while airborne under the control of Atlanta Air Route Traffic Control Center, Atlanta Airport Tower or Atlanta NAS Tower. The location of the aircraft at the time the delay is experienced and the extent of each delay should be determined. In order to accomplish this, the following information shall be recorded for each diverted or delayed aircraft:

(a) Inbound Aircraft:

(1) Time the weather information was made available to the controller and/or pilot.
(2) Time the pilot informed the ground facilities of his intention to divert.

(b) Aircraft in the Enroute Area: (Based on observations from air-ground communications)

(1) Winds aloft
(2) Turbulence and icing
(3) Cloud bases and tops.

(c) Aircraft arriving, departing or on an airport surface: (Based on data secured from weather charts)

(1) Ceiling
(2) Surface visibility
(3) Surface wind (Direction and speed)
(4) Weather and/or obstruction to vision
(5) Hazardous weather in the approach zone.

Also include effects of precipitation, including type, as it relates to the condition of the airport and accumulation on aircraft. Determine amount of delay caused by this condition.

The data sources for this task were communications recordings and Weather Bureau records, with very little information gleaned from the flight strips.

Tables 3, 8, and 11, App. J. Vol. II list the weather-influenced and weather-caused delays and diversinns. Detailed narratives of individual flights affected are also found in Appendix J of Volume II.

It has been found that PIREPS (pilots' reports) and other weather information from the weather circuit is not readily available to the controllers. It appears that PIREPS are a potential source of much vital information. However, our analysis has uncovered very few of them, and, generally speaking, they do not find their way to the weather circuits for distribution apparently because controller workload does not allow time for delivery to the weather station.

Problems also exist with respect to the collection and dissemination, for control use, of thunderstorm data in the Atlanta area. The ASR radar, a potential source of thunderstorm data for the terminal area, is circularly polarized so that is cannot be used as a source of such data. Conceivably, if the data were available, it could be occasionally painted onto the controller's scope at periodic intervals by video mapping. There are other conceivable possibilities for such displays, but development of display techniques and mechanizations are needed in this field.

In dwelling on the general problem of collecting and using weather data to best advantage, we have concluded that the addition of weather specialists to the traffic control staff might be beneficial. Qualified personnel brought to grips with the problems first hand should be in a position to recommend those areas where procedural changes, development of new techniques, and development of displays will yield the greatest advantages.

The following paragraphs present in summary form comments on weather delays and diversions as extracted from the data collected. More detailed information is presented in Volume II, Appendix J. The test days included in the study may be described generally as follows:

<u>March 20-21</u>

A high-density traffic day having the greatest number of delays; weather of the early morning hours (0800Z and 0900Z) caused both delays and diversions.

March 29-30

A high-density traffic day having the greatest amount of delay; weather of the early morning hours (0900Z and 1000Z) caused both delays and diversions.

April 13

A high-density traffic day with no evidence of serious problems caused by weather.

May 22

A high-density traffic day showing both the least number of delays as well as the least amount of delay; weather of the early morning hours (0700Z, 0800Z, and 0900Z) caused both delays and diversions. The amount of delay attributable to weather is greatest for this day. The communications show that there would have been considerably more delays for this day were it not for the fact that aircraft, many of which had been given holding instructions, were able to cancel their IFR flight plans before reaching their clearance limit. Obviously, also, the fact that the aircraft chose to divert rather than wait out the weather was a factor limiting the number of delays and the amount of delay.

The results of this task are summarized in Table S below.

Table S - Summary of Delays and Diversions Caused by Weather

Time	No. Delayed	Total Delay Minutes	No. of these Diverted	Other Diversions
March 21, 1959 0800Z-0933Z	10	333	10	2
March 30, 1959 0938Z-1048Z	4	65	4	1
April 13, 1959	No weather delays or diversions			
May 22, 1959 0754Z-0937Z	13	260	9	8
One of these aircraft attempted to divert to Anderson and lost an additional 32 minutes.				

Weather delays were measured by the amount of time the aircraft was delayed at a specific fix. However, a greater amount of time than shown on delay tables was lost by some aircraft. This may be shown by the following flights on March 30:

(1) E145, listed as being delayed 14 minutes at the Outer Marker, if considered an overflight to Chattanooga, lost 28 minutes between the time he departed the approach fix (previous to making a missed approach) and the time he left the Outer Marker on course to Chattanooga.

(2) E745, listed as a 17 minute delay at the Outer Marker, if considered an overflight, actually lost 21 minutes between the time he reported over the Outer Marker and the time he left the Omni on course to Tampa.

TASK 8 - HIDDEN DELAYS IN IFR

Task 8 was an analysis of hidden delays to all arrivals and departures during the two(2) peak hours of each of the four (4) IFR days selected, including analysis to determine the difference in distance flown and the delay resulting from the Air Route Traffic Control Center assigning a flight path other than that requested by the pilot. The paths considered are those along the airways between the ARTCC Area and the airport boundaries. The (hidden) delays include those resulting from undesired altitude assignments as well as those due to route deviations.

The data source was the center and tower strips. While pilot questionnaires were widely distributed, the response was negligible. Only one posted a delay time in the hidden delay classification. For details on Pilot Questionnaires, see the last paragraph in this task.

Route revision delays were calculated by the added mileage, and delays in forward progress due to altitude changes were based on one (1) minute delay for each 2,000 feet of climb. No delay is charged to descending aircraft.

Delays in the approach pattern were taken from the tower strips where available, but since in radar approaches no landing time is shown on the strip, many of these delays were calculated.

Pilot Questionnaires:

Pilot questionnaire cards were distributed to 29 locations. There were 221 cards returned; (85 "inbound" and 136 "outbound"). These cards were returned throughout the entire survey period, with a total of 34 filled out for the 4 test days. These were:

	IN	OUT	TOT.
Mar. 20 - 21	4	0	4
Mar. 29 - 30	4	6	10
Apr. 13	10	10	20
May 22	0	0	0

In the total of 221 returns, 111 had comments in the "Remarks" section. These comments were mostly brief statements of conditions; however, about 15 were critical or caustic remarks leveled at the control system, while some pilots had high praise for the controllers. Some complaints were made about communications: "could not raise controller", "need more frequencies", etc. The comments, in general, ranged all the way from criticism of airline's scheduling to recommending additional runways.

Two references were made to the survey itself, and only one was in any way critical -- where the pilot complained that the questionnaire did not go far enough. Neither of these cards happened to be dated on one of our test days. No one complained about being asked to fill in the forms.

Figures 21 (a., b), are reproductions of the questionnaire form (BB-04-R050) showing both sides of the card.

The 2 peak hours for the four survey days were 1600 and 1700Z (1100 and 1200 EST). The aircraft are arranged by commercial, military and general aviation, and by traffic class within each category. The traffic class codes are:

(1) Inbound to the ATL ARTCC
(2) Outbound from the ATL ARTCC
(3) Overflight
(4) Local flight within the ATL ARTCC

The delays due to altitude changes were nominal, i.e., 1 to 3 minutes. The rerouting delays were usually less than 10 minutes.

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Figure 21a

OUTBOUND TRAFFIC

Date__________

Flight No.__________

☐ VFR ☐ DVFR

☐ IFR

From·

☐ Atlanta

☐ DeKalb Peachtree Airport

☐ Dobbins A.F.B.

☐ Fulton County

To·__________ Destination

A/C Type__________

TAXI DATA

From__________ Gate or Area

at __________ E.S.T. hr. - min.

To:__________ Active Runway

off at__________ E.S.T hr. - min.

Owner Class

☐ Commercial

☐ Military

☐ General

INDICATE TRAFFIC DELAYS:	Estimate Delay Min.
During Taxi	
☐ At the Gate	
☐ Devious Taxi Route	
☐ Taxi Stops (No. of Stops)	
At Active Runway	
☐ Landing Traffic	
☐ Departing Traffic	
☐ ATC Clearance	
☐ Weather	
☐ Others Specify	
While Airborne (If IFR in Atlanta ARTCC)	
☐ Restricted Climb	
☐ Revised Altitude	
☐ Revised Route	
☐ Hold at Fix	

Fix	When	Why

Receive Flight Plan Route? Yes___ No___

Extra Miles if "No"______

Altitude: Desired ______ Assigned ______

No. of Altitude Changes in ATL. ARTC ______

Departure: ☐ Radar ☐ Non-Radar

Remarks·

tear here

tear here

ATTENTION ALL PILOTS

The Federal Aviation Agency is conducting an analysis of Air Traffic in the Atlanta Area during the months of March and April, 1959. The purpose of this analysis is to investigate the factors which produce air traffic delays. The results will be used to plan improvements in the Air Traffic Control System to reduce these delays in the future.

IF YOU HAVE EXPERIENCED A DELAY DUE TO TRAFFIC, OR WEATHER, (EITHER ON THE GROUND OR WHILE AIRBORNE) WHEN ENTERING OR DEPARTING FROM THE ATLANTA AREA, PLEASE FILL OUT THE APPROPRIATE FORM AND RETURN BY MAIL.

Your Cooperation is greatly appreciated.

Research and Development Bureau
Federal Aviation Agency

Form BB-04-R050

tear here

tear here

INBOUND TRAFFIC

Date__________

Flight No.__________

☐ VFR ☐ DVFR

☐ IFR

From __________ Origin

To

☐ Atlanta

☐ DeKalb Peachtree Airport

☐ Dobbins A.F.B.

☐ Fulton County

A/C Type__________

TAXI DATA

From:__________ Active Runway

down at__________ E.S.T. hr. - min.

To:__________ Gate or Area

at __________ E.S.T. hr. - min.

Owner Class

☐ Commercial

☐ Military

☐ General

INDICATE TRAFFIC DELAYS·	Estimate Delay Min.
Enroute (Approaching ATL. ARTCC)	
☐ Revised Altitude	
☐ Revised Route	
☐ Hold at Fix	

Fix	When	Why

Enroute (In Atlanta ARTCC)	
☐ Revised Altitude	
☐ Revised Route	
☐ Hold at Fix	

Fix	When	Why

Approach	
☐ Hold in Stack Fix	
☐ Path Stretching	
☐ Speed Changes	
On the Ground	
☐ Taxi Stops (No. of Stops)	
☐ Devious Taxi Route	
☐ Waiting for Gate	

No. of Altitude Changes in ARTC Area:

Assigned ______ Requested ______

Remarks·

Figure 21b

Table 1 (A, B, C, D), App. G, Vol. II lists "Hidden Delays Caused by Rerouting".

Table 2 (A, B, C, D), App. G, Vol. II lists Hidden Delays Caused by Altitude Changes.

TASK 9 - FLIGHT STRIP UPDATING IN IFR

Task 9 included recording and tabulation, for each hour of one (1) selected IFR day, the number of cases per hour where estimated arrival times and assigned altitudes were updated or revised. Updating was tabulated for all flights at all fixes within the Atlanta area. The hour of each update was the hour posted on the flight strip.

Flight strip updating was analyzed for April 13 and the results are listed in Table 1, App. H, Vol. II. Updates for altitude and estimated arrival times are shown for each hour of the day at each fix, with the fixes listed alphabetically.

The maximum number of ETA updates was 303 at 1600Z while the minimum was 8 at 1200Z. For altitude updates, the maximum was 554 at 1600Z and the minimum was 6 at 1100Z. The average number of ETA changes per strip is 0.50 and the average number of altitude updates per strip is 0.80. The Atlanta VOR (omni) strips have, by far, more updates than any other fix.

TASK 10 - OPERATIONS AT FOUR ATLANTA TERMINAL AREA AIRPORTS DURING ONE VFR TEST DAY

Task 10 included the following requirements: for one of the four same 8-hour VFR test periods as Task 6 (Sunday, 17 May 1959) tabulate operations for all flights operating at the following four airports within the Atlanta area:

(a) Dobbins AFB
(b) Atlanta
(c) DeKalb - Peachtree (formerly NAS, or North Atlanta)
(d) Fulton County

For the 8-1/2 hour period between 1630 and 0100 Z, the total of all landing and take-off operations at all 4 airports was 701, an average of about 83 per hour; 334 at Atlanta Airport, 69 at Dobbins AFB, 234 at Fulton County, and 64 at DeKalb-Peachtree. The peak hour of 99 operations was at 2300-2400Z. Of the 701 total operations, the direction and associated origin-destination airports for 428 operations were accounted for, 238 were "locals," and 35 were "unknown". A general direction-oriented breakdown of the 428 recorded landing-take off operations is shown on Figure 22. It is seen that the busiest direction is the NE-SW leg (Washington, NewYork, etc.), 24% of the total. The next busiest is the SE-NW leg (Miami, Jacksonville, etc.), 16% of the total.

TASK 11 - INSTALLATION OF VOICE RECORDING EQUIPMENT

In Task 11, six (6) ground-air-ground communication channels were recorded by monitoring six type S-124 "Soundscriber" units. These were 24-hour units using 3-inch wide tape. The frequencies recorded were: 120.3, 118.9, 125.2, 120.9, 121.0, and 124.9 mc.

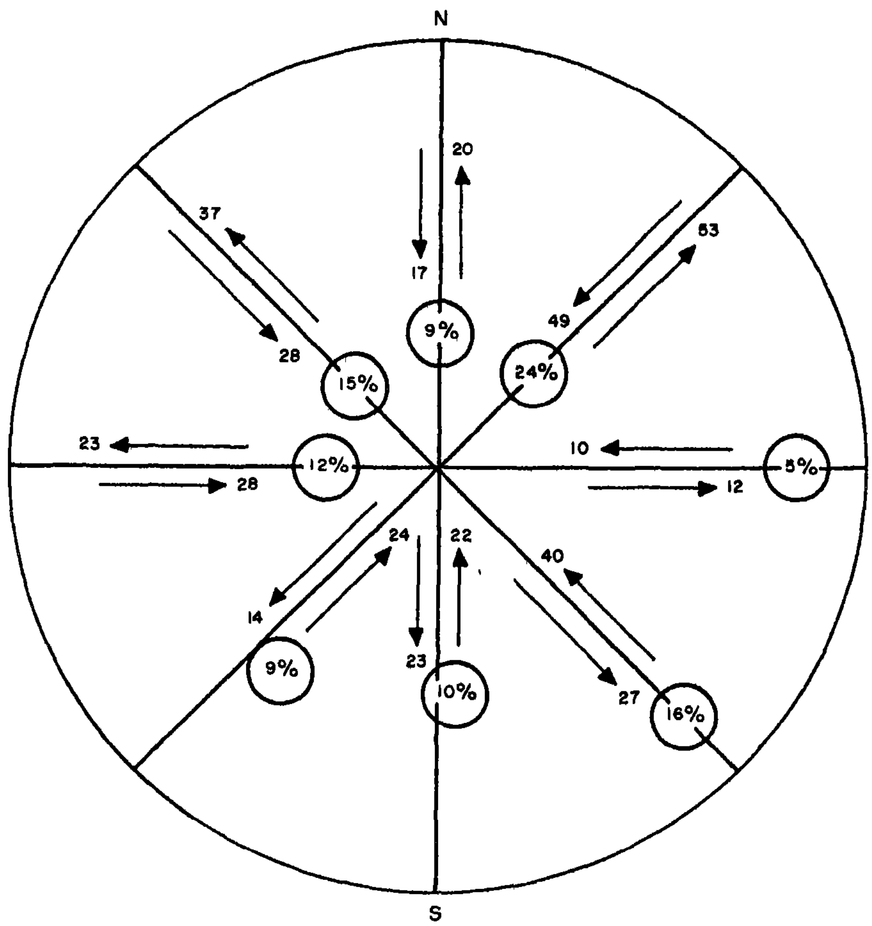
The recording units were leased for 3 months, covering the data-gathering period of the survey. In addition, two transcribing units were leased for the duration of the project.

The recordings from the above units were used to supplement other data in the analysis of delays. Appendix J of Volume II contains transcriptions of certain recordings found useful in the delay and traffic analysis.

TASK 12 - OVER-ALL RECOMMENDATIONS TO BE MADE BY CONTRACTOR

The requirements for Task 12 stated that the contractor shall include in the basic section of final report specific recommendations for changes and/or improvements to the Air Traffic Control System in the Atlanta Terminal Area. These recommended changes and/or improvements shall be based on the data collected and analysis performed under the provisions of Tasks 2, 3, 6, 7, 8, and on the knowledge and familiarity of contractor personnel with the Atlanta Terminal Area as a result of this project. In addition, the contractor shall furnish general recommendations which may not be supported by statistical data, but which, in his opinion, warrant further investigation as a possible means of improving the system.

Specific and general recommendations for changes and improvements in accordance with provisions of this task were included in the section entitled, "Summary, Atlanta Air Traffic Analysis".



NOTE:

DIRECTION DETERMINED FOR 306 OF 334 TOTAL OPERATIONS AT ATLANTA (9 LOCALS & 19 UNKNOWN)
DIRECTION DETERMINED FOR 49 OF 69 TOTAL OPERATIONS AT DOBBINS AFB (18 LOCALS & 2 UNKNOWN)
DIRECTION DETERMINED FOR 45 OF 234 TOTAL OPERATIONS AT FULTON CO (184 LOCALS & 5 UNKNOWN)
DIRECTION DETERMINED FOR 28 OF 64 TOTAL OPERATIONS AT DE KALB PEACHTREE (27 LOCALS & 9 UNKNOWN)

TOTAL ⟶ 428 701

Distribution of VFR Traffic During 1630 - 0100Z on Sunday 17, May 1959 at Atlanta, Dobbins AFB, De Kalb Peachtree & Fulton County Airports

Figure 22

SECTION III

OBSERVATION OF OPERATIONAL FACILITIES IN ATLANTA AREA

During the data-taking portion of the survey, a close study was also made of the facilities, operating problems, and policies. Following is a brief summary of observations in these areas, and recommendations relating thereto have been included in Section IV.

Airport Lighting

It is believed that blue lights used for surface marking exist in such abundance as to be confusing, resulting in less efficient movement of aircraft during darkness than would be possible if a more positive marking and direction system existed. It was pointed out that an experimental installation of centerline button lights down the runway and turning into the selected taxiway would undergo test at NAFEC and San Francisco, and that such a system might eventually prove useful to Atlanta.

Controllers say that the strobe-line lights, while quite adequate, are too bright when the pilot breaks out at about 300 - 400 feet. The comment was made that an extra man is needed just to turn the lights on and off under these conditions.

Radar

The next most congested area to Atlanta (in the Atlanta Center's Area) is Charlotte. ASR radar is needed there to help relieve congestion. ARSR radar would also be useful at Etowah, Tenn. The Atlanta Center has recommended such an installation rather than an installation at Middlesboro, Ky. which is now programmed. The ARSR radar south of Montgomery will help in that area. Another ARSR between Birmingham and Chattanooga would be of great assistance in providing both jet coverage and terminal area coverage for Birmingham and Chattanooga terminals. (It is programmed, of course, that these radars would be microwaved into the center.) When the commercial jet routes go into effect in September, radar coverage will be needed. Good coverage would be provided by FAA staffing of ADC sites, but Atlanta personnel recognize that personnel administration and morale problems are created in handling the situation in this manner.

As soon as the radar beacon equipment is available, Atlanta Center and Tower would like to have it, if for no other reason than for target reinforcement. A scan-converted drop on the Center ARSR has been recommended for the tower.

With respect to ASDE, and in view of the good surface visibility expected with the new tower, there was some indecision as to whether it would be necessary or prove useful.

Communications

More interphone connections are needed to adjacent centers for coordination purposes. Coordination problems are believed to contribute to the inefficient use of airspace. It is not the mere addition of lines that is needed. What is required is hot lines (discrete lines) between adjoining inter-center sectors so that the appropriate controller can be reached on the other end of the line for coordination purposes. The lines are not needed 24 hours per day, but it is vital they be available on demand. Atlanta Center believes several delays per day can be charged to this shortcoming, particularly with respect to traffic between Atlanta and Washington, Jacksonville and Memphis, It is thought that the Bell 300 series system will solve this problem, but its implementation is understood to be at least two years away.

Atlanta Center feels it needs immediately 1 additional outbound and 1 overflight radio frequency. Their ultimate goal is 4 outbound, 4 inbound, 3 overflight, and 1 Dobbins frequency (to match the planned one-way structure discussed later).

It is believed that peripheral station frequencies are adequate except for Charlotte's low altitude coverage. A frequency at Hickory would take care of this requirement.

Atlanta Center believes that the frequencies requested will be adequate to handle jet traffic, but will not be sure until operational experience is acquired.

Atlanta Center is plagued with traffic handling problems arising from the frequent (and, it is believed, excessive) radio failures incurred by T33 aircraft.

Airway Route Structure

Currently Atlanta Center has three exclusive departure routes and one exclusive inbound route. The departure routes are V454 to Charlotte in the northeast direction, V51W to Macon in the southeast direction and via V97 to Crabapple thence direct to Crossville omni in the north-northwest direction. The inbound route is V20W from Spartanburg in the northeast direction. It is believed that traffic handling in the terminal area can be both eased and expedited if exclusive in, out, and over paths can be provided in all four quadrants. A change in route structure resulting in exclusive routings has been proposed, but is not yet implemented. The proposed structure simplifies greatly the handling of in-out traffic, but complicates the handling of over traffic somewhat by creating more possible confliction points. In this connection (as well as at other locations), it is believed that the route structure has become such that the present method of displaying traffic is rapidly becoming obsolete. Interpretation of the present display is lacking in efficiency.

Navigation Aids

Atlanta Center believes it needs several new VOR's both as gap filters and to eliminate ILS airways. Between Birmingham and Augusta, the airway depends on using the back-course and the front-course of the Atlanta ILS. Atlanta Center and Tower would like to see this link replaced with a VOR east of Atlanta. The use of an ILS in this fashion is felt to be a doubtful procedure, especially at high altitudes where the localizer receiver could possibly be receiving signals from more than one localizer and thereby generate erroneous readings. A similar situation exists between Meridian and Birmingham, where the Birmingham ILS is used. Atlanta Center believes a VOR should be located N.E. of Birmingham to make this a complete VOR airway.

At Jasper, Ga., Clemson, S.C., and Eutaw, Ala., Atlanta Center needs VOR's as gap fillers to maintain standard airway widths so they do not overlap creating an inefficient airway structure. (The probable error of present day VOR's is such that angular inaccuracy causes the airway to exceed 10 miles in width at distances in excess of 45 miles from VOR stations. Gap filler VOR's, therefore, are used to fill in between VOR stations more than 90 miles apart where it is necessary to maintain standard airway width over the entire length of the path.)

Other

Atlanta Center and Tower believe they would make good use of closed circuit TV for data transfer between center and center IFR room and between tower cab and tower IFR room (as at Dallas) provided good equipment is available and provided the tower display could be illustrated at night completely enough to give good transmission without raising the ambient level too high in the tower.

Operations

Atlanta Center and Tower would like air carrier scheduling to be along more realistic lines. The Center has studied airline schedules quite thoroughly, and estimates that during IFR conditions, approximately 75 hours of delay will accrue to inbounds during a 24 hour period and that approximately 30 hours of delay will accrue to outbounds. The only relief to be expected will have to come from reduced landing and takeoff intervals or from realistic scheduling.

Procedures

Atlanta Center and Tower want an IFR room with approach control to serve within a 50 mile radius of Atlanta. This area would have a definite altitude ceiling.

Maintenance procedures give rise to problems. Maintenance personnel work primarily daytime hours and are not readily available nights, weekends, or holidays except on call. Breakdowns occurring during such periods cannot be quickly remedied. Also, this procedure means that practically all preventive maintenance (often requiring shut down of facilities) occurs during daylight hours (heavy traffic) and frequently during peak daylight hours.

Atlanta Center has developed flow control procedures and agreements, but urge that a National policy be established to make uniform flow control procedures effective throughout the ATC system. Flow control procedures are not compatible with non-scheduled jet operations. By the time Atlanta Center realizes it should impose flow control restrictions on jet operations, it is too late to restrict aircraft on the ground at their point of departure.

Training

The training school has qualified instructors and adequate equipment to turn out well-trained personnel. It is believed that upgrading of the criteria used in the selection, screening, and grading of trainees will make more efficient use of these facilities and result in the production of first-class controller material.

SECTION IV

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The foregoing discussion may be summarized briefly in the following conclusions:

(1) A major limiting bottleneck is airport capacity.

(2) With the present terminal and airport configuration at Atlanta, both VFR and IFR operations are close to maximum theoretical capacity as stated in the "Curtis Report."

(3) One major cause of delays is "bunched" airline scheduling.

(4) There are usually two combined landing and take-off traffic peaks every day. One from about 1130 to 1400 and the second from about 1700 to 1930 EST.

(5) Present methods for displaying traffic in towers and centers are obsolete.

(6) There was no indication from measured delays that the route structure in the enroute area is inadequate.

(7) About 80% of the enroute delays were attributable to Atlanta terminal saturation.

(8) Traffic inbound to the area, traffic outbound from the area, traffic overflying the area and traffic with origin and destination within the area (local) is made up as follows in IFR:

Inbound	26%
Outbound	28%
Overflights	29%
Local	17%

(9) Delays separated by class, total numbers and accumulated time for Mar 20, the busiest IFR day surveyed, are listed below:

Class	No. of Delays	Accumulated Time
Enroute - overflights	45	9 hours
Inbound to ARTCC Area	137	31 hours
Departure - ground	128	12 hours

(10) Postings were made for 167 fixes during the survey. There is a total of 322 fixes in the area - 34 with three-letter identifiers and 288 with two-letter identifiers.

(11) The highest and lowest number of fix postings and ownership proportions for the four 24-hour survey periods in IFR were:

Fri. Mar. 20, beginning 0800 EST. 6904 postings

Commercial	52%
Military	36%
General Aviation	12%

Sun. Mar. 29, beginning 1000 EST 4744 postings

Commercial	69%
Military	25%
General Aviation	6%

(12) The highest and lowest number of daily postings for the 12 busiest fixes in the area were:

Atlanta VOR (ATL) 661 postings on May 22 - 0001 to 2400

Spartanburg 85 postings on Mar 29 - 30 1000 to 1000

The greatest number of postings per hour was Atlanta VOR (1300 to 1400 EST) 68 postings.

(13) In the search for cancellations and diversions due to actual or forecast delays in the area, the data source specified was airline companies' records. Two airline operators responded to our questionnaire with the information that no such cancellations or diversions were experienced.

It should be noted that negative answers from some operators and no answers from the balance is not a guarantee, per se, that no trouble existed. Only actual data results can be recorded.

(14) The average number of flight progress strips prepared per flight for each traffic class were:

Traffic Class	Average strips prepared per flight
Inbound - to ATL area	4
Outbound - from ATL Area	4
Overflight	5
Local - flight within the area	4

(15) The average number of hidden delays in the two-hour peak periods in each of the IFR days surveyed were:

Due to rerouting	8
Due to altitude changes	16

Except for several unusual cases, the average hidden delay approximated 2 minutes.

(16) The maximum number of ETA updates was 303 at 1600Z while the minimum was 8 at 1200Z. For altitude updates the maximum was 554 at 1600Z and the minimum was 6 at 1100Z. The average number of ETA changes per strip is 0.50 and the average number of altitude updates per strip is 0.80. The Atlanta (omni) strips have, by far, more updates than any other fix, presumably because this is a feeder fix. (This information derived from April 13, 1959 data)

(17) Communications, in the overall analysis, yield very little in total results. They are useful in certain delay investigations and sometimes uncover delays that would not otherwise have been found. The use of these recordings is extremely expensive. Had all channels, center and approach control, been recorded and completely examined, the listening time alone for this entire survey would have been 3,744 hours.

Recommendations

On the basis of both the measurements and observations made during the Atlanta Air Traffic Analysis, the contractor recommends that the following specific actions for improvement of operations in the Atlanta Area be considered.

The first of these recommendations are based upon the data recording and measurements program.

(1) Several features should be designed into the present Atlanta Airport ground environment as follows:

- (a) Multiple warm-up pads
- (b) Taxiway by-passes
- (c) Taxiway widening
- (d) High speed turnoffs, judiciously located

(2) To meet TSO-N6b for continental airports, runway lengths must be extended.

(3) The airlines should be encouraged to eliminate bunching by rescheduling in the interest of economy of their own operations. Further to this, a mathematical analysis should be made of the decrease in delays, and their economic implications, by various degress of re-scheduling.

(4) In addition to recommendation (1), plans for a supplemental airport (of the high performance type) should be considered seriously by cognizant Atlanta authorities.

(5) By 1960 provision should be made for at least a total of 75 gates, of which 10 should be special jet gates with their appropriate blast fences.

(6) Studies should be made to determine the width of taxiways needed for safe and efficient large transport operations.

(7) It is recommended that the airway route structure be reviewed with respect to the number of fixes, since our survey showed that only 167 fixes were in active use out of a total of 322 fixes in the area.

The following additional recommendations submitted for consideration are based upon discussion between contractor and operational personnel.

(1) The strobe line lights and the attendant control system generate problems because of individual pilot preference for varying degrees of brightness. Atlanta Tower reports that an extra controller must often be used just to handle the controls. This situation requires study and analysis to determine if optimum compromises can be achieved. Possibly a control system governed by ceiliometer and transmissometer outputs could result in acceptable strobe line lighting.

(2) To relieve congestion at Charlotte during IFR, an ASR radar is recommended.

(3) The ARSR radar planned for Middlesboro, Ky. should be relocated at Etowah, Tenn.

(4) An ARSR radar is recommended between Birmingham and Chattanooga for both jet coverage and terminal coverage at these locations.

(5) As soon as available, beacon equipment should be provided for the center and the Tower.

(6) The Tower should be provided with a scan converted drop on the center ARSR.

(7) Additional discrete telephone lines to Washington, Jacksonville, and Memphis are needed.

(8) Atlanta Center currently needs one additional outbound and one additional over traffic frequency.

(9) Atlanta Center needs a peripheral frequency at Hickory to take care of Charlotte's low altitude traffic.

(10) The frequency needs of Atlanta Center should be rechecked after some operational experience with jets has been acquired.

(11) Traffic handling in the terminal area could be both eased and expedited in IFR if exclusive inbound, outbound, and over routes can be provided in all four quadrants surrounding the terminal area.

(12) VOR's are needed east of Atlanta and northeast of Birmingham to replace ILS airways.

(13) VOR's are needed at Jasper, Georgia, Clemson, S.C. and Eutaw, Alabama as gap fillers.

(14) Experimentation with closed circuit TV should be conducted between the center and the tower IFR room, and also between the tower cab and tower IFR room.

(15) The center and tower should be provided with a single IFR room for common control to cover a 50-mile radius with a definite altitude ceiling.

(16) Atlanta facilities should have 24-hour maintenance available and provisions should be made to conduct preventive maintenance during off-peak periods.

(17) It is felt that the Oklahoma City controller training school could be very helpful in supplying needed personnel if there were some upgrading of the criteria used in selecting, grading, and screening of trainees.

(18) Improved displays and procedures should be developed to facilitate collection and transmission of pertinent weather information.

(19) Consideration should be given to supplementing the air traffic control staff with weather specialists.

(20) A coordinated effort by the airlines and FAA should be made to analyze the economic and operational impacts of re-scheduling during the serious "noon" and evening peaks.

Contractor's Statement

The contractors feel that the objectives of this program have been satisfactorily met by the data gathered and the analyses to which they have been subjected. It is also thought that the methods used both in acquisition and processing have resulted in an accurate source of information for the conclusions reached, as well as for any further analyses to which the data may be subjected.

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APPENDIX I-A

DATA GATHERING AND REDUCTION FOR IFR ANALYSIS

Data for the IFR portion of the survey, Tasks 1, 2, 3, 5, 7, 8 and 9, were mostly in the form of flight progress strips furnished by the Center and Tower after each test day had been selected.

An exception to the general use of flight strips is Tasks 2 and 7, where extensive use of frequency and intercom recordings had to be made. The intercom "MEMOBELTS" were furnished by the Center and the recordings on six (6) frequencies were made by temporarily-installed model 124 "SOUNDSCRIBERS" as directed in Task 11. These units, installed and maintained by the contractor for the duration of the project, were equipped with 24-hour time marked tapes and performed with utmost satisfaction throughout the survey.

Processing information from a total of nearly 30,000 flight strips for the four (4) test days was greatly facilitated by the development of a technique for reproducing the strip in trip-oriented groups. The method was to sort the strips in any desired order and to reproduce in bunches, on 8-1/2 x 11 inch sheets. This avoids the multiple handling of masses of strips, beyond the initial sorting, and renders the transcription of entries, such as for punch cards and many other processing operations, a much simpler task.

The equipment used was an EASTMAN "VERIFAX" COPIER, although there are likely many other suitable methods. Figure I-A-1 is a reproduction of a single flight orientation.

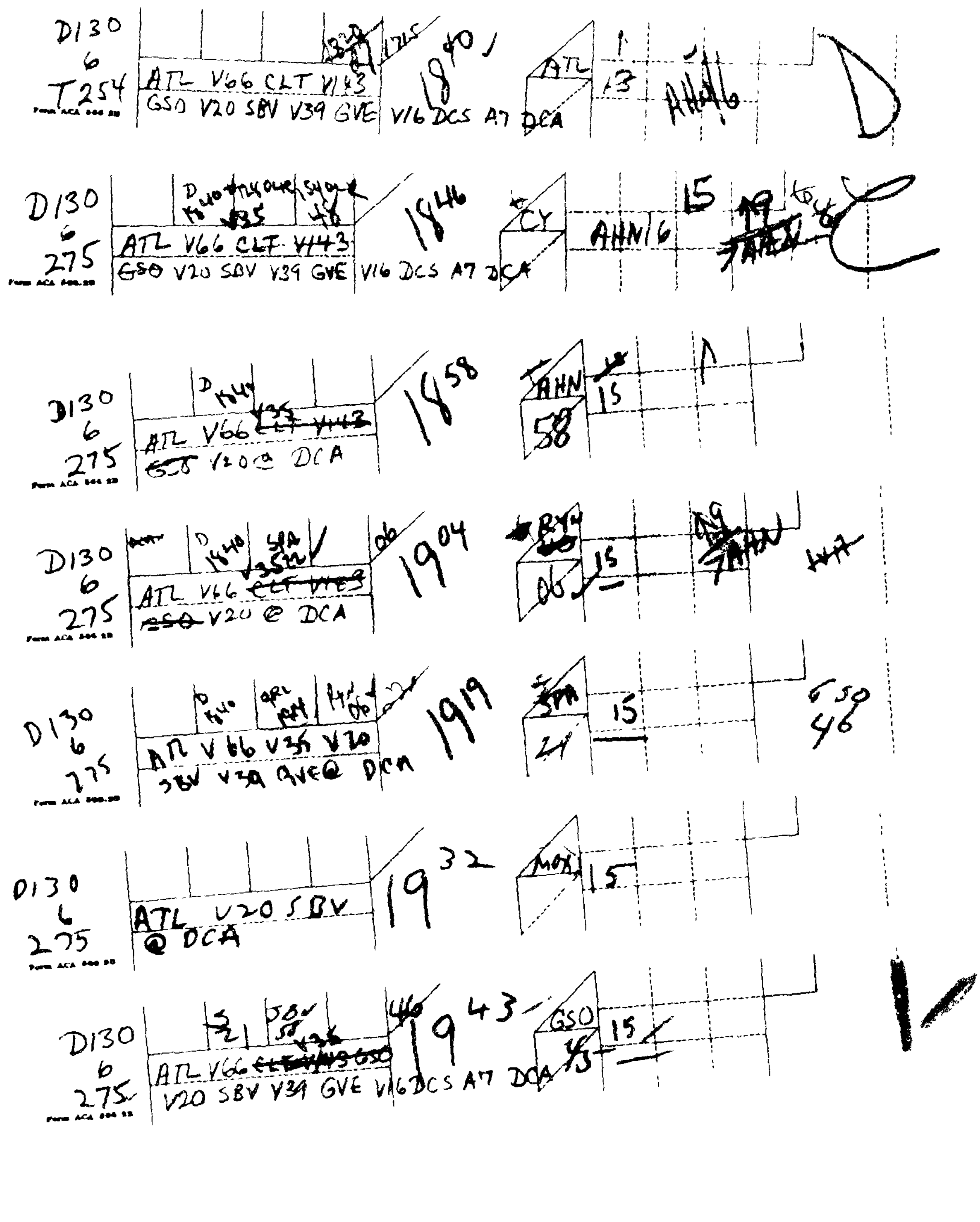


Figure I-A-1 Sample of Trip-Oriented Strip Arrangement

APPENDIX I-B

DATA GATHERING TECHNIQUES AND DEVELOPMENT OF PRELIMINARY TEST RESULTS

Task 4 - Radar Scope Photography

A. Requirements

Task 4 generally required motion-picture photography of the Atlanta Tower and Atlanta Center radar PPI's in order to provide data for analysis of traffic movements on four (4) high-activity IFR days. The data analysis consisted of the following three specific tasks:

Task 4a - Preparation of a 16 mm motion picture film strip showing traffic movement during the two peak hours of each of the four "test" days. The film shall include a simple map overlay and shall be speeded up (by multiple printing of frames) so that one minute of flight time is viewed in one second.

Task 4b - Preparation of pictorial displays showing instantaneous position of all aircraft at one-hour intervals for one test day, and at five-minute intervals during the peak traffic hour of that day. Ownership category of each aircraft shall be indicated.

Task 4c - Determine actual position of each aircraft relative to a given fix at the instant it reports being over that fix. Tabulate by ownership category and plot distributions of deviations. Sample shall include 6 fixes, with up to 50 aircraft per fix.

B. Radar Indicators at Atlanta

The Atlanta Tower is equipped with an ASR-3 (Bendix) radar which is used for both approach and departure vectoring. Two ASR-3 scopes are located in an IFR room under the tower, and a monitor ASR-3 scope is located in the tower cab. The maximum range of the ASR-3 is 50 nautical miles, and the antenna scan rate is 13 RPM. The ASR-3 is equipped with a video mapper.

The ASR-3 monitor in the tower cab was used for photographic recording. The camera assembly was designed to permit quick removal in the event that Tower personnel had to use the radar scope. Philco suggested that a separate 7-inch monitor scope be installed in the equipment room for photography, but this could not be arranged by FAA personnel.

At the start of the program, Philco was advised that the ARSR-1 long-range radar, then being installed at Dobbins AFB and microwaved to Atlanta, was also to be photographed as soon as it was operational. The ARSR-1 was not officially recorded because it did not reach operational condition before completion of the specified IFR tests.

C. Equipment

Photographic equipment consisted of a 16 mm motion picture camera and hood-mounting assembly as shown in Figure I-B-1. Two such units were supplied: one each for the ASR-3 and ARSR-1 radars.

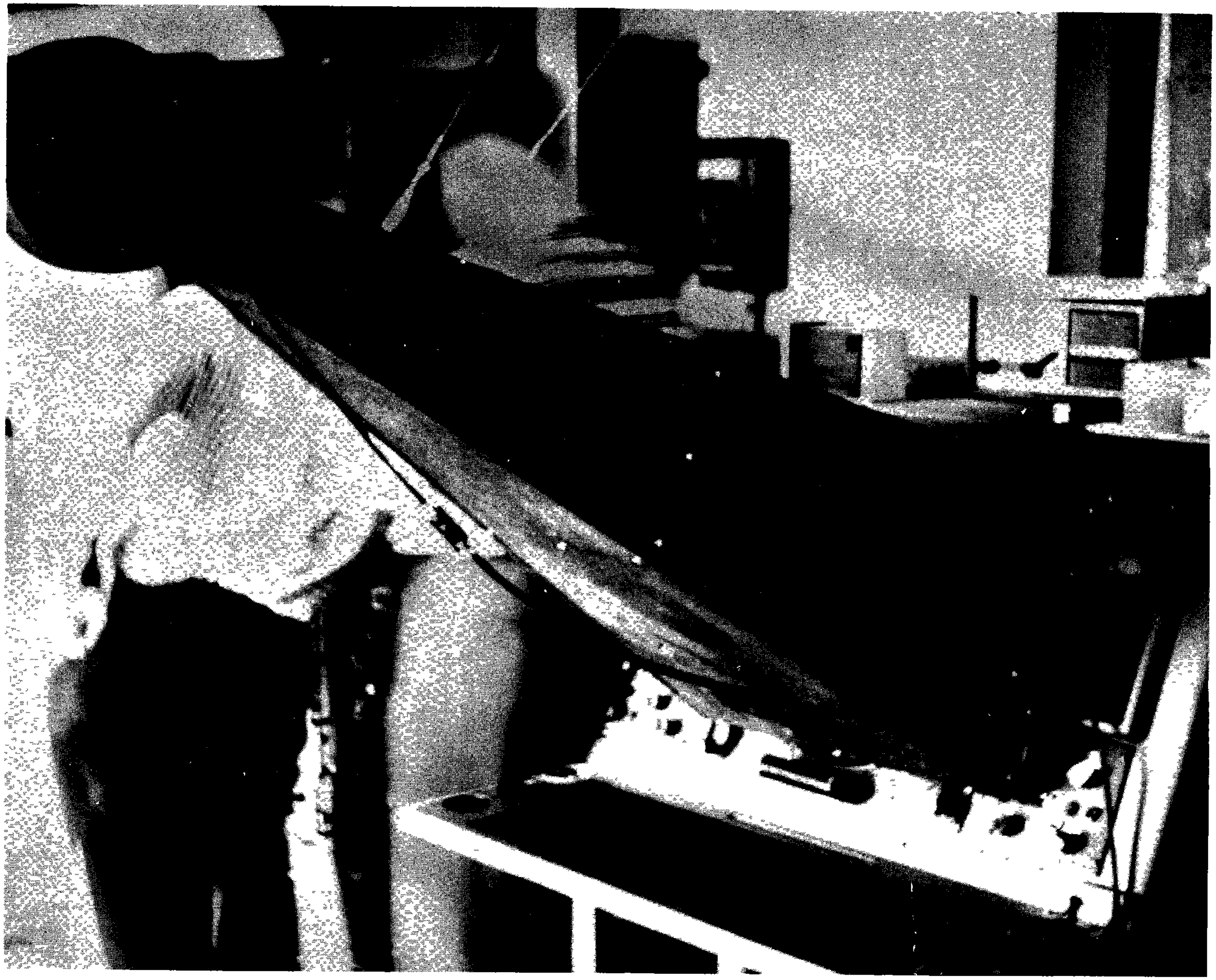
The equipment provided for each scope included the 16 mm camera, motor drive, timer, camera mount, and hood. In addition, a card holder (for date, etc.), a frame counter, and a clock were mounted within the hood so as to be included in each frame photographed. A trigger pulse from the radar was supplied to the timer which actuated the shutter and film advance mechanism.

The camera assembly was designed, fabricated, and installed by the Philadelphia Air Transportation Company (PATCO), Norristown, Pennsylvania.

D. Photography

Radar scope photography was conducted continuously during all forecasted IFR weather conditions. The four days to be analyzed were selected after their occurrence on the basis of high activity. The ASR-3 radar was photographed at the 50-mile range on all occasions. (Had the ARSR-1 radar been operational, it would have been photographed at 100-mile range, with the ASR-3 at 20-mile range). The photographic rate was two frames per minute.

Figure I-B-1



ARSR-1 Radar Camera
Installation

The radar was photographed with MTI on, which eliminated most ground return and clutter. At intervals, the MTI was turned off for several frames in order to provide ground reference points on the film.

E. Film Strip - Task 4a

As required by Task 4a, Philco prepared a 16 mm motion picture film strip showing the traffic movements during the two peak hours of each of the four test days. The film was "speeded up" so that one minute of flight time will be viewed in one second. The film is headed by appropriate title blocks, and time and date of each test period are shown. A map overlay was provided on each frame showing the primary fixes, airways, and airports.

The peak traffic periods for all four IFR test days were found, by actual count, to be from 1630 to 1830 Z time.

The radar scope was photographed at a rate of two frames per minute. In order to achieve the desired 60 : 1 speed-up in the finished film, it was necessary to duplicate each frame 12 times:

(2 frames/min. x 12 = 24 frames/minute of flight)
When projected at 24 frames per second, one minute of flight will therefore be viewed in one second.

F. Methods of Identifying Aircraft - Tasks 4b and 4c

Task 4b required the preparation of 35 charts showing instantaneous positions of all aircraft at hourly intervals during the busiest 24-hour period, and at five-minute intervals during the busiest one-hour period.

A map overlay was prepared showing all airways, fixes, and landing fields within the ASR-3 50-mile radar range. Map scale used was the same as the Sectional Aeronautical Charts. The 16 mm photographic recordings of the radar display were projected on this map using a mapmatching frame and projector previously built by F.I.L. The motion-study type projector which was used allowed continuous viewing of a single frame as well as manual operation and variable-speed forward-reverse drive.

Aircraft were identified by use of the flight strips written for that day in the Atlanta ARTCC. These strips were sorted by F.I.L. (as part of another Task) so that all strips for one flight could be reproduced on a single sheet. Philco was provided copies of all flight-oriented strip data. The flights were then arranged in time-order and used as follows:

1. The film was set to project the frame exposed at the selected time; for example, 1600 Z.

2. Strip data for all flights which had appeared within radar range at the selected time were examined, one at a time.

3. For a given flight, the fix reporting time closest to the selected hour was found. The film was shifted to the frame exposed at that time (nearest 1/2 minute), and the target identified at the given fix. In cases of conflict (more than one target appearing), identification could usually be made up shifting the film one or two frames to determine direction of flight. If this procedure was not successful, another fix report was used.

4. After identification of a given target, it was tracked visually through successive frames while the film was repositioned at the selected hour where its position was plotted on the map overlay.

5. After all IFR flights in the area at a given time were identified, the remaining targets appearing in the photograph were marked and labeled as VFR or uncorrelated aircraft.

The instantaneous pictorial displays show flight number for' each identified aircraft and denote ownership category by the symbol used. Volume II contains these pictorial displays which are accompanied by a tabulation of pertinent flight data for each aircraft.

In Task 4c, it was necessary to determine the actual location of aircraft relative to a given "fix" at the time the pilot reported being over that fix. This was done for a maximum of 50 aircraft at each of six selected fixes in the Atlanta area.

For Task 4c, the flight progress strips were "fix-oriented" or sorted by reporting point, and were arranged in time sequence. The film was projected on the map overlay as described above and aircraft identified one fix at a time. The procedure for identifying an aircraft was similar to that used in Task 4b, except that the position recorded was that at the instant of reporting rather than at hourly (or 5-minute) intervals.

After an aircraft was identified, its position with respect to the fix was measured using a special ruler marked in nautical miles. Deviations measured were miles early or late along the route traveled, and miles to the left or right of the route. Pertinent flight data and deviations were tabulated for each aircraft identified.

APPENDIX I-C

DATA GATHERING TECHNIQUES AND DEVELOPMENT OF PRELIMINARY TEST RESULTS

Task 6 - Analysis of Airport Surface Traffic Movements -

A. Requirements

Task 6 generally required the "determination of the nature, volume, and distribution of aircraft movements on the surface of the Atlanta Airport." Ground observations were made throughout an eight-hour period on four (4) pre-selected, good VFR days. A map layout was prepared to identify all gates, parking and run-up areas, intersections, taxiways, and ramp areas. Ground observers located at key positions identified each aircraft, and timed and recorded all of its movements. The main coordinating-observation site was in the Tower, Site No. 1.

B. Data Acquisition

The ground observations were made by crews consisting of experienced, off-duty FAA controllers assisted by college students recruited from Georgia Tech. It is felt that the experience of the FAA personnel contributed greatly to the reliability of data and that their willing cooperation was largely responsible for the success of the data gathering process.

Figure 16 showed the map used for identification of gates, intersections, etc. This map also shows the locations of observation sites, shows runway light distances for aid in measuring touchdown point, and lists some pertinent notes for the observers.

The various observation sites were selected to provide overlapping coverage of all aircraft movements. Sites 1, 2, 3, 4, and 8 were manned at all times during observations, while the other sites used depended upon the runway in use at a given time. When wind conditions made it necessary to change runways, the field observer crews were re-located so that each crew continued to record the same data (inbound or outbound).

Intercommunications between certain sites and radio monitors at others were provided to facilitate identification of aircraft by flight number and to aid in following ground movements. At sites 1, 2, and 3 (Tower, Eastern Ramp and Delta Ramp), the observers could monitor all radio communications directly. These three sites were also interconnected by direct telephone lines. All field sites were equipped with VHF radio receivers for monitoring local approach or ground control communications, as needed. In addition, 2-way portable radio (walkie-talkie) communication was provided between condition site 1 (Tower) and sites 4, 5, 6, 7 and 8.

Each site was provided with an electric clock, with calibrated seconds wheel or seconds hand. Clocks were synchronized with the Tower at the start of the test, and were checked frequently throughout the day.

Figures I-C-1 and I-C-2 are reproductions of the data forms used to record Take-off and Landing operations. These sheets show all items of information which were recorded for each operation. The observers at each site were instructed to record all items which could be obtained from that position, with the requirement that each site record aircraft identify (tail and/or flight number). To insure positive identification, sites 2 and 3 were required to obtain both flight number and tail number for all aircraft.

The data gathering system was checked out in a preliminary practice session on 10 March 1959, to insure that all necessary information could be acquired and to familiarize the student observers with the airport and its operations. After examination of the data recorded and observations of the operations on this day, a few changes were made in observer duties and position. This practice session and the minor changes made resulted in a relatively smooth operation on the first actual test day, and subsequent days were well-coordinated.

C. Preliminary Data Reductions

The log sheets filled in by the observers constituted the raw data for each test day. Prior to analysis, it was necessary to correlate these data on a single master copy: that is, the data describing the movements of a given aircraft were transferred from the several observers' records to a single log sheet which then showed the complete record for that aircraft. Entries were arranged in time order (runway threshold). These complete log sheets were used as the basic records in all subsequent data processing.

SHEET No. ________

LANDINGS - ATL.AIRPORT

Date ______ Site ______

Recorder ____________

Categories: Airline, Mil., Gen. Av.

Taxi Stop Reasons

IA - Landing A/C or priority
NC - No clearance
EM - Emergencies
GT - Ground A/C Traffic
GD - Gate Delay
RU - Run up
SS - Sched. Stop
UF - Unfamiliarity
VT - Vehic. Traffic
WR - Weather
UN - Unusual (others)

	Item						
	1. Category						
	2. Airline						
	3. Airl. Flt. No.						
	4a. A/C type						
	4b. Tail No.						
	5. Land. R'y. No.						
	6. Time over thresh.						
	7a. TD light No.						
	7b. TD dist.						
	8. TD time						
	9. R'y. exit time						
	10. R'y. exit used						
	11. TAXI ROUTE						
TAXI STOP	12. Place taxi stop						
	13. Time " "						
	14. Reason " "						
	15. Time " start						
	12. Place " stop						
	13. Time " "						
	14. Reason " "						
	15. Time " start						
	12. Place " stop						
	13. Time " "						
	14. Reason " "						
	15. Time " start						
	12. Place " stop						
	13. Time " "						
	14. Reason " "						
	15. Time " start						
	16. Gate Arr'l. time						
	17. Gate used						
	REMARKS						

Figure I-C-1 Raw Data Sheet - Landings

Sheet No. ________

TAKE-OFF's - Atlanta Airport
Date ____________ Site ________
Recorder ______________
Categories: Airline, Mil., Gen. Av.

Taxi Stop Reasons
IA - Landing A/C or priority
NC - No clearance
EM - Emergencies
GT - A/C Traffic
GD - Gate Delay
RU - Run up
SS - Sched.Stop
UF-Unfamiliarity
VT-Vehic.traffic
WR-Weather
UN-Unusual(others)

	Item						
1.	Categories						
2.	Airline						
3.	Airl.Flt.No.						
4a.	A/C type						
4b.	Tail No.						
5.	T taxi cl.req.						
6.	T taxi cl.gr.						
6a.	T.O. R'y.						
7.	T enr.cl.req.						
8.	T enr.cl.gr.						
9.	Gate						
10.	T Gate Dep.						
11. TAXI ROUTE							
TAXI STOPS	12. Place						
	13. T stop						
	14. Reas.stop						
	15. T start						
	12. Place						
	13. T stop						
	14. Reas.stop						
	15. T start						
	12. Place						
	13. T stop						
	14. Reas.stop						
	15. T start						
	12. Place						
	13. T stop						
	14. Reas.stop						
	15. T start						
	12. Place						
	13. T stop						
	14. Reas. stop						
	15. T start						
	16. T.eng.r.u.						
	17. Pl.eng.r.u.						
	18. T TO cl.req						
	19. T TO cl.gr.						
	19a T.cl.to r'y.						
	20. T arv. r'y.						
	21. T TO roll						
	22. Type T.O.						
	23. T r'y.thresh.						

 REMARKS

Figure I-C-2 Raw Data Sheet - Take-Offs

The observed data were then recorded on IBM punch cards in accordance with the "standard" formats and codes agreed upon by FAA, Cook, Convair, F.I.L., and Philco. These codes and formats are described in Volume III along with the print-out tabulations from the cards. The following cards were made for each operation:

a. Departure card (basic): each card records the pertinent data for each of the Atlanta Airport take-off operations.

b. Departure card (supplemental): this card is to be used as a second card to record taxi-stop data on a take-off.

c. Arrival card (basic): each card records the pertinent data for each of the Atlanta Airport landing operations.

d. Arrival card (supplemental): to be used as the second card for a landing operation when there are more than 3 taxi stops.

e. "Taxi" or "Tow" (basic): each card records the pertinent data for each Atlanta Airport aircraft that is being taxied or towed; i.e., is not a landing or a take-off. The same type of card is to be used for either type of operation, and the card identifier code punched in column 79 will indicate whether it is a "taxi" or a "tow."

f. "Taxi" or "Tow" (supplemental): to be used as the second card for a taxi or two operation when there are more than 3 taxi stops.

g. Surface Weather: each card records the pertinent surface wind and gust data for each Atlanta Airport take-off or landing on this Task 6.

Under the contract requirements, it was also stated that analysis of these data should include tabulations of the following additional items for each runway:

a. <u>For arrivals</u> -

(1) The time interval between successive landings on a given runway which are not interspersed by a take-off from that runway: i.e. threshold-to-threshold times.

(2) Runway occupancy time; i.e. threshold-to-runway exit time.

(3) The undelayed taxi time from the active runway to the gate identifying the runway and taxi route; i.e. the time from runway exit to the gate minus the taxi delay times for stopping. This is to be further tabulated by aircraft type and ownership category, indicating the company if a scheduled airline (air carrier).

b. <u>For departure</u> -

(1) The time interval between successive take-offs from a given runway which are not interspersed by a landing on that runway; i.e. take off-to-take off times.

(2) Runway occupancy time; i.e. runway occupancy-to-take off threshold time.

(3) Undelayed taxi time from the gate to the active runway, identifying the runway, taxi route and engine run-up area and time; i.e. same as for arrivals above (3), in reverse.

The above data were extracted directly from the refined raw data sheets, and means and deviations were calculated. In addition, numerous other items (times, distances, or delays) were evaluated in order to determine their significance. These are discussed in the text of Volume II and also in this Volume I.