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MIAMI INTERNATIONAL AIRPORT TECHNICAL PLAN. AIRPORT IMPROVEMENT--ETC(U)

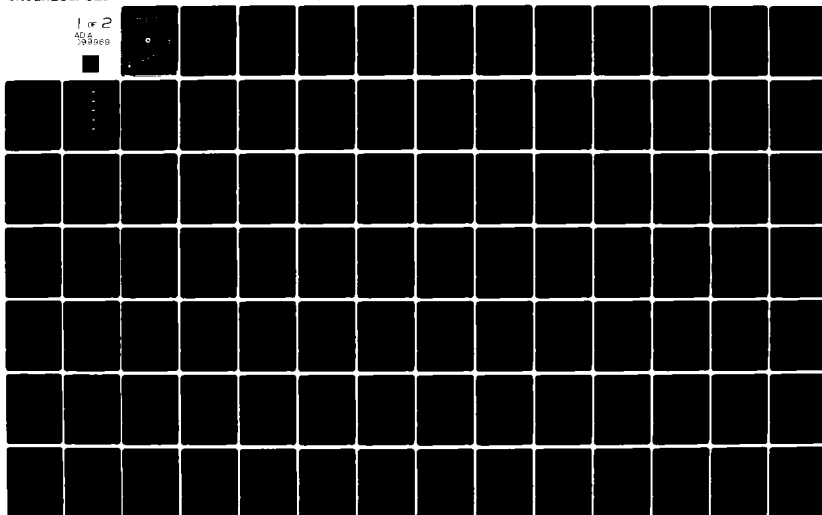
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AIRPORT IMPROVEMENT TASK FORCE DELAY STUDIES



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16. Abstract This report contains supporting documentation for the detailed analysis of the Miami International Airport. The analysis was conducted by the Airport Improvement Working Group which has representatives from the airport sponsor, the Air Transport Association, the airlines serving Miami, and the Federal Aviation Administration. Technical support was provided by Peak, Marwick, Mitchell & Co., and the FAA Technical Center. The purpose of the analysis was to determine the causes of delay and the potential delay reduction benefits of recommended improvements. The effort was part of the Airport Improvement Program.			
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MIAMI INTERNATIONAL AIRPORT TECHNICAL PLAN.

Airport Improvement Task Force Delay Studies.

Volume II.

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Federal Aviation Administration
National Aviation Facilities Experimental Center
Atlantic City, New Jersey

and

Peat, Marwick, Mitchell & Co.
San Francisco, California

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ACKNOWLEDGEMENT

Except for site specific revisions to schedules and design of experiments, this technical plan is essentially the same as the basic technical plan developed by Peat, Marwick, Mitchell and Company for the Airport Improvement Task Forces. NAFEC appreciates the efforts of PMM & Co. in the development of the basic plan and the specific efforts of Dr. Stephan Hockaday in the review of this technical plan.

CONTENTS

I	INTRODUCTION	I-1
	Task Force Objectives	I-1
	Approach and Milestones	I-2
	Experimental Design	I-2
	Data Requirments	I-3
II	APPROACH AND MILESTONES	II-1
	Organization	II-1
	Work Tasks and Responsibilities	II-1
	Milestones and Schedule	II-5
III	EXPERIMENTAL DESIGN	III-1
	Simulation Model Experiments	III-3
	Annual Delay Model Experiments	III-9
IV	DATA REQUIREMENTS	IV-1
	Data Needs for Model Runs	IV-1
	Data Sources	IV-6
	Field Data Collection Plan	IV-12

Appendixes

- A MODELS AVAILABLE TO TASK FORCE
- B IMPROVEMENT ITEMS
- C INPUT DATA FORMS

LIST OF TABLES

II-1	Task Force Airport Milestones	II-6
II-2	Recommended Task Force Meetings	II-7
II-3	Suggested Task Force Activity Schedule. . .	II-13
III-1	Miami Delay Experiments	III-4
IV-1	Sources of Data for Airfield Simulation. . . . Model Calibration	IV-8
IV-2	Sources of Baseline Data for Annual Delay Model	IV-11

LIST OF FIGURES

I-1	Preliminary Airfield Network	I-4
II-1	Organizational Framework	II-2
II-2	Airport Task Sequence	II-3
III-1	Study Cases	III-6
III-2	Hypothetical Results of Nine Annual Delay Experiments	III-10
IV-1	Arrival Data Collation Form	IV-15
IV-2	Departure Data Collation Form	IV-16
C-1	Link Data Form	C-1
C-2	Gate Data.	C-2
C-3	Separation Data Form	C-3
C-4	Route Data Form	C-4
C-5	Aircraft Gate Service Times	C-5
C-6	Airspace Travel Time Data Form	C-6
C-7	Arrival Aircraft Lateness Distribution.	C-7
C-8	Demand Data Form	C-8

I. INTRODUCTION

This technical plan has been designed for use by FAA Headquarters, the Miami Task Force, NAFEC, and PMM & Co. during the Miami International Airport Delay Improvement Study. The plan consists of three parts and includes recommendations for the following:

- . Approach and Milestones--establishes work tasks, responsibilities, and the interrelationship of Task Force participants, as well as major milestones representing decision/approval/redirection points in the study. (Chapter II)
- . Experimental Design--describes criteria and recommendations for model runs to prepare delay estimates. (Chapter III)
- . Data Requirements--specifies model inputs and outputs, and data collection needs and responsibilities. (Chapter IV)

Task Force Objectives

FAA Headquarters established the following objectives to guide the delay analysis:

- . Identify causes of delay associated with terminal airspace, airfield, and apron/gate area operations.
- . Determine delay reduction benefits of alternative air traffic control (ATC) procedures, Facilities and Equipment (F&E), Airport Development Aid Program (ADAP), and Research, Engineering and Development (R, E&D) improvement options for immediate, near-term (pre-1985) and long-term (post-1985) implementation.
- . Establish the relationships between air traffic demands and delay in the present and in the future.

This technical plan describes a recommended approach for the Miami Task Force delay studies in response to these objectives and to the specific needs of the Miami Task Force. The delay studies are oriented to assist the Task Force in evaluating high-priority airfield improvements

that can be implemented in the near future, and to assist FAA Headquarters in evaluating the potential benefits of its research and development activities.

Approach and Milestones

Chapter II of this technical plan identifies specific milestones and task responsibilities for FAA Headquarters, the Miami Task Force, NAFEC, and PMM&Co.

Six major tasks are identified:

- . Develop Technical Plan and Experimental Design
- . Collect Input Data
- . Perform Model Calibration
- . Run Delay Models
- . Interpret Delay Results
- . Develop Airport Delay Analysis Report

In addition, coordination meetings at key decision points and for purposes of monitoring Task Force progress are discussed in Chapter II together with recommendations for meeting objectives, agendas, and preparation responsibilities.

Experimental Design

Chapter III of this technical plan describes the process of developing and selecting experiments to be used for estimating delays. This process is referred to as "experimental design."

Because of the large number of possible near-term and long-term improvements, as well as the variety of operating conditions to be considered (runway use, weather, demand level, ATC system scenarios, etc.), a screening process was used to select the delay experiments that are recommended to meet the stated objectives.

As noted in Chapter III, experiments are planned to be conducted in two stages so that final decisions on experiments scheduled for the second stage can be reviewed after the results of the first-stage experiments are evaluated.

Data Requirements

A series of models are available to assist the Task Force in computing delays to aircraft. These models are outlined in Appendix A.

The PMM&Co. airfield simulation model is available for computations of hourly and/or daily delays to aircraft. The simulation model also computes aircraft flow rates and travel times.

The annual delay model is available for computations of annual delays to aircraft. The annual delay model also computes distributions of average aircraft delays.

A number of additional models are also available to the Task Force, including (1) a weather model to analyze weather occurrence at an airport based on raw airport climatological data from the National Weather Records Center, and (2) an analytical runway capacity model that computes estimates of hourly runway capacity.

Data needs for model calibration and model runs to prepare delay estimates are discussed in Chapter IV. Some data are available from the Miami Interim Report*, some data will be derived from an analysis of historical data, and other data will be collected by field observations.

A preliminary airfield network reflecting the current configurations for Miami International Airport was prepared from available data and is set forth in Figure I-1.

*Miami International Airport Improvement Program, Interim Report, October 1977.

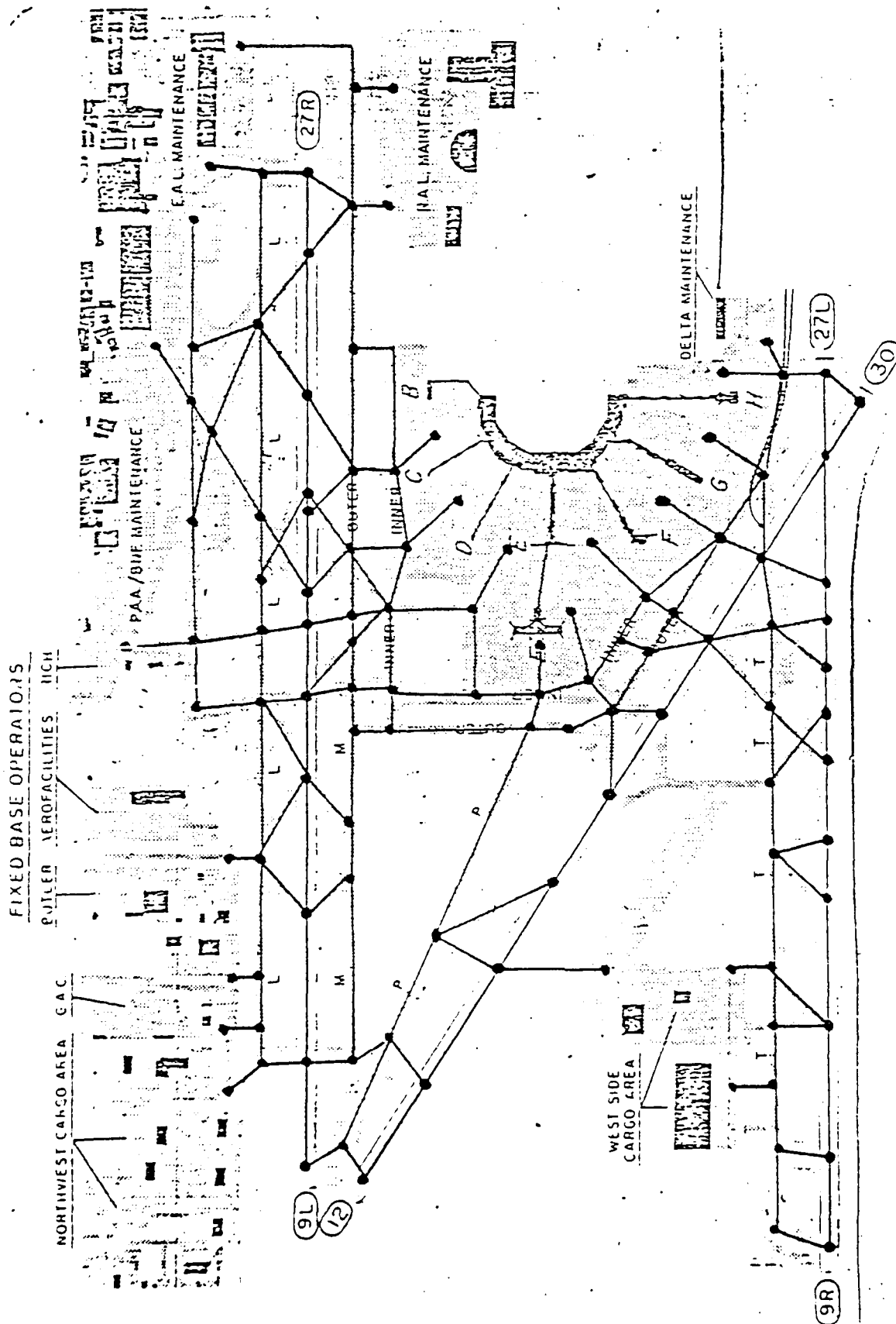


Figure I-1
 PRELIMINARY AIRFIELD NETWORK
 Miami International Airport
 Delay Improvement Study
 October 1978

II. APPROACH AND MILESTONES

Organization

The organizational framework for the Miami Task Force activity is shown in Figure II-1.

The FAA Southern Region manages the activities of the Miami Task Force. Executive direction for the activities is provided by the FAA Air Traffic and Airways Facilities Program Management Staff (ATF-4).

The FAA Office of Systems Engineering Management (AEM-100) manages the technical support for the Task Force analysis, including resources from NAFEC, PMM&Co., and other support.

Work Tasks and Responsibilities

Six major tasks are to be performed by the Miami Task Force, FAA Headquarters, NAFEC, and PMM&Co.:

1. Develop Technical Plan and Experimental Design
2. Collect Input Data
3. Perform Model Calibration
4. Run Delay Models
5. Interpret Delay Results
6. Develop Task Force Delay Analysis Report

Task interrelationships are given in Figure II-2. Descriptions of the six major tasks are given below.

Task 1--Develop Technical Plan and Experimental Design. NAFEC prepares a suggested technical plan for the airport. The technical plan describes the recommended method of approach for the conduct of the delay studies at the airport, including a recommended airport-specific experimental design, task responsibilities, and time schedules.

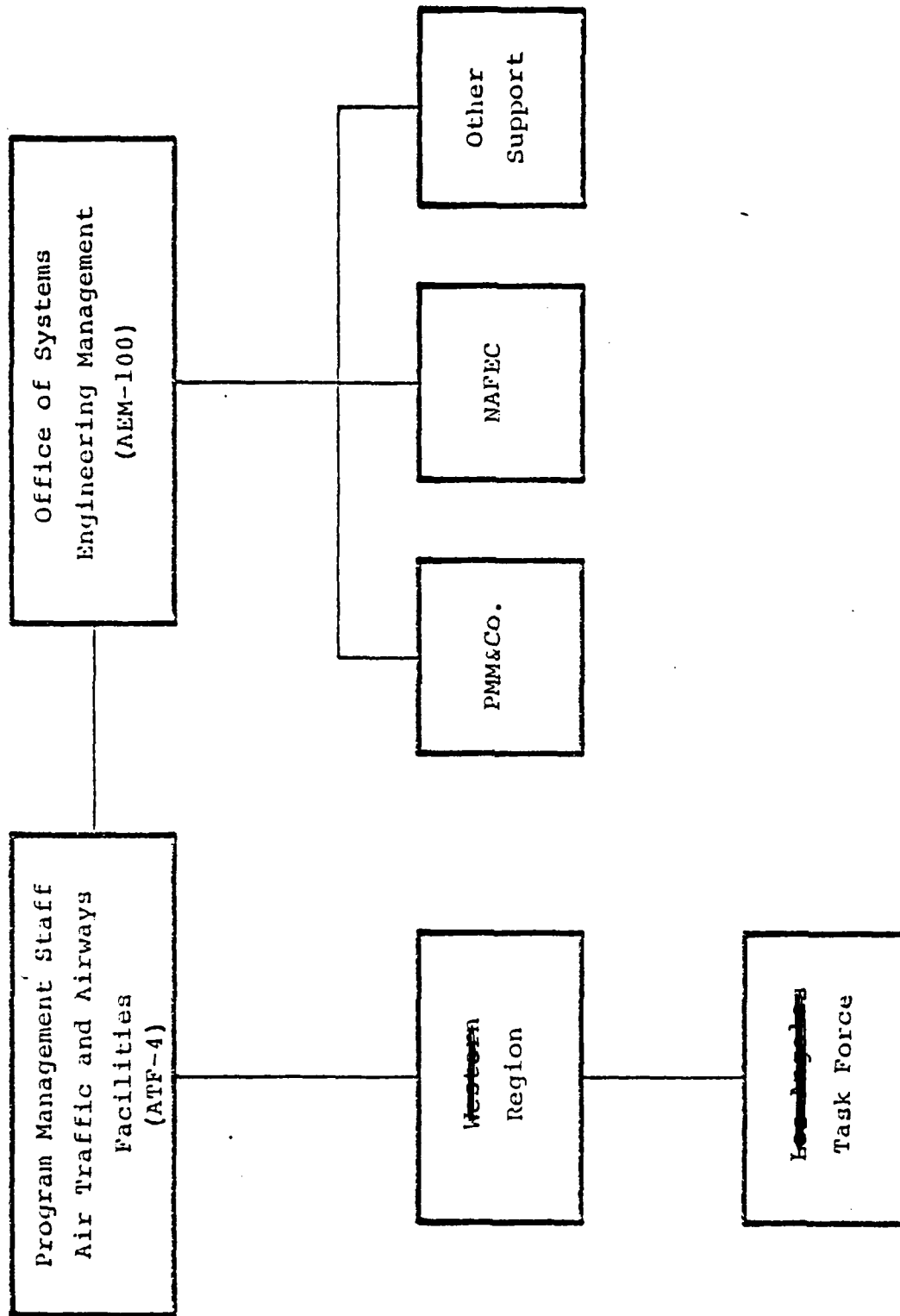


Figure II-1
ORGANIZATIONAL FRAMEWORK
Miami International Airport
Delay Improvement Study
October 1978

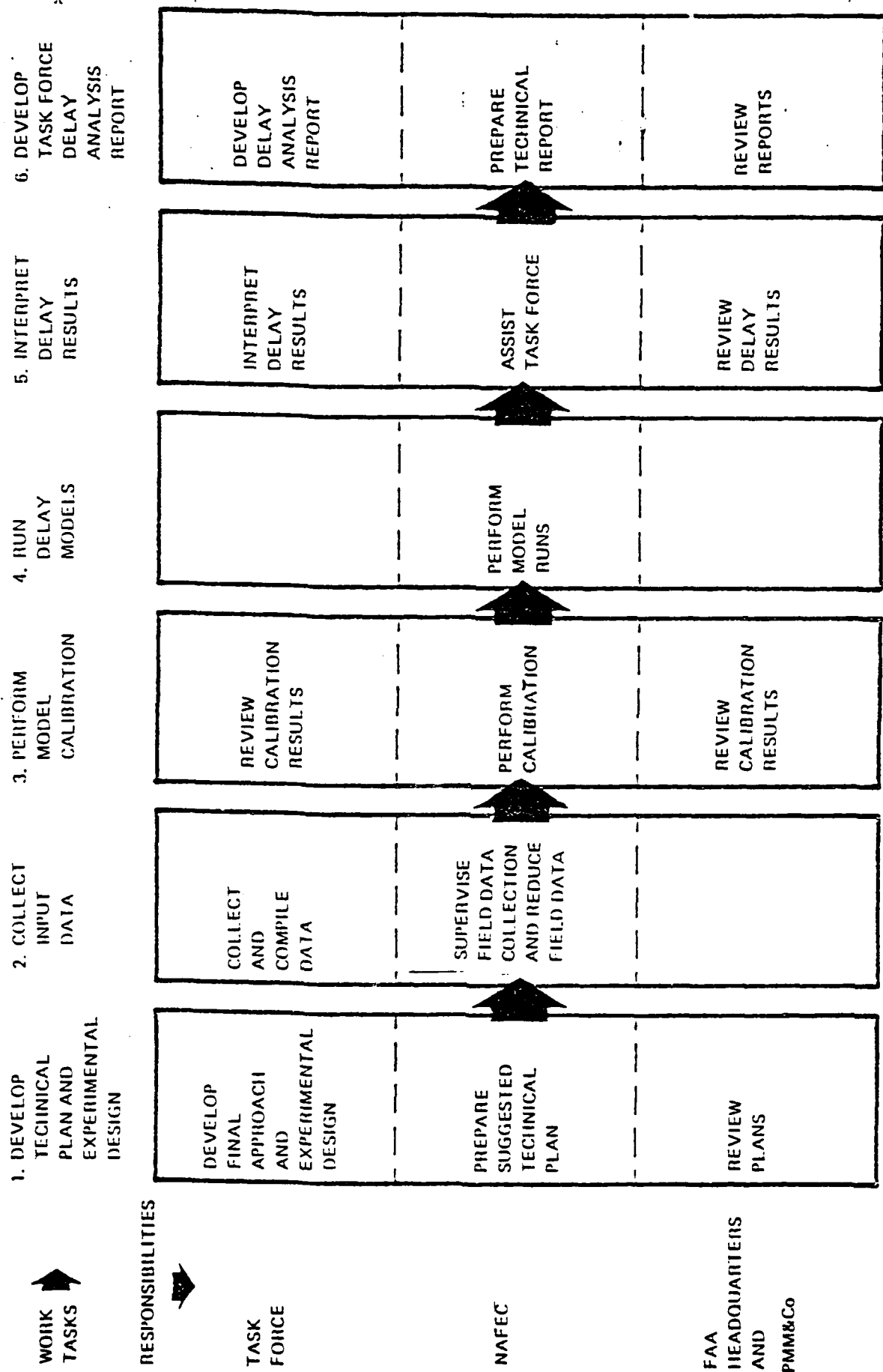


Figure II-2
 AIRPORT TASK SEQUENCE
 Miami International Airport
 Delay Improvement Study
 October 1978

The plan also identifies methods for obtaining delay estimates using the PMM&Co. airfield simulation model, annual delay model, or other techniques as appropriate. The Task Force and FAA Headquarters review the plan and the Task Force develops a final technical approach and experimental design.

Task 2--Collect Input Data. NAFEC describes data requirements for applying the delay model(s) for developing delay estimates. The Task Force (with assistance from NAFEC and PMM&Co.) establishes data needs for delay experiments, and collects, compiles, and reviews the data. The data to be collected include field data, data currently in the possession of Task Force members, and data to be provided by NAFEC and PMM&Co. The field data are reduced by NAFEC using currently available data reduction computer programs.

Task 3--Perform Model Calibration. On the basis of data obtained in Task 2, NAFEC consolidates the data, performs calibration model runs, and demonstrates results to the Task Force. The model calibration assures that the simulation model correctly reflects the site-specific airport situation.

Task 4--Run Delay Models. NAFEC performs model runs for delay estimates. Models used may include the airfield simulation model, as well as ancillary models such as the annual delay model. The model runs result in the production of delay estimates for the experiments established in the experimental design.

Task 5--Interpret Delay Results. The Task Force (with assistance from NAFEC and PMM&Co.) interprets the delay estimates. Interpretation of the total set of delay estimates provides guidance in evaluating the impact on delay (for the appropriate study cases) of one or more of the following: (1) changes in demand level, including aircraft mix; (2) changes in runway use patterns; (3) changes to runway/taxiway/apron areas; (4) new ATC procedures, including changes in separation standards; and (5) navigation aids and other ATC improvements.

Task 6--Develop Task Force Delay Analysis Report. NAFEC prepares a technical report that documents the delay analyses performed. The Task Force, FAA Headquarters, and PMM&Co. review the technical report. The Task Force develops a Delay Analysis Report

that includes (1) the conclusions drawn by the Task Force from the delay analyses and (2) a set of recommendations for reducing delays to aircraft at the airport.

Milestones and Schedule

A series of overall milestones are recommended concerning the completion of significant tasks, delivery of products, and decision points of Miami Task Force activities, as listed in Table II-1.

Task Force Meetings. At key decision points and for purposes of monitoring progress in relation to the study milestone, a series of Task Force meetings are recommended.

The specific objectives and outputs of the meetings are summarized in Table II-2. Suggested details on the objectives, agendas, and preparation responsibilities for these meetings are shown in the following list.

Task Force Meeting No. 1:

a. Objectives

Briefings will be given to bring Task Force members up to date on plans, schedules, and responsibilities. The technical plan and experimental design will be reviewed, and a plan will be established to collect and compile the required model input data to obtain delay estimates.

b. Agenda

1. Introduction and background
2. Presentation on technical plan
3. Presentation and discussion of data requirements for model calibration and delay experiments
4. Establishment of data collection and reduction procedure (including commitment of personnel and data responsibilities)

TABLE II-1
TASK FORCE AIRPORT MILESTONES
Miami International Airport Delay Improvement Study

<u>Milestone No.</u>	<u>Milestone</u>	<u>Target Completion Date</u>
1	Review technical plan	October 12, 1978
2	Identify data requirements	October 12, 1978
3	Collect field data	November 3, 1978
4	Consolidate calibration data	November 30, 1978
5	Complete model calibration	December 15, 1978
6	Consolidate delay input data	December 15, 1978
7	Complete delay runs	February 28, 1979
8	Interpret impact of delay results	March 14, 1979
9	Review draft reports	April 12, 1979
10	Prepare reports	April 30, 1979

TABLE II-2

RECOMMENDED TASK FORCE MEETINGS

Miami International Airport Delay Improvement Study

<u>Meeting No.</u>	<u>Objectives</u>	<u>Outputs</u>	<u>Target Meeting Date</u>
1	Give briefing on technical plan, experimental design, and data requirements	Comments on technical plan and data requirements for calibration and delay study	October 12, 1978
2	Review calibration and finalize experimental design	Calibration data and experimental design	November 30, 1978
3	Review calibration results and delay input data	Approved model and input data for delay studies	January 17, 1979
4	Review Stage 1 delay runs and plan for Stage 2 delay runs	Updated Stage 2 delay input data	February 14, 1978
5	Review and interpret impacts of delay results	Impacts of delay results	March 14, 1979
6	Review draft NAFEC technical report and Task Force delay analysis report	Comments on draft report	April 12, 1979

5. Establishment of experimental design subgroup
6. Working session on experimental design
7. Definition of procedure to develop demand forecasts
8. Description of tasks to be performed prior to Task Force Meeting No. 2
9. Preparations for Task Force Meeting No. 2

c. Preparation Responsibilities

NAFEC will develop briefing materials on the technical plan, experimental design, data requirements, and field data collection and Task Force members will read and review the technical plan. The Task Force Chairman will work with FAA Headquarters to determine resource needs and commitments.

Task Force Meeting No. 2:

a. Objectives

The Task Force will review the data for model calibration, review progress on development of model input data for delay estimates, and finalize the experimental design.

b. Agenda

1. Review of minutes of Task Force Meeting No. 1
2. Presentation on model calibration data collection and reduction
3. Working session on calibration data
4. Selection of input and output data for model calibration run
5. Review of progress on data development for delay estimates

6. Review of experimental design
7. Finalization of demand forecast data
8. Description of tasks to be performed prior to Task Force Meeting No. 3
9. Arrangements for Task Force Meeting No. 3

c. Preparation Responsibilities

NAFEC, and the Task Force will develop briefing materials describing model input data collected and reduced. The experimental design subgroup will develop a recommended experimental design for review and discussion.

Task Force Meeting No. 3:

a. Objectives

The Task Force will review the model calibration results and establish the input data for delay estimates.

b. Agenda

1. Review of minutes of Task Force Meeting No. 2
2. Presentation and discussion of model calibration results
3. Presentation and discussion of input data for delay estimates
4. Select input data for delay estimates
5. Description of tasks to be performed prior to Task Force Meeting No. 4
6. Arrangements for Task Force Meeting No. 4

c. Preparation Responsibilities

NAFEC will prepare briefing materials describing model calibration results and input data developed for delay

estimates. The Task Force will prepare briefing materials describing input data developed for delay estimates.

Task Force Meeting No. 4:

a. Objectives

The Task Force will review results of Stage 1 delay estimates and update requirements for Stage 2 delay estimates.

b. Agenda

1. Review of minutes of Task Force Meeting No. 3
2. Interpretation and discussion of Stage 1 delay estimates
3. Definition of requirements for Stage 2 delay estimates
4. Description of tasks to be performed prior to Task Force Meeting No. 5
5. Arrangements for Task Force Meeting No. 5

c. Preparation Responsibilities

NAFEC will develop briefing materials on the results of Stage 1 delay estimates and input data for Stage 2 delay estimates.

Task Force Meeting No. 5:

a. Objectives

The Task Force will review the results of Stage 2 delay estimates and interpret the impacts of the results. The Task Force will also review the schedules and outlines of the Task Force delay analysis report and NAFEC technical report.

b. Agenda

1. Review of minutes of Task Force Meeting No. 4
2. Presentation of Stage 2 delay estimates
3. Interpretation of impact of delay results
4. Review of Task Force and NAFEC report outlines and completion schedules
5. Description of tasks to be performed prior to Task Force Meeting No. 6
6. Arrangements for Task Force Meeting No. 6

c. Preparation Responsibilities

NAFEC will develop briefing materials on results of Stage 2 delay estimates and on the target schedule and outline for the NAFEC technical report. The Task Force will develop briefing materials on the schedule and preliminary outline of the Task Force delay analysis report.

Task Force Meeting No. 6:

a. Objectives

The draft technical report prepared by NAFEC and the delay analysis report prepared by the Task Force will be reviewed. Plans to work toward implementation of improvements will be discussed.

b. Agenda

1. Review of minutes of Task Force Meeting No. 5
2. Presentation and discussion of draft NAFEC technical report
3. Presentation and discussion of draft Task Force delay analysis report

4. Description of remaining reporting and implementation activities
5. Concluding remarks by FAA Headquarters, including discussion of Task Force recommendations

c. Preparation Responsibilities

The Task Force and NAFEC will develop briefing materials on the draft reports. The Task Force will review the draft NAFEC technical report and draft Task Force delay analysis report.

Schedule. A suggested schedule for performance of the various tasks is illustrated in Table II-3. The schedule is keyed to the milestones and Task Force meetings described previously, as well as the time requirements and interactions of the various tasks shown in Figure II-2. The suggested schedule also reflects the planning for other Task Force airports to conserve resources and overall schedules.

TABLE II-3

SUGGESTED TASK FORCE ACTIVITY SCHEDULE

MIAMI INTERNATIONAL AIRPORT DELAY IMPROVEMENT STUDY

<u>Task or Major Subtask</u>		<u>Target Start Date</u>	<u>Target Completion Date</u>
1.	Develop recommended Technical Plan and Experimental Design	September 6, 1978	October 6, 1978
2.	Collect input data Establish input data requirements Collect field data Collect Task Force data Collect FAA ATC system scenario data Consolidate input data for delay estimates Review input data Update Stage 2 data	September 6, 1978 October 30, 1978 October 12, 1978 October 12, 1978 October 12, 1978 November 10, 1978 December 16, 1978 November 16, 1978	September 14, 1978 November 3, 1978 November 10, 1978 November 10, 1978 November 10, 1978 December 23, 1978 January 17, 1979 November 24, 1978
3.	Perform model calibration Consolidate calibration data Perform calibration model run Review calibration results	November 13, 1978 November 30, 1978 December 16, 1978	November 30, 1978 November 16, 1978 January 17, 1979
4.	Run delay models Perform Stage 1 runs Review Stage 1 runs Perform Stage 2 runs	January 17, 1979 February 7, 1979 February 20, 1979	February 7, 1979 February 14, 1979 February 28, 1979
5.	Interpret delay results Interpret Stage 1 results Interpret Stage 2 results Review delay results	February 7, 1979 March 1, 1979 March 1, 1979	February 14, 1979 March 8, 1979 March 14, 1979
6.	Develop NAFEC technical report and Task Force delay analysis report Prepare draft reports Review draft reports Prepare final reports	March 14, 1979 March 28, 1979 April 12, 1979	March 28, 1979 April 12, 1979 April 30, 1979

III. EXPERIMENTAL DESIGN

The process of selecting and developing delay experiments to be used for estimating delay values is referred to as "experimental design." Because there are many combinations of possible near- and long-term improvements as well as a variety of operating conditions to be considered (runway use, weather, demand level, ATC scenarios, etc.), one important activity was the selection of the combinations of improvements and operating conditions for recommended experiments.

The process of screening and evaluation of possible experiments used in preparing the technical plan reflects the following:

- . Objectives of the Miami Task Force and FAA Headquarters
- . Results of the capacity phase of the Miami Task Force Study documented in the Interim Report
- . Improvements and changing conditions since the Miami Interim Report
- . Impact of near- and long-term improvements on delay reduction (reflecting the frequency of impact, as well as the magnitude and importance of the impact during critical periods at the airports, e. g., high delays in low visibility conditions)
- . ATC system scenarios considered likely in the future

To achieve Task Force objectives, two types of delay estimates are required: (1) hourly and/or daily delays, which may be produced by the airfield simulation model, and (2) annual delays, which may be produced by annual delay model.

Descriptions of the airfield simulation model, annual delay model, and other ancillary models available to the Task Force are presented in Appendix A.

Hourly and/or daily delay estimates will be used:

- . To assess details of aircraft operations on the existing airfield
- . To estimate the impact of near-term (pre-1985) improvements

Annual delay estimates will be used:

- . To estimate the impact of long-term (post-1985) improvements
- . To facilitate economic analysis in both the near term and the long term

To achieve these objectives, a set of experiments is recommended for three time frames: today, pre-1985, and post-1985. The experiments will estimate aircraft delays that may occur in these three time frames.

Delay experiments are recommended that will illustrate the delays to aircraft that may occur in the future under alternative assumptions or "scenarios."

The first scenario is the situation "most likely" to occur in a particular time frame--for example, the pre-1985 most likely scenario.

To estimate aircraft delays for this scenario, it is necessary to establish (1) the most likely level of demand, (2) the package of near-term improvements that is most likely to be implemented, and (3) the most likely ATC system scenario. Development of this scenario requires judgments by the Task Force on the most likely situation in the pre-1985 time frame.

The impact of individual improvement items can then be assessed by performing additional experiments and comparing the resulting delays with the delays estimated for the most likely scenario.

For example, assume that an additional taxiway is planned for implementation in the post-1985 time frame. Then the most likely pre-1985 scenario will exclude this additional taxiway. The impact of the additional taxiway on delays in the pre-1985 time frame can be estimated by comparing two delay estimates: (1) delays computed for the pre-1985 most likely scenario (without the additional taxiway), and (2) delays

computed by an additional experiment that adds the additional taxiway to the package of most likely pre-1985 near-term improvements.

Therefore, delay experiments are recommended that establish most likely delays to aircraft and estimate delay savings associated with individual improvement items.

Thirty-three experiments are recommended for Miami International Airport, as listed in Table III-1.

The experiments are divided into two stages. This permits the results of the first-stage experiments to influence and possibly redirect the second-stage experiments.

Table III-1 shows that 24 delay experiments are planned to be performed with the airfield simulation model (ASM), and 9 experiments are planned to be performed with the annual delay model (ADM).

For each delay experiment, Table III-1 also shows the study case, arrival and departure runways, weather, and the time frame for the demand, ATC system scenario, and near-term improvements.

Simulation Model Experiments

Twenty-four simulation model experiments are recommended to compute hourly and/or daily delays to aircraft.

To establish the appropriate delay experiments, the capacity analyses documented in the Miami Interim Report were examined, and discussions were held with Task Force members. The interim report identified study cases (combinations of runway use and weather). Four of the six study cases and values of baseline hourly runway capacity considered in the Miami Interim Report are depicted in Figure III-1, together with 5 additional study cases suggested for inclusion in the delay study.

Six baseline experiments (Experiments 1 through 6) are recommended to assess delays to aircraft in 1978 for different runway uses and weather conditions.

Five additional experiments (Experiments 7, 8, 9, 10, and 17) are included to show the consequences of not making any airfield or ATC

TABLE III-1

MIAMI DELAY EXPERIMENTS

Experiment Number	Model	Study Case	Arrival Runways	Departure Runways	Weather	Demand	ATC System Scenario ^b	Near-term Improvements ^c
Stage 1 Experiments								
1	ASM ^d	1	9L, 9R, 12	9L, 9R, 12	VFR1	Todays	Todays	None
2	ASM	2	27L, 27R, 30	27L, 27R, 30	VFR1	Todays	Todays	None
3	ASM	3	27L, 27R	27L, 27R, 30	VFR2	Todays	Todays	None
4	ASM	4	9L, 9R	9L, 9R, 12	IFR1	Todays	Todays	None
5	ASM	5	27L, 27R	27L, 27R	IFR1	Todays	Todays	None
6	ASM	8		9L	IFR2	Todays	Todays	None
7	ASM	1	9L, 9R, 12	9L, 9R, 12	VFR1	Pre-1985	Todays	None
8	ASM	2	27L, 27R, 30	27L, 27R, 30	VFR1	Pre-1985	Todays	None
9	ASM	4	9L, 9R	9L, 9R, 12	IFR1	Pre-1985	Todays	None
10	ASM	8		9L	IFR2	Pre-1985	Todays	None
11	ASM	1	9L, 9R, 12	9L, 9R, 12	VFR1	Pre-1985	Pre-1985	Pre-1985 ^e
12	ASM	7	27L, 27R, 30	27L, 27R, 30	VFR2	Pre-1985	Pre-1985	Pre-1985 ^e
13	ASM	9	9L, 9R	9L, 9R, 12	IFR2	Pre-1985	Pre-1985	1, 2
14	ASM	1	9L, 9R, 12	9L, 9R, 12	VFR1	Pre-1985	Pre-1985	Pre-1985, 50% less GA. 9
15	ASM	5	27L, 27R	27L, 27R	IFR1	Pre-1985	Pre-1985	Pre-1985, 50% less GA. 9
20	ASM	5	27L, 27R	27L, 27R	IFR1	Pre-1985	Pre-1985	Pre-1985, 50% less GA. 9
Stage 2 Experiments								
17	ASM	3	27L, 27R	27L, 27R, 30	VFR2	Pre-1985	Todays	None
18	ASM	2	27L, 27R, 30	27L, 27R, 30	VFR1	Pre-1985	Pre-1985	Pre-1985
19	ASM	3	27L, 27R	27L, 27R, 30	VFR2	Pre-1985	Pre-1985	Pre-1985
21	ASM	9	9L, 9R	9L, 9R, 12	IFR2	Pre-1985	Pre-1985	Pre-1985
22	ASM	1	9L, 9R, 12	9L, 9R, 12	VFR1	Pre-1985	Pre-1985	Pre-1985, 25% less GA. A.
23	ASM	1	9L, 9R, 12	9L, 9R, 12	VFR1	Pre-1985	Pre-1985	Pre-1985, 75% less GA. A.
24	ASM	5	27L, 27R	27L, 27R, 30	IFR1	Todays	Todays	61
25	ASM	2	27L, 27R, 30	27L, 27R, 30	VFR1	Pre-1985	Pre-1985	Pre-1985 + overflow parking ^j
26	ADM ^h	n.a.	n.a.	n.a.	n.a.	Todays	Todays	Todays
27	ADM	n.a.	n.a.	n.a.	n.a.	Pre-1985	Pre-1985	Pre-1985
28	ADM	n.a.	n.a.	n.a.	n.a.	Pre-1985	Pre-1985	Pre-1985
29	ADM	n.a.	n.a.	n.a.	n.a.	Pre-1985	Todays	Pre-1985
30	ADM	n.a.	n.a.	n.a.	n.a.	Post-1985	Post-1985	Post-1985
31	ADM	n.a.	n.a.	n.a.	n.a.	Post-1985	Post-1985	Post-1985
32	ADM	n.a.	n.a.	n.a.	n.a.	Todays	Todays	Post-1985
33	ADM	n.a.	n.a.	n.a.	n.a.	Post-1985	Todays	None

See footnotes following page

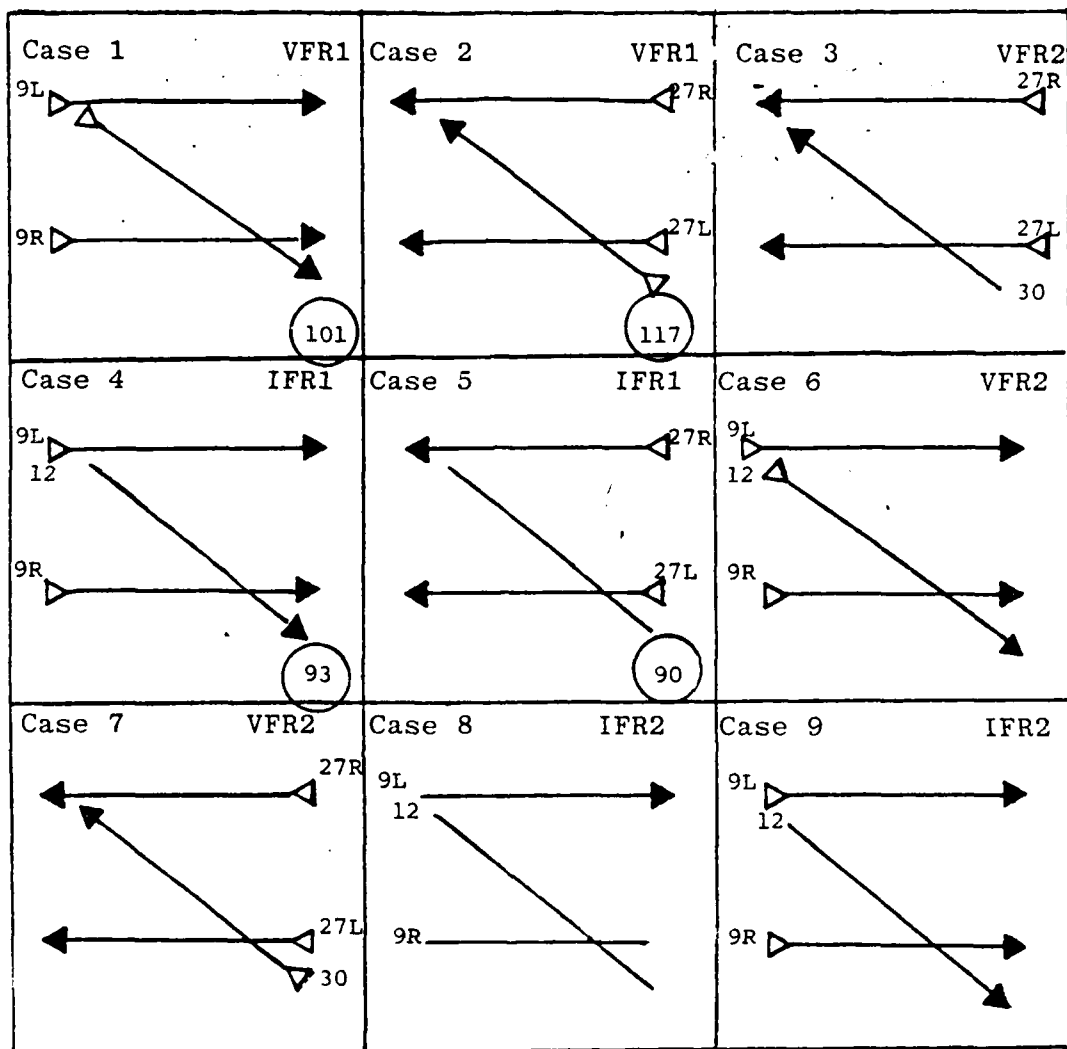
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n.a. = not applicable

- a. Study cases (combination of runway use and weather conditions) are defined in Figure III-1.
- b. FAA will describe impact of pre-1985 and post-1985 ATC systems on model inputs.
- c. Potential near-term improvements are identified in the Miami International Airport Improvement Task Force Interim Report, and in Appendix B.
- d. Airfield Simulation Model
- e. Task Force will establish packages of near-term improvements most likely to be implemented in the pre-1985 and post-1985 time frames. Improvements to runways 9L/27R, 9R/27L, and 12/30 identified as improvements 1, 2, and 3 in Appendix B most likely to be included in pre-1985 improvements.
- f. Improvement #1 is an improved taxiway system of runway 9L/27R, centerline lighting and touch down zone lighting on runway 9L, and 250-foot baseline RVR systems on runway 9L/27R.
- g. Improvement #2 is centerline lighting and dual 250-foot baseline RVR systems on runway 9R/27L.
- h. Reduction in general aviation achieved by upgrading Opa Locka and Tamiami General Aviation Reliever Airports.
- i. Annual Delay Model
- j. Improvement #6 is the use of 2 mile in-trail staggered parallel approaches.
- k. Improvement #8 is overflow parking positions within the terminal area.

12/8/78

STUDY CASES--MIAMI INTERNATIONAL AIRPORT DELAY IMPROVEMENT STUDY--OCT. 1978



◁ Arrival Aircraft

◀ Departure Aircraft

Weather VFR1--Ceiling greater than 1500 feet and visibility greater than 5 miles

VFR2--Ceiling between 1000 feet and 1500 feet and visibility between 3 miles and 5 miles

IFR1--Ceiling between 200 feet and 1000 feet and/or visibility between 2400 feet RVR and 3 miles

IFR2--Ceiling between 200 feet and 1000 feet and/or visibility between 1800 feet RVR and 2300 feet RVR

FIGURE III-1

improvements in the near term while airport demand increases from today's level of activity to that forecast for the pre-1985 time frame.

Six experiments (Experiments 11, 12, 18, 19, 20, and 21) are recommended to assess delays to aircraft in the pre-1985 time frame if an improved ATC system scenario is available and if various physical improvements are implemented. These runs study the most likely situation with the most likely airfield and ATC near-term improvements.

To develop other experiments to estimate the impact of near-term improvements, the near-term improvement items identified in the Miami Interim Report (and listed in Appendix B) were assessed. This assessment resulted in recommendations to perform simulation model experiments associated with the following improvement items:

- #1 Improve the taxiway system of runway 9L/27R. Install runway centerline lighting and touch down zone lighting on runway 9L. Install dual 250-foot baseline RVR systems on runway 9L/27R.
- #2 Install runway centerline lighting and dual 250-foot baseline RVR systems on runway 9R/27L.
- #3 Install high intensity runway lights, an Instrument Landing System, and an Approach Lighting System on runway 30. Provide paved blast protection shoulders on runway 12/30. Implement operational procedures to make greater use of the intersection take-off position on runway 30 and simultaneous use of runway 12 and 9R.
- #4 Upgrade Opa Locka and Tamiami General Aviation Reliever Airports, to encourage low performance general aviation aircraft to relocate out of MIA.
- #5 Study the feasibility of installing a VOR-DME on or in close vicinity to MIA.
- #6 Use 2 mile in-trail staggered parallel approaches at MIA, to improve capacity without the extra tower staff required for full independent parallel approaches.
- #7 Install Vortex Advisory System (VAS) monitors at both ends of all three runways at MIA.

- #8 Provide overflow aircraft parking positions within the terminal area.

Experiment 13 is recommended to assess the delay impact of the runway lighting improvements listed in improvements #1 and #2. The improved taxiway system identified in #1 is tested in experiments 11 and 18 for both eastwardly and westwardly flow of traffic under VFR¹ weather conditions.

Improvements to runway 12/30 (listed as improvement #3) can be assessed by evaluating the results of experiments 12, 17, 20, and 21.

Four experiments are recommended to study improvement #4, the upgrading of General Aviation Reliever Airports. Experiments 14, 15, 22, and 23 study the effects of this improvement by reducing the amount of general aviation using Miami International Airport.

Experiment 24 is recommended to study improvement #6, the use of 2 mile in-trail staggered parallel approaches at MIA. Improvement #8, the installation of overflow parking positions is recommended to be studied using experiment 25.

The benefits of installing Vortex Advisory Systems (VAS) monitors at both ends of all three runways is tested by being included in the most likely pre-1985 ATC scenario. Experiments 11, 12, 18, 19, 20, and 21 are included to test the most likely pre-1985 airport and ATC improvements.

Therefore, a total of 24 simulation model experiments are recommended:

- . 6 1978 baseline experiments
- . 5 experiments to show the impact of not making improvements while demand increases to the pre-1985 forecast level
- . 6 pre-1985 experiments for most likely scenarios of ATC and airport improvements
- . 7 experiments to assess near-term improvements identified in the Interim Report

Annual Delay Model Experiments

Nine annual delay model experiments are recommended to compute annual delays to aircraft.

One baseline delay experiment is recommended to estimate annual average delay to aircraft for today's situation (Experiment 16).

Two additional experiments are recommended to cover the most likely scenario for two future time frames--pre-1985 (Experiment 26) and post-1985 (Experiment 30).

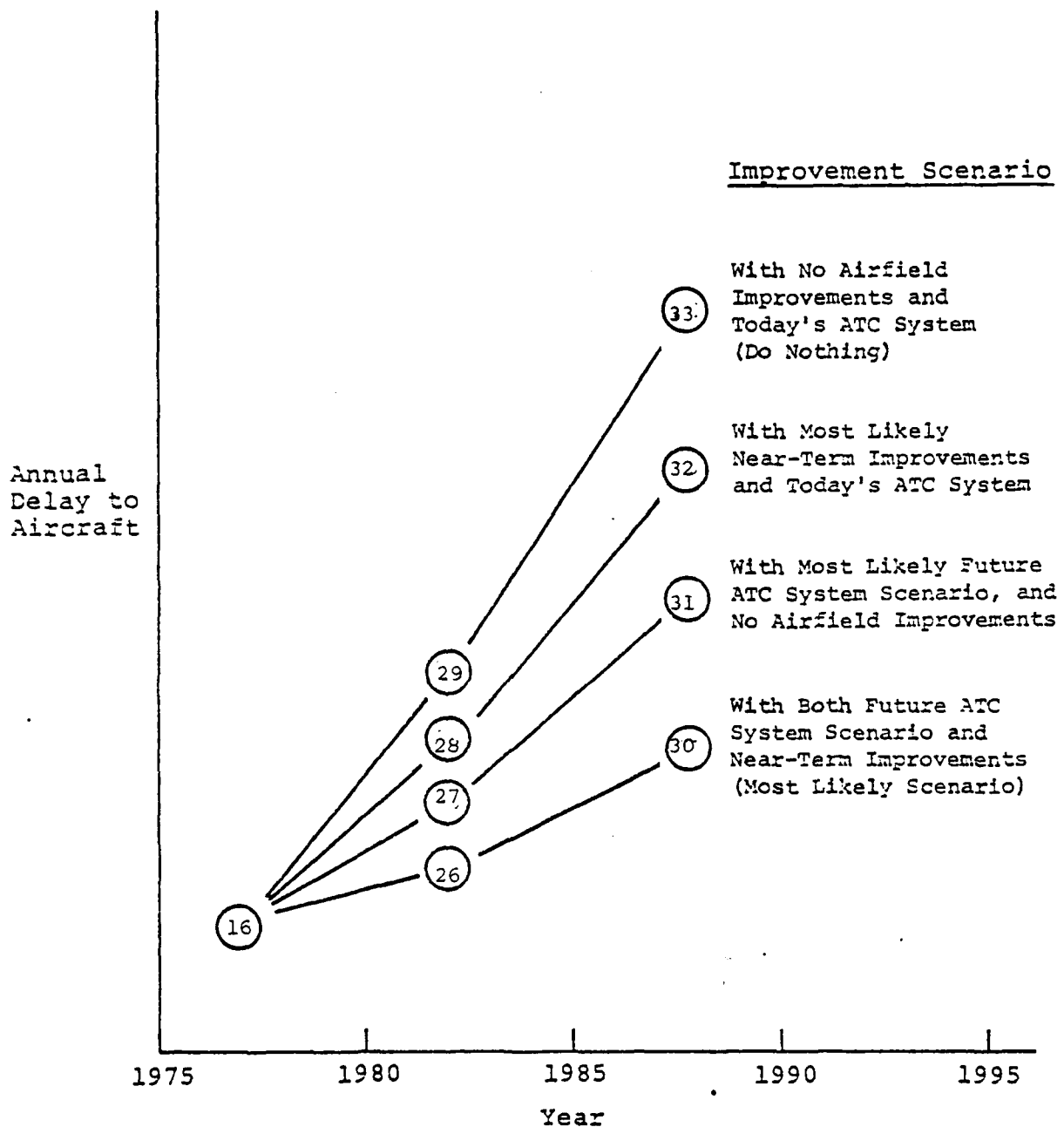
Six additional sensitivity experiments are recommended to assess the delays that may occur if the most likely scenario of combinations of near-term improvements and ATC systems is not implemented, three experiments in each of the pre-1985 and post-1985 time frames. The three pre-1985 experiments are designed to assess:

- . the absence of airfield improvements (Experiment 27)
- . the absence of future ATC systems (Experiment 28), and
- . the do-nothing situation (Experiment 29)

The three post-1985 experiments (Experiments 31, 32, and 33) are designed to perform the same assessments in the longer time frame.

The interrelationship of these nine annual delay model experiments is illustrated in Figure III-2, which shows the variation of average annual aircraft delay with time. The variation is based on hypothetical results of the nine annual delay estimates.

The foregoing paragraphs describe 33 recommended delay experiments. Additional or alternative delay experiments may be considered by the Task Force. It is suggested that an experimental design subgroup meet to discuss the recommended experiments and to finalize those experiments to be performed.



Legend

(31) Delay experiment number

Figure III-2

HYPOTHETICAL RESULTS OF NINE
ANNUAL DELAY EXPERIMENTS
Miami International Airport
Delay Improvement Study
October 1978

IV. DATA REQUIREMENTS

Data Needs for Model Runs

The airfield simulation model and the annual delay model are recommended to be run to perform the model calibration and to prepare the delay estimates. Each model run requires a set of input data that describes the conditions being investigated.

Input Data for Airfield Simulation Model. The 38 types of input data required to run the simulation model are described below:

a. Logistics

1. Title: A brief description of the model application.
2. Random Number Seeds: Each random number seed represents a daily set of variations of events. (The number of random number seeds is selected to achieve stochastic convergence of results.)
3. Start and Finish Times: The times when the run is to start and finish.
4. Print Options: Several options are available concerning level of detail of output, debugging statements, etc.
5. Airline Names: The two-letter codes for each airline included in the demand data (include dummy code for general aviation or military aircraft).
6. Processing Options: Several options are available concerning the way input data are processed, e.g., print input data only.
7. Truncation Limits: Applies to the limits of normal distribution used in the Monte Carlo sampling technique. Defined in terms of a number of standard deviations.

8. Time Switch: Permits variation of model inputs during a model run at a particular time. (Special care must be taken when using the time switch to avoid model operation inconsistencies.)

b. Airfield Physical Characteristics

9. Airfield Network: A description of the airfield in terms of a network of links and nodes.
10. Number of Runways: The number of runways.
11. Runway Identification: Their identifiers.
12. Departure Runway End Links: The taxiway link(s) that can be occupied by aircraft prior to being given departure clearance.
13. Runway Crossing Links: The taxiway link(s) that can be occupied by aircraft prior to crossing an active runway, together with clearance times to the crossing taxiway for arriving and departing aircraft.
14. Exit Taxiway Location: The distance from the threshold of each exit taxiway, by runway.
15. Holding Areas: Those sections of taxiways or apron that are used for storing arrival aircraft that are awaiting a gate.
16. Airline Gates: The gates belonging to each airline.
17. GA Basing Areas: The basing areas for general aviation aircraft.

c. ATC Procedures

18. Aircraft Separations: Mean and standard deviation of minimum separations for each aircraft pair class for arrival-arrival, departure-arrival, departure-departure, and arrival-departure sequences (for each runway and for pairs of dependent runways).

19. Route Data: Link sequence for routes from each exit taxiway to each gate and each gate to each departure runway. Also, link sequence for routes from each exit taxiway to each holding area and from each holding area to each gate.
20. Two-Way Path Data: Link sequence for those sections of taxiway used by aircraft that may be traveling in either direction.
21. Common Approach Path(s): Length of the common approach to each runway by aircraft class.
22. Vectoring Delays: Level of airborne delay (by fix) to arrival aircraft at which holding delays start to occur.
23. Departure Runway Queue Control: Queue lengths (by runway) above which aircraft may be diverted to a different departure runway.
24. Gate Hold Control: Queue lengths (by runway) above which aircraft may be held at gate.
25. Departure Airspace Constraints: Mean and standard deviation of effect of departure airspace constraints on delays, and percentage of departures affected.
26. Departure Queue Control: Departure queue lengths above which interarrival spacings will be increased to release departures.
27. Runway Crossing Delay Control: Delays to taxiing aircraft waiting to cross an active runway above which interarrival spacings will be increased to permit crossings.

d. Aircraft Operational Characteristics

28. Exit Taxiway Utilization: Distribution of exit taxiway usage by aircraft class.

29. Arrival Runway Occupancy Times: Data on runway occupancy times for different distances from runway threshold by aircraft class.
30. Touch-and-Go Runway Occupancy Times: Mean and standard deviation by aircraft class.
31. Departure Runway Occupancy Times: Mean and standard deviation by aircraft class.
32. Taxi Speeds: Aircraft taxiing speeds for each of six taxiway link-types.
33. Approach Speeds: Mean and standard deviation by aircraft class.
34. Gate Service Times: Mean and standard deviation by aircraft class.
35. Airspace Travel Times: Undelayed travel times from approach fix to threshold and from threshold to departure fix by aircraft class.
36. Runway Crossing Times: Time for taxiing aircraft to cross active runway.
37. Lateness Distribution: Distribution of deviations from scheduled arrival times to be used in conjunction with an airline schedule (if applicable).
38. Demand: Detailed list of aircraft, including scheduled arrival and departure times, aircraft class, desired arrival and departure runway and fixes, flight type, preferred gate assignment for air carrier aircraft, and basing area for general aviation.

Four classes of aircraft are used when defining the model inputs (Classes 1, 2, 3, and 4). Each aircraft using the airport is assigned to one of the four classes. The definitions of the aircraft classes should reflect the significant groupings of aircraft at the airport that have similar operating characteristics (e.g., approach speed).

In defining the classes, it is important to note that the simulation model gate logic assumes that an aircraft can use a gate for its class number or a lower class number.

Blank data forms that may be used to assemble key input data items (Nos. 9, 18, 19, 34, 35, 37, and 38) are presented in Appendix C.

Input Data for Annual Delay Model. Fifteen types of input data required to run the annual delay model are listed below.

1. Annual Demand: Number of annual operations.
2. Group Specification: Number of day groups (up to 7); week groups (up to 52); weather groups (up to 10); and runway uses (up to 10).
3. Weekly Traffic: Proportion of total annual traffic in one week of each week group.
4. Number of Weeks: In each group.
5. Daily Traffic: Proportion of weekly traffic in one day of each group.
6. Number of Days: In each day group.
7. Weather Group Demand Factors: Ratio of demand in each weather group to the demand in the first weather group. There are as many factors as weather categories.
8. Weather Occurrences: Proportion of occurrence of each weather group in any given week group (i.e., the sum of all weather group occurrences for any week group is 1.0).
9. Hourly Runway Capacity: Hourly runway capacities for each runway use and weather combination.
10. Runway Use Occurrences: Proportion of time each runway use will be operated in the different weather conditions.

11. Hourly Traffic: Proportion of daily traffic to be distributed to each of the 24 hours.
12. Demand Profile Factor: (The proportion of peak-hour traffic in the peak 15 minutes.) This factor can take one of six values: 25, 30, 35, 40, 45, and 50.
13. Runway Use Demand Factor: Ratio of demand for each runway use to the demand for the first runway use. There are as many factors as runway uses.
14. Aircraft Mix: Mix for each runway use and weather combination. The mix should be that used to compute the hourly runway capacity.
15. User-Specified Title: Identifying alphanumeric name to be printed in the output.

Data Sources

Data required for model runs will be developed by the Task Force, with assistance from NAFEC and PMM&Co. Planned responsibilities and procedures for development of the data are described below under the following classifications:

- Airfield Simulation Model Calibration Data
- Revisions to Simulation Model Input Data for Delay Experiments
- Annual Delay Model Baseline Data
- Revisions to Annual Delay Model Input Data for Delay Experiments

Airfield Simulation Model Calibration Data. Model calibration is designed to make the model site-specific to the Miami situation. The calibration effort involves a comparison of observed field data on aircraft flow rates, delays, and travel times with outputs from a simulation model run. The simulation model run requires a set of input data that reflects the operating conditions prevalent during the collection of the observed field data.

Therefore two types of data are needed for model calibration-- (1) model input data and (2) field data for comparison with model outputs. The three planned sources for these two types of data--the Task Force, Field Data, and NAFEC--are listed in Table IV-1.

- Data from the Task Force refers to information currently in the possession of or available to the Task Force. For example, estimates of the level of airborne delay to arrival aircraft at which holding starts to occur (Input No. 22) may be obtained from ATC personnel.
- Field data refers to information that will be obtained by the Task Force by field observation during a data collection activity. For example, the travel time for aircraft taxiing from gate to runway may be obtained by visual observation of the time the aircraft leaves its gate and the time that it reaches the runway. (Details of field data collection are given later in this chapter.)
- Data from NAFEC refers to information currently in the possession of or to be developed by NAFEC. For example, NAFEC will provide departure runway occupancy times based on the previously performed capacity analyses.

Revisions to Simulation Model Input Data for Delay Experiments. Each simulation model experiment described in Chapter III requires input data that describe the situation being examined. The data will be based on the model calibration data described above. Revisions will be made to the model calibration input data to reflect the conditions to be investigated in each delay experiment. The revisions may impact any of the 38 types of input.

All of the revisions to simulation model input data for delay experiments will be developed by the Task Force, with assistance from NAFEC, PMM&Co. and FAA Headquarters. No additional field data collection is anticipated.

Table IV-1
SOURCES OF DATA FOR
AIRFIELD SIMULATION MODEL CALIBRATION

Data Type	Source
<u>1 INPUT DATA</u>	
<u>a. Logistics</u>	
1 Title	NAFEC
2 Random number seeds	NAFEC
3 Start and finish times	Field Data
4 Print options	NAFEC
5 Airline names	NAFEC
6 Processing options	NAFEC
7 Truncation limits	NAFEC
8 Time switch	NAFEC
<u>b. Airfield Physical Characteristics</u>	
9 Airfield network	NAFEC
10 Number of runways	NAFEC
11 Runway identification	NAFEC
12 Departure runway end links	NAFEC
13 Runway crossing links	NAFEC
14 Exit taxiway location	NAFEC
15 Holding areas	Task Force
16 Airline gates	Task Force
17 General aviation basing areas	Task Force
<u>c. ATC Procedures</u>	
18 Aircraft separations	Field Data
19 Route data	Task Force
20 Two-way path data	Task Force
21 Common approach paths	Task Force
22 Vectoring delays	Task Force
23 Departure runway queue control	Task Force
24 Gate hold control	Task Force
25 Departure airspace constraints	Task Force
26 Departure queue	Task Force
27 Runway crossing delay control	Task Force
<u>d. Aircraft Operational Characteristics</u>	
28 Exit taxiway utilization	Task Force
29 Arrival runway occupancy times	Task Force
30 Touch-and-go runway occupancy times	NAFEC
31 Departure runway occupancy times	NAFEC
32 Taxi speeds	Field Data
33 Approach speeds	Field Data
34 Gate service times	Task Force
35 Airspace travel times	Field Data
36 Runway crossing times	Field Data
37 Lateness distribution	Task Force
38 Demand	Field Data
<u>2 OUTPUT DATA</u>	
A Flow rates	Field Data
B Delays	Field Data
C Travel times	Field Data

Each delay experiment involves some or all of the following types of changes from the model calibration situation:

- Study Case--the runways in use and the weather condition may differ
- Demand--the number of aircraft operations in each hour may differ
- Near-Term Improvements--improvement items may be added that impact aircraft operations
- ATC System Scenarios--a future ATC system may be added that changes ATC procedures

For example, from Table III-1 it can be seen that Experiment 21 is designed to investigate the potential benefits of a remote parking position for international arrivals. To develop the input data for this experiment, the input data for model calibration should be revised as follows.

The Study Case is changed from the calibration condition to a special study case that permits arrivals to park at the remote location. To correspond with this change, a number of model inputs must be revised--for example, the arrival taxiing routes must now connect the runways with the remote parking areas.

The Demand is changed from the calibration demand level to a level that reflects 1982 conditions. A revised schedule must be prepared that reflects forecasts of traffic increases and changes in aircraft mix that represent the Task Force view of the 1982 time period.

The ATC System Scenario that is considered most likely to be implemented in the 1982 time period is defined. Model inputs are then revised to reflect the improvement package--for example, aircraft separations may be reduced to reflect the presence of a wake vortex advisory system.

Annual Delay Model Baseline Data. Delay Experiment 17 calls for an estimate of average annual delay to aircraft under 1977 baseline conditions.

The planned sources for the 15 types of data required for the baseline run are shown in Table IV-2. No additional field data collection is anticipated. However, discussion of some of the data types will be required to help define the input definition. For example, definition of the occurrence of runway uses may involve a comparison of Task Force historical data on runway uses with data on crosswinds, ceiling, and visibility.

One of the major input data items is the hourly runway capacity associated with each baseline study case. Some of this capacity information can be derived directly from the previous capacity work of the Task Force. Additional capacity information will be required, and the hourly runway capacity model (that was previously used for Los Angeles) will be used to provide the additional capacity information. A description of this capacity model is included in Appendix A.

Revisions to Annual Delay Model Input Data for Delay Experiments. Each annual delay model experiment recommended in Chapter III requires input data that describe the situation being examined. The 1977 baseline delay experiment is described above.

Input data for the remaining experiments will be based on the input data developed for the 1977 baseline delay experiment. Revisions will be made to the baseline input data to reflect the conditions to be investigated in each delay experiment. The revisions may impact any of the 15 types of input.

All of the revisions to annual delay model input data for delay experiments will be developed by the Task Force, with assistance from NAFEC, PMM&Co., and FAA Headquarters. No additional field data are anticipated.

The annual delay model experiments involve the following types of changes in input data from the baseline condition:

- Demand
- Near-Term Improvements
- ATC System Scenarios

In many cases, these types of changes in input data are similar to the changes for the simulation model described previously.

Table IV-2

SOURCES OF BASELINE DATA FOR ANNUAL DELAY MODEL

Data Type	Source
1 Annual demand	Task Force
2 Group specification	NAFEC
3 Weekly traffic	Task Force
4 Number of weeks in each group	NAFEC
5 Daily traffic	Task Force
6 Number of days in each group	NAFEC
7 Weather group demand factors	Task Force
8 Weather Occurrences	NAFEC
9 Hourly runway capacity	NAFEC
10 Runway use occurrences	Task Force
11 Hourly traffic	Task Force
12 Demand profile factor	NAFEC
13 Runway use demand factor	NAFEC
14 Aircraft mix	NAFEC
15 User-specified title	NAFEC

For example, the 1982 do-nothing experiment (Experiment 30) requires a change in the demand from the 1977 baseline demand and aircraft mix to the most likely 1982 demand and aircraft mix. Any corresponding changes in runway capacity are also required. Other inputs would remain unchanged, i.e., the same as the 1977 baseline.

Field Data Collection Plan

Field data are to be collected to provide input and output data for simulation model calibration. The major types of data that will be obtained are:

a. Inputs

- Airspace travel times
- Taxi times and speeds
- Demand
- Aircraft separations

b. Outputs

- Flow rates
- Delays
- Travel times

To obtain these data, field data are planned to be collected during the week of Monday, October 30, 1978. Data will be collected during peak periods on five consecutive weekdays. In the event of exceptional weather conditions or other contingencies, the data collection may extend into the following week.

The data to be obtained are the time that each aircraft in the observation period passes points on the airfield and in the airspace, as follows:

Arrival Aircraft

Arrival Fix
Runway Threshold
Onto Ramp

Departing Aircraft

Off Ramp
Departure Roll

In addition, sample data will be obtained for the following:

- Airspace and taxiway routes
- Undelayed travel times
- Exit utilization and runway occupancy times
- Runway crossing times

Visual observations will be made from vantage points in the ATC Tower (or other suitable locations) and by monitoring appropriate radar scopes. The data will be recorded manually on data forms and then reduced by NAFEC personnel using NAFEC data reduction computer programs.

The number of data collection personnel required will depend on the skills of the personnel and the available locations for observing aircraft operations. A preliminary assessment performed by NAFEC personnel indicates the potential need for 7 persons, plus the NAFEC supervisor and 2 clerical assistants to help collate the data. Potential assignments for the personnel are:

<u>Personnel Number</u>	<u>Data Collection Assignment</u>
1, 2	Arrival fix times (watching ARTS scope in TRACON)
3, 4	Arrival runway threshold time (observing from tower, and tuned to local control)
5	Departure roll times (observing from tower, and tuned to local control)
6	Ramp on and off times (observing from tower and tuned to ground control)
7	Backup for data collection and taking samples of aircraft routes, etc.

The data collection supervisor is responsible for noting details of airport operations (weather, runway use, special events, problems, etc.) and for assuring the completeness, clarity, and accuracy of the data collection forms. The supervisor ensures the continued availability of controller voice tapes (approach, local, and ground control) to assist in clarifying any uncertainties that arise during data reduction, and obtains the ARTS tapes, and the FAA Aircraft Delay Report (ADR) for the data collection period. The supervisor also arranges to receive the tower counts, PMS reports, and weather observations for the data collection period.

At the end of each data collection period, the supervisor checks the forms for completeness and accuracy and then organizes the collation of the data onto two sets of forms--one set each for arrivals and departures--that will show the time that each aircraft passes the fix, the runway, and the ramp. Sample data collation forms are shown in Figures IV-1 and IV-2. The form shown in Figure IV-1 is used for recording arrival aircraft information. Each observer of arrival aircraft records for each aircraft, in order, the aircraft identification (e.g., UA 390), the aircraft type (e.g., B727), and the aircraft class (A, B, C, or D). The observer also records the identification of the station (fix, runway, or gate) and the time (GMT, to the nearest second) the aircraft passes or reaches the station. A similar procedure is used for departure aircraft. Departure data are recorded on the form shown in Figure IV-2.

DATA COLLATION FORM - ARRIVALS

DATE		AIRCRAFT IDENT.	A/C TYPE	CLASS	APPR. FIX I.D.	ARRIVAL FIX TIME	R/W I.D.	RUNWAY THRESHOLD TIME	GATE I.D.	ARRIVAL GATE TIME
1	2	3	4	5	6	7	8	9	10	11
12	13	14	15	16	17	18	19	20	21	22
23	24	25	26	27	28	29	30	31	32	33
34	35	36	37	38	39	40	41	42	43	44
45	46	47	48	49	50	51	52	53	54	55
56	57	58	59	60	61	62	63	64	65	66
67	68	69	70	71	72	73	74	75	76	77
78	79	80	81	82	83	84	85	86	87	88
89	90	91	92	93	94	95	96	97	98	99
100	101	102	103	104	105	106	107	108	109	110
111	112	113	114	115	116	117	118	119	120	121
122	123	124	125	126	127	128	129	130	131	132
133	134	135	136	137	138	139	140	141	142	143
144	145	146	147	148	149	150	151	152	153	154
155	156	157	158	159	160	161	162	163	164	165
166	167	168	169	170	171	172	173	174	175	176
177	178	179	180	181	182	183	184	185	186	187
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199	200	201	202	203	204	205	206	207	208	209
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287	288	289	290	291	292	293	294	295	296	297
298	299	300	301	302	303	304	305	306	307	308
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716	717	718	719	720	721	722	723	724	725	726
727	728	729	730	731	732	733	734	735	736	737
738	739	740	741	742	743	744	745	746	747	748
749	750	751	752	753	754	755	756	757	758	759
760	761	762	763	764	765	766	767	768	769	770
771	772	773	774	775	776	777	778	779	780	781
782	783	784	785	786	787	788	789	790	791	792
793	794	795	796	797	798	799	800	801	802	803
804	805	806	807	808	809	810	811	812	813	814
815	816	817	818	819	820	821	822	823	824	825
826	827	828	829	830	831	832	833	834	835	836
837	838	839	840	841	842	843	844	845	846	847
848	849	850	851	852	853	854	855	856	857	858
859	860	861	862	863	864	865	866	867	868	869
870	871	872	873	874	875	876	877	878	879	880
881	882	883	884	885	886	887	888	889	890	891
892	893	894	895	896	897	898	899	900	901	902
903	904	905	906	907	908	909	910	911	912	913
914	915	916	917	918	919	920	921	922	923	924
925	926	927	928	929	930	931	932	933	934	935
936	937	938	939	940	941	942	943	944	945	946
947	948	949	950	951	952	953	954	955	956	957
958	959	960	961	962	963	964	965	966	967	968
969	970	971	972	973	974	975	976	977	978	979
980	981	982	983	984	985	986	987	988	989	990
991	992	993	994	995	996	997	998	999	1000	1001

*Number of hours per post may vary slightly

Figure IV-1
ARRIVAL DATA COLLATION FORM
Miami International Airport
Delay Improvement Study
October 1978

DATA COLLATION FORM - DEPARTURES

DATE		AIRCRAFT IDENT.	AIRCRAFT TYPE	CLASS	GATE I.D.	DEPARTURE PUSHBACK TIME	R/W I.D.	DEPARTURE ROLL TIME	DEP. FIX I.D.	DEPARTURE FIX TIME
1	2	3	4	5	6	7	8	9	10	11
12	13	14	15	16	17	18	19	20	21	22
23	24	25	26	27	28	29	30	31	32	33
34	35	36	37	38	39	40	41	42	43	44
45	46	47	48	49	50	51	52	53	54	55
56	57	58	59	60	61	62	63	64	65	66
67	68	69	70	71	72	73	74	75	76	77
78	79	80	81	82	83	84	85	86	87	88
89	90	91	92	93	94	95	96	97	98	99
100	101	102	103	104	105	106	107	108	109	110
111	112	113	114	115	116	117	118	119	120	121
122	123	124	125	126	127	128	129	130	131	132
133	134	135	136	137	138	139	140	141	142	143
144	145	146	147	148	149	150	151	152	153	154
155	156	157	158	159	160	161	162	163	164	165
166	167	168	169	170	171	172	173	174	175	176
177	178	179	180	181	182	183	184	185	186	187
188	189	190	191	192	193	194	195	196	197	198
199	200	201	202	203	204	205	206	207	208	209
210	211	212	213	214	215	216	217	218	219	220
221	222	223	224	225	226	227	228	229	230	231
232	233	234	235	236	237	238	239	240	241	242
243	244	245	246	247	248	249	250	251	252	253
254	255	256	257	258	259	260	261	262	263	264
265	266	267	268	269	270	271	272	273	274	275
276	277	278	279	280	281	282	283	284	285	286
287	288	289	290	291	292	293	294	295	296	297
298	299	300	301	302	303	304	305	306	307	308
309	310	311	312	313	314	315	316	317	318	319
320	321	322	323	324	325	326	327	328	329	330
331	332	333	334	335	336	337	338	339	340	341
342	343	344	345	346	347	348	349	350	351	352
353	354	355	356	357	358	359	360	361	362	363
364	365	366	367	368	369	370	371	372	373	374
375	376	377	378	379	380	381	382	383	384	385
386	387	388	389	390	391	392	393	394	395	396
397	398	399	400	401	402	403	404	405	406	407
408	409	410	411	412	413	414	415	416	417	418
419	420	421	422	423	424	425	426	427	428	429
430	431	432	433	434	435	436	437	438	439	440
441	442	443	444	445	446	447	448	449	450	451
452	453	454	455	456	457	458	459	460	461	462
463	464	465	466	467	468	469	470	471	472	473
474	475	476	477	478	479	480	481	482	483	484
485	486	487	488	489	490	491	492	493	494	495
496	497	498	499	500	501	502	503	504	505	506
507	508	509	510	511	512	513	514	515	516	517
518	519	520	521	522	523	524	525	526	527	528
529	530	531	532	533	534	535	536	537	538	539
540	541	542	543	544	545	546	547	548	549	550
551	552	553	554	555	556	557	558	559	560	561
562	563	564	565	566	567	568	569	570	571	572
573	574	575	576	577	578	579	580	581	582	583
584	585	586	587	588	589	590	591	592	593	594
595	596	597	598	599	600	601	602	603	604	605
606	607	608	609	610	611	612	613	614	615	616
617	618	619	620	621	622	623	624	625	626	627
628	629	630	631	632	633	634	635	636	637	638
639	640	641	642	643	644	645	646	647	648	649
650	651	652	653	654	655	656	657	658	659	660
661	662	663	664	665	666	667	668	669	670	671
672	673	674	675	676	677	678	679	680	681	682
683	684	685	686	687	688	689	690	691	692	693
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859	860	861	862	863	864	865	866	867	868	869
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914	915	916	917	918	919	920	921	922	923	924
925	926	927	928	929	930	931	932	933	934	935
936	937	938	939	940	941	942	943	944	945	946
947	948	949	950	951	952	953	954	955	956	957
958	959	960	961	962	963	964	965	966	967	968
969	970	971	972	973	974	975	976	977	978	979
980	981	982	983	984	985	986	987	988	989	990
991	992	993	994	995	996	997	998	999	1000	1001

Number of hours per day may vary slightly

Figure IV-2
DEPARTURE DATA COLLATION FORM
Miami International Airport
Delay Improvement Study
October 1978

The collated field data are then transferred to NAFEC for data reduction to produce the desired model inputs and outputs. After data reduction, the model inputs and outputs are used in the model calibration. It is planned that the data will be reviewed by the Task Force during the second Task Force meeting prior to use of the data for model calibration.

Appendix A

MODELS AVAILABLE TO TASK FORCE

This appendix provides an overview of the models that are available to assist the Task Force in computing delays to aircraft.

The PMM&Co. airfield simulation model is available for computations of hourly and/or daily delays to aircraft. The simulation model also computes aircraft flow rates and travel times.

The annual delay model is available for computations of annual delays to aircraft. The annual delay model also computes distributions of average aircraft delays.

A number of additional models are also available to the Task Force, including (1) a weather model to analyze weather occurrence at an airport based on raw airport climatological data from the National Weather Records Center, and (2) an analytical runway capacity model that computes estimates of hourly runway capacity.

I. AIRFIELD SIMULATION MODEL

The PMM&Co. airfield simulation model contains a set of logic statements that describe the significant movements performed by aircraft on the airfield and in the adjacent airspace. The simulation model operates by tracing the path of each aircraft through space and time on the airfield and adjacent airspace. The airfield is represented by a series of links and nodes depicting the paths that an aircraft could follow. The traces of the paths of all aircraft are made by continually advancing clock time and recording the new location of the aircraft. The records of aircraft movement are then processed by the model to produce desired outputs including delays, travel times, and flow rates.

The PMM&Co. airfield simulation model is a critical events model that employs Monte Carlo sampling techniques. Variable time increments are used as the time flow mechanism; clock time is advanced by the amount necessary to cause the next most imminent (i.e., critical) event to take place. Running time for the model, therefore, depends on the levels of aircraft demand (and the size of the airfield) for any particular application.

The use of Monte Carlo sampling techniques permits the day-to-day variations encountered in real life to be simulated by the model. Certain of the model parameters are stochastic (time variant and random) in nature. For example, arrival aircraft approach speeds will vary from day to day for any given aircraft depending on such factors as payload, wind, and pilot technique. The distribution of these variations can be approximated by the normal distribution. The model assigns arrival aircraft approach speeds by sampling values from a normal distribution with mean and standard deviation specified by the user. Other stochastic model parameters are:

- Arrival/arrival separations
- Departure/arrival separations
- Arrival/departure separations
- Departure/departure separations
- Arrival runway occupancy time
- Touch-and-go runway occupancy time
- Departure runway occupancy time

- Exit taxiway choice
- Gate service time
- Arrival aircraft deviation from schedule

Because of the modular structure of the model, analysis of the total airfield or its individual components can be performed by manipulation of the model inputs. This approach is more flexible and efficient than having separate submodels for the individual components and a composite model for the total airfield.

In the following paragraphs, further details of simulation model logic are described as follows:

- Movement of aircraft--description of the progress of an aircraft through the airfield system.
- Runway and airspace operations--description of ATC algorithms that separate pairs of aircraft on the runways and in the airspace.
- Taxiing operations--description of model logic that processes aircraft on taxiways.
- Gate operations--description of model logic that processes aircraft in the apron-gate area.

Movement of Aircraft

Arrival aircraft commence at the appropriate arrival fixes in accordance with generated demand inputs. For each arrival aircraft, approach speeds are assigned from an empirical distribution according to the class of the aircraft. For each arrival pair, interarrival times, final approach speeds, and wake turbulence characteristics are checked so that sufficient separation exists on the common approach path. (The length of the common approach path is specified by the user.) As each aircraft arrives over the threshold, an exit taxiway and associated runway occupancy time are assigned to the aircraft.

The aircraft's routing to the gate or basing area is established in the following manner. As an air carrier aircraft exits the runway, a check is made on the availability of a gate of the correct size belonging to the airline under

consideration. In the event a gate is not available, the aircraft is routed to a holding area where further checks on gate availability are made. In the case of general aviation or military aircraft, the aircraft's route to the basing area is assigned on the basis of the exit taxiway used and the location of the basing area.

Once an aircraft's route to the gate or basing area has been established, the aircraft is moved along its route from link-to-link on the airfield network. Checks are made at each link to determine whether the next link on the route is available or occupied by another aircraft. If the next link is occupied, the aircraft is not moved until the link is vacated. Thus, the travel time is increased for the particular aircraft, and delay is incurred.

When the aircraft reaches its gate, a gate occupancy time is assigned from empirical distributions and is added to the gate arrival time. This information, when compared with the scheduled departure time, determines the earliest time when the aircraft could leave the gate. The empirical distributions for gate occupancy time may reflect the typical bunching of the schedules of air carrier departures. When an aircraft is ready to leave the gate, a check is made to ensure that the ramp area is clear for push-back. The route to the departure runway is determined by the aircraft's basing area or gate location, the aircraft class, and the departure runways in use at that particular time.

In the case of general aviation or military aircraft, when the aircraft reaches the basing area, it is assumed to be parked and to have left the system. This assumption is necessary because of the unstructured nature of general aviation or military operations on the apron. The flow of aircraft from the basing area is generated from the demand inputs by producing an expected departure time from the basing area for each general aviation aircraft. The route to the departure runway is established by the location of the basing area and the departure runways in use.

When an aircraft reaches the threshold of the departure runway, compliance with ATC procedures is checked and confirmed before the aircraft is cleared for takeoff. The following checks are made:

- Has the previous dependent arrival cleared the runway?
- Is there sufficient separation from the next incoming dependent arrival?

- Is there sufficient separation from the previous dependent departure?

If all of these checks are positive, the aircraft is cleared for takeoff.

Runway and Airspace Operations

An ATC algorithm allows the specification of separations between aircraft on the same runway and on dependent runways. These separations are defined for an arrival following an arrival, a departure following an arrival, a departure following a departure, and an arrival following a departure. For arrivals or departures on each runway, the model checks that sufficient separation exists between the aircraft under consideration and any other aircraft operation on the same runway or any dependent runway. In determining the time separation between a pair of successive arrival aircraft at the runway threshold, the model takes into account:

1. The required air traffic control separation for the aircraft pair.
2. The final approach velocity of each aircraft.
 - a. If the trail aircraft is faster than the lead aircraft, the required arrival separation is assured at the runway threshold.
 - b. If the trail aircraft is slower than the lead aircraft, the required arrival separations are set up at the beginning of the common approach path. The amount of time the trail aircraft falls behind is included in the time separation over threshold for the aircraft pair.
3. Runway occupancy. Only one aircraft is permitted to occupy the runway at any given time.

The model determines a time separation between a pair of successive departure aircraft which takes into account the required air traffic control separation by aircraft pair. The model will permit a departure to roll on a runway (thus

interweaving arrivals and departures) when all of the following conditions have been fulfilled:

1. The previous arrival aircraft has exited.
2. When the departure begins to roll, the next arrival is far enough from the threshold for the departure to clear the runway before the arrival is over its threshold.
3. Sufficient separation from the previous departure exists.

For pairs of intersecting runways, the user must also input arrival-departure separations so the model checks that the arrival aircraft has cleared the intersection before a departure that is being cleared on the intersecting runway.

Several special ATC features are incorporated into the simulation model logic. One ATC feature included in the model increases arrival aircraft spacings on final approach to allow departure queues to be dissipated. The length of the departure queue (number of aircraft) at which the interarrival spacing is increased and the desired interarrival spacing (minutes) must be specified.

Another ATC feature included in the model searches departure runways for congestion before assigning a departure runway to an aircraft leaving its gate. A runway is selected that minimizes delay. If runway congestion is too heavy, the aircraft is held on the gate until the congestion reduces.

Taxiing Operations. The normal operation of the model moves aircraft from link to link on a predetermined path which is defined in terms of a series of links. The model performs a check to ensure that the next link on the path is not occupied by another aircraft before moving on to the link. It is assumed in the logic that the taxiway is used by aircraft moving in the same direction at all times, unless the user specifies to the contrary.

Taxiways on which aircraft may taxi in both directions are defined as two-way taxiways. These taxiways, which are defined by the user, may occur at several places on the airfield and are often found between pier fingers at a terminal building. The model checks aircraft movements to determine if the aircraft is about to enter a two-way path. In the event that an aircraft is about to enter a two-way path, the model then checks along the path to determine if there

are other aircraft on the path that may be moving toward a potential conflict. If a potential conflict exists, the aircraft for which the check is being made is delayed until the conflict condition no longer exists.

If an aircraft is about to taxi across an active runway, the model performs certain checks in accordance with ATC procedures to determine if it is safe for the aircraft to cross. Priority is always given to aircraft operating on the runway.

Gate Operations. Once a gate is assigned to an arriving air carrier aircraft, the model moves the aircraft from link to link on the network to the gate, observing a first-come-first served rule in the event of conflicts (except for taxiways across active runways). For those airfields having terminal buildings with pier fingers, a "two-way path" will often serve the gates between any two pier fingers. Thus, prior to entering the two-way path, the model will check for aircraft moving either toward or away from a particular gate on the path. In the event an aircraft is moving on the path toward a gate (i.e., away from the arrival aircraft for which the check is being performed), the model permits the arrival aircraft to taxi on the path toward its gate in "platoon fashion" similar to real-life operations. If an aircraft is taxiing from the gate or is in the process of pushing back, the arrival aircraft is held until the departing aircraft is clear of the two-way path.

When the model detects that an aircraft is ready to push back from the gate, a check is performed to see if the aircraft will push back onto a two-way path. If it will push back onto a two-way path, the model then checks for aircraft on the two-way path and permits "platooning" in a similar fashion as described for arrivals. If there is an aircraft taxiing toward the area which the departing aircraft will occupy during push-back, the aircraft is delayed on the gate until the arrival aircraft has cleared the area in question.

Procedure for Application of Model

The following is a typical procedure for applying the simulation model to evaluate aspects of airfield operations:

- Establish the conditions under which the application will be performed.

- Visit site to obtain first-hand familiarization with airfield operations.
- Assemble input data from (a) discussions with ATC, airport sponsor, and airline personnel; (b) historical data; and (c) field data collection as necessary. The preprocessor models should be used to prepare demand and routing data in machine compatible format.
- Coordinate input data with ATC, airport sponsor, and airline personnel.
- Load input data and use output options that permit input data to be reviewed before execution. Correct as necessary.
- Perform trial model run using one random number seed, with all diagnostic print options functioning, to check that the model is operating correctly for the input data that is being used. Correct as necessary.
- After confidence in model inputs has been established, suppress diagnostic print options before making the model runs for evaluation of airfield improvements.
- Determine level of output detail required for evaluation and specify appropriate print options.
- Perform model runs.
- Use postprocessor models as required to develop detailed statistical information on aircraft delays.

Inputs

The airfield simulation model was developed to be applicable to the range of airfield configurations currently in existence and to those configurations that are likely to evolve in the future. Consequently, the model does not contain any airport-specific or aircraft-class-specific data; all data are input.

Thus, the model may be applied to airfields ranging from a nontower general aviation field to an airfield with the complexity of Chicago O'Hare International Airport. It should be noted, however, that simulation model application is relatively expensive because of the model's complexity and the volume of input data required to run it. Therefore, the model is most often applied at airports with more complex airfield layouts that experience significant aircraft delays.

The 38 types of input data required to run the simulation model are listed below:

a. Logistics

1. Title: A brief description of the model application.
2. Random Number Seeds: Each random number seed represents a daily set of variations of events. (The number of random number seeds is selected to achieve stochastic convergence of results.)
3. Start and Finish Times: The times when the run is to start and finish.
4. Print Options: Several options are available concerning level of detail of output, debugging statements, etc.
5. Airline Names: The two-letter codes for each airline included in the demand data (include dummy code for general aviation or military aircraft).
6. Processing Options: Several options are available concerning the way input data are processed, e.g., print input data only.
7. Truncation Limits: Applies to the limits or normal distribution used in the Monte Carlo sampling technique. Defined in terms of a number of standard deviations.
8. Time Switch: Permits variation of model inputs during a model run at a particular time. (Special care must be taken

when using the time switch to avoid model operation inconsistencies.)

b. Airfield Physical Characteristics

9. Airfield Network: A description of the airfield in terms of a network of links and nodes.
10. Number of Runways: The number of runways.
11. Runway Identification: Their identifiers.
12. Departure Runway End Links: The taxiway link(s) that can be occupied by aircraft prior to being given departure clearance.
13. Runway Crossing Links: The taxiway link(s) that can be occupied by aircraft prior to crossing an active runway, together with clearance times to the crossing taxiway for arriving and departing aircraft.
14. Exit Taxiway Location: The distance from the threshold of each exit taxiway, by runway.
15. Holding Areas: Those sections of taxiways or apron that are used for storing arrival aircraft that are awaiting a gate.
16. Airline Gates: The gates belonging to each airline.
17. GA Basing Areas: The basing areas for general aviation aircraft.

c. ATC Procedures

18. Aircraft Separations: Mean and standard deviation of minimum separations for each aircraft pair class for arrival-arrival, departure-arrival, departure-departure, and arrival-departure sequences (for each runway and for pairs of dependent runways).
19. Route Data: Link sequence for routes from each exit taxiway to each gate and each gate to each departure runway. Also, link

sequence for routes from each exit taxiway to each holding area and from each holding area to each gate.

20. Two-Way Path Data: Link sequence for those sections of taxiway used by aircraft that may be traveling in either direction.
21. Common Approach Path(s): Length of the common approach to each runway by aircraft class.
22. Vectoring Delays: Level of airborne delay (by fix) to arrival aircraft at which holding delays start to occur.
23. Departure Runway Queue Control: Queue lengths (by runway) above which aircraft may be diverted to a different departure runway.
24. Gate Hold Control: Queue lengths (by runway) above which aircraft may be diverted to a different departure runway.
25. Departure Airspace Constraints: Mean and standard deviation of effect of departure airspace constraints on delays, and percentage of departures affected.
26. Departure Queue Control: Departure queue lengths above which interarrival spacings will be increased to release departures.
27. Runway Crossing Delay Control: Delays to taxiing aircraft waiting to cross an active runway above which interarrival spacings will be increased to permit crossings.

d. Aircraft Operational Characteristics

28. Exit Taxiway Utilization: Distribution of exit taxiway usage by aircraft class.
29. Arrival Runway Occupancy Times: Data on runway occupancy times for different distances from runway threshold by aircraft class.

30. Touch-and-Go Runway Occupancy Times: Mean and standard deviation by aircraft class.
31. Departure Runway Occupancy Times: Mean and standard deviation by aircraft class.
32. Taxi Speeds: Aircraft taxiing speeds for each of six taxiway link-types.
33. Approach Speeds: Mean and standard deviation by aircraft class.
34. Gate Service Times: Mean and standard deviation by aircraft class.
35. Airspace Travel Times: Undelayed travel times from approach fix to threshold and from threshold to departure fix by aircraft class.
36. Runway Crossing Times: Time for taxiing aircraft to cross active runway.
37. Lateness Distribution: Distribution of deviations from scheduled arrival times to be used in conjunction with an airline schedule (if applicable).
38. Demand: Detailed list of aircraft including scheduled arrival and departure times, aircraft class, desired arrival and departure runway and fixes, flight type, preferred gate assignment for air carrier aircraft, and basing area for general aviation.

Four classes of aircraft are used when defining the model inputs (Classes 1, 2, 3 and 4). Each aircraft using the airport is assigned to one of the four classes. The definitions of the aircraft classes should reflect the significant groupings of aircraft at the airport that have similar operating characteristics (e.g., approach speed).

In defining the classes, it is important to note that the simulation model gate logic assumes that an aircraft can use a gate for its class number or a lower class number.

At the beginning of each run, the model assumes that there are no aircraft on the airfield. Aircraft are generated at

various locations on the airfield and in the adjacent airspace according to the demand schedule. To obtain relevant data for the time period being simulated, it is recommended that preloading be used. Preloading may be accomplished in one of two ways:

1. Start the simulation run approximately one hour ahead of the period of interest, using appropriate demand levels for that hour, or
2. Include in the demand schedule the aircraft that may be parked at the various airline gates at the beginning of the period of interest.

The first alternative is normally preferred if the period of interest being simulated is relatively short, i.e., one or two hours. If the period being simulated is greater than two hours, then the second alternative may be used.

Tests on the convergence of the model's stochastic parameters have indicated that it is normally desirable to use at least ten random number seeds when making a model run. Ten random number seeds, in effect, simulate the day-to-day variations of aircraft operations on ten days, for the period of the day under consideration.

Outputs

The primary outputs from the delay model are aircraft delays, travel times, and flow rates. In addition, the locations of aircraft delays are shown and departure runway queuing statistics are produced. The model outputs may be obtained in two levels of detail.

Summary Output. The summary output, which is automatically produced by the program together with a listing of the output data, contains the following information for each hour of the model run.

- Flow rates on runways, taxiways, and gates by aircraft class for arrival and departure aircraft.
- Delays (in minutes) for arrival and departure aircraft. For arrival aircraft, air delays are broken down into holding and

vectoring delays by approach fix and by runway, while ground delays are identified as taxi-in, runway crossing, and gate delays. For departure aircraft, ground delays are broken down into gate, taxi-out, runway crossing, and runway delays; departure gate delays (gate holds) and runway delays are broken down by cause (i.e., runway congestion and airspace congestion).

- Travel times (in minutes) for arrival and departure aircraft are given by fix, runway, and aircraft class.
- In addition to the summary information noted above, delays are provided for individual arrival and departure aircraft and for the location of those delays, (i.e., by link number). It is not meaningful to provide these data as average values over a number of random number seeds. Therefore, individual aircraft delays and link delays are provided for the last random number seed specified in the input data.

Detailed Output. The detailed output is a time-ordered record of the movements of individual aircraft as they move from link to link in the network. The information contained in the detailed output for each individual aircraft movement includes the following:

- Aircraft identification number
- Aircraft state
- Aircraft class
- Gate assignment (where applicable)
- Time over threshold (for arrival)
- Gate service time (where applicable)
- Gate departure time
- Simulation clock time
- Location of aircraft

All times are given in hours, minutes, and seconds except for times included in error messages and diagnostics which are given in minutes.

In addition to this detailed information, the number of aircraft in the queue for a departure runway is printed out each time an aircraft joins the queue and each time an aircraft is given clearance for takeoff. The information contained in this detailed output permits the user to follow the movement of individual aircraft and identify the cause(s) of the delay that an aircraft may experience.

II. ANNUAL DELAY AGGREGATION MODEL

Annual delay is made up of the sum of the individual aircraft delays that occur in each hour of the 365 days of the year. The annual delay aggregation model is an analytical model that takes information on airfield demand and capacity, computes hourly and daily delay, and aggregates daily delays to compute total annual delay, average delay per aircraft, and the distribution of delays.

The annual delay aggregation model computes hourly delays for a number of conditions that are representative of the seasonal and daily variations in demand, weather, runway use, and capacity.

The model assumes that the variations in demand over the year can be characterized by a number of representative daily demands. The number of representative daily demands used in an analysis for a particular airport depends on (1) the variability of daily and hourly demands through the year, and (2) the desired level of refinement in estimating annual delay. The model is capable of accommodating up to 365 daily demands, if desired or necessary.

The model converts annual demand into representative hourly demands using three demand distributions:

- Week-group distribution of demand
- Day-group distribution of demand
- Hourly distribution of demand

A week group is a set of weeks that have similar demand and weather characteristics. The week-group distribution of demand provides the proportion of annual demand that occurs in each week of a week group.

A day group is a set of days within a week that have similar demand characteristics. The day-group distribution of demand provides the proportion of weekly demand that occurs in each day of a day group.

The hourly distribution of demand provides the proportion of daily demand that occurs in each hour of the day.

The occurrence of different weather conditions and runway uses, and the hourly runway capacities corresponding to these occurrences, are provided as input to the model. These inputs are used to determine hourly demand and capacity.

Hourly delays are calculated for each hour of the year using delay curves built into the model. The average delay per operation for the year is computed by aggregating these hourly delays.

The three major steps in the model's calculation process are summarized as follows:

1. Determine each representative daily demand as follows:
 - a. Identify annual demand
 - b. Estimate demand for each week group
 - c. Estimate daily demand for each week group
 - d. Determine percent of time each weather condition occurs in each week group
 - e. Determine number of days represented (i.e., number of days in each week group multiplied by percent of time each weather condition occurs)
2. Calculate daily delay for each representative daily demand as follows:
 - a. Identify different runway uses which may be used
 - b. Determine percent of time each runway use occurs
 - c. Determine percent of daily demand occurring in each hour for each runway use
 - d. Calculate demand in each hour of the day
 - e. Calculate hourly capacity for each runway use

- f. Determine hourly delay for each hour for each runway use
 - g. Determine daily delay for each runway use
 - h. Estimate daily delay for each representative daily demand
3. Estimate annual delay from daily delays.

Inputs

The inputs for the annual delay aggregation model are stored in a file for processing by the model.

The five types of input data required to run the annual delay model are listed below.

1. Annual Demand: Number of annual operations.
2. Group Specification: Number of day groups (up to 7); week groups (up to 52); weather groups (up to 10); and runway uses (up to 10).
3. Weekly Traffic: Proportion of total annual traffic in one week of each week group.
4. Number of Weeks: In each group.
5. Daily Traffic: Proportion of weekly traffic in one day of each group.
6. Number of Days: In each day group.
7. Weather Group Demand Factors: Ratio of demand in each weather group to the demand in the first weather group. There are as many factors as weather categories.
8. Weather Occurrences: Proportion of occurrence of each weather group in any given week group (i.e., the sum of all weather group occurrences for any week group is 1.0).
9. Hourly Runway Capacity: Hourly runway capacities for each runway use and weather combination.

10. Runway Use Occurrences: Proportion of time each runway will be operated in the different weather conditions.
11. Hourly Traffic: Proportion of daily traffic to be distributed to each of the 24 hours.
12. Demand Profile Factor: (The proportion of peak-hour traffic in the peak 15 minutes.) This factor can take one of six values: 25, 30, 35, 40, 45, and 50.
13. Runway Use Demand Factor: Ratio of demand for each runway use to the demand for the first runway use. There are as many factors as runway uses.
14. Aircraft Mix: Mix for each runway use and weather combination. The mix should be that used to compute the hourly runway capacity.
15. User-Specified Title: Identifying alpha-numeric name to be printed in the output.

Outputs

The outputs from the model are as follows:

- Average annual delay per aircraft
- Total annual delay to aircraft
- Distribution of average aircraft delays

The distribution of annual delay is computed and listed by time interval. Each time interval is printed only if the interval contains delayed aircraft.

III. OTHER ANCILLARY MODELS

A number of additional models can be used in the Task Force efforts to accomplish the analyses more efficiently, to permit greater depth of analysis, and to broaden the types of information that can be provided for evaluation of alternatives, including:

- A demand schedule preprocessor model that permits generation of aircraft movement schedules from Official Airline Guide (OAG) data and other data sources in a form that is compatible with the simulation model input requirements.
- A routing generator preprocessor model that simplifies the procedure of specifying aircraft routings on the airfield.
- Two postprocessor models that assist in interpreting the simulation model outputs. The postprocessors can generate statistics on mean values, standard deviations, and confidence limits, and can provide detailed distributions for user-specified parameters. Graphical plots of various kinds can also be developed.
- An Automated Radar Terminal System (ARTS) data model that analyzes data output from Federal Aviation Administration ARTS data extraction and reduction programs and processes the information into a format that is compatible with the simulation model input requirements.
- A weather model to analyze weather occurrence at an airport based on raw airport climatological data from the National Weather Records Center. This model permits development of wind, ceiling, and visibility data for input to airfield delay studies.
- A runway capacity model that computes hourly runway capacity based on user-provided inputs, including runway use, weather, percent arrivals, and aircraft mix.

Demand Schedule Preprocessor Model

The airfield simulation model requires input data covering aircraft demand on the airfield system. Data requirements are:

1. Aircraft identifier (e.g., flight number for air carrier aircraft)
2. Aircraft class
3. Arrival time
4. Departure time
5. Arrival fix and runway
6. Departure fix and runway
7. Preferred gate assignment (for air carrier aircraft) or basing area (for general aviation and military aircraft)

At air carrier airports, one available source of demand information is the Official Airline Guide (OAG), which is available in hard copy and in magnetic tape format. The OAG data contain data items 1, 2, 3, and 4 listed above.

The demand schedule preprocessor model extracts these items from the OAG data and combines them with other data to provide demand data for scheduled air carrier and air taxi operations. The output from the model can include a printed schedule and punched cards suitable for use with the PMM&Co. airfield simulation model.

Three sets of inputs are required:

- OAG arrival data
- OAG departure data
- User-specified data

Model output is the demand schedule, printed out or punched on cards as the user specifies.

Routing Generator Preprocessor Model

Routing data requirements for the airfield simulation model consist of defining the typical paths aircraft use between the runways and the apron areas. More specifically, routes have to be defined for each exit taxiway/gate (or basing area) combination and for each gate (or basing area)/departure-runway combination. In addition, if holding areas or penalty boxes are used, routes have to be defined to and from these locations. The routing generator preprocessor model minimizes the effort involved in identifying the many routes that are typically used at a large air carrier airport.

Input to the preprocessor model consists of defining typical routes in a fashion similar to that required for the airfield simulation model. However, the logic of the preprocessor model is such that once a particular sequence of links is defined on a route, it is possible to abbreviate subsequent routes that contain the sequence by specifying the first link, a minus sign ("-"), and the last link of the sequence.

When the routing preprocessor model encounters a minus sign, it assumes the link numbers adjacent to the minus sign are part of a previously defined route. The program then searches through previous routes until it finds one containing these two links. It assumes that the complete route includes all links in between these links.

The model then generates the proper route. This program considerably reduces the amount of work required to identify the routes and prepare the input data for the airfield simulation model. The output from the preprocessor model is formatted such that it is directly usable as input to the airfield simulation model.

Postprocessor Models

Varying levels of detail may be obtained from the PMM&Co. airfield simulation model. Even though these levels of detail are adequate for many applications, in some situations further levels of detail may be desirable. Examples include aircraft delays by airline and aircraft type. Two postprocessor models are available that use detailed information on individual aircraft movements generated by the airfield simulation model to provide additional analytic capabilities. One is a statistical postprocessor that generates frequency distributions, bar charts, and other data. The second is a graphical postprocessor.

The statistical postprocessor model utilizes the Statistical Package for the Social Sciences (SPSS) computer programs to derive user-specified statistical measures such as the mean, standard deviation, and confidence limits for a given parameter, and distributions of delay values, travel times, and queue lengths. SPSS is maintained as an application package by the Control Data Corporation at their Western Cybernet Center.

The statistical postprocessor program uses the FREQUENCIES subprogram contained in the SPSS package. The user manipulates various SPSS statements to control both the type of output, such as delays to arrival aircraft, and the form of the output, statistical measures, bar graphs, etc. The postprocessor is structured to use a specific output file from the PMM&Co. airfield simulation model as the input for statistical analysis.

The statistical postprocessor is currently structured to print three sets of outputs:

- Frequency tables
- Frequency bar graphs
- Statistical measures

These outputs can be obtained for any combination of delays and travel times for arrivals and departures. For the frequency tables and bar graphs the output data are rounded to the nearest integer. The frequency table output includes:

- Absolute frequencies
- Relative frequencies
- Adjusted frequencies
- Cumulative frequencies

The statistical measures include:

- Mean
- Mode
- Median
- Standard deviation
- Variance
- Kurtosis
- Skewness
- Range
- Minimum
- Maximum
- Sum
- Standard error of the mean
- Coefficient of variance
- 95% confidence interval for the mean

- Number of valid cases
- Number of missing cases

The graphic postprocessor model produces graphic plots of various data. Data may be delay values, travel times, or other data obtained from the PMM&Co. airfield simulation model. The postprocessor is structured to take an output file from a single run of the airfield simulation model and plot total arrival and departure delays by hour.

The graphic postprocessor model consists of two computer programs that utilize the DISSPLA plotting software developed by Control Data Corporation. The first program reads in the data and uses DISSPLA routines to build the plot file. The second program performs the plotting manipulations.

To build the plot file, the first program generates the proper inputs for the plotting routines. Maximum values and step sizes for both sets of data are determined, and arrays are established that contain the plotting points. Then, a series of plotting routines are called to develop axes, labels, titles, and the curves themselves. The output file is then cataloged for use as input for the second program.

The second program takes the output of the first program and creates a file that is graphically plotted by a CALCOMP plotter. The program also controls the disposition of the plots.

The output from the first plotting program lists the hours that will be plotted along the x-axis, the number of hours to be plotted, and the actual delay values to be plotted.

The output from the second program is a listing of the control cards for plotting and the actual plot.

ARTS Data Model

The ARTS data model analyzes output from Federal Aviation Administration ARTS III data extraction and reduction programs, and processes the information into a format that is compatible with inputs required by the airfield simulation model.

Capacities and delays at airports depend largely on aircraft separations which reflect operational procedures and air traffic control requirements. The Automated Radar Terminal System (ARTS) tracks individual aircraft. Data contained on Federal Aviation Administration ARTS III magnetic tapes

include aircraft location, identity, altitude, and time of observation. The PMM&Co. ARTS data model uses such data to determine relevant statistics on:

- Aircraft separation (both arrivals and departures)
- Approach and departure speeds
- Air traffic distribution over runways and coordinate fixes
- Utilization of each runway and coordinate fix

The ARTS data model requires three types of input from the user.

The first type of input is the output data from the Federal Aviation Administration ARTS III extraction and reduction programs. This tape records the movements of each aircraft studied, and is expected to be available from FAA. The information required by the PMM&Co. ARTS data model includes: aircraft identity; operation type (i.e., arrival or departure); the time that an aircraft passes through a coordinate fix, and the name of the coordinate fix; the time that an aircraft is at the runway threshold; and the runway used.

The second type of input is a correspondence table between aircraft identity and aircraft class. The model uses this information in compiling separation, velocity, and traffic distribution statistics by aircraft class. Such a correspondence table can usually be constructed using the Official Airline Guide. This table is read according to 8(1X,A6,1X,A1) format. Each card will contain eight pairs of aircraft identity (airline and flight identifiers) and the associated aircraft class.

The third type of input covers some airport-specific information. In all, 12 different items are required, including the number of runways and fixes.

The ARTS model produces information that can be used as inputs to the airfield simulation model. These include:

- Arrival-arrival separation distributions over runways and over fixes classified by aircraft class

- Departure-departure separation distributions over runways and over fixes classified by aircraft class
- Approach-speed distributions for arrivals and takeoff speeds for departures by aircraft class
- Utilization of each runway and fix
- Aircraft mix for each runway and fix

Weather Model

The weather model extracts and processes relevant information from airport climatological data compiled on magnetic tape by the National Weather Records Center in Asheville, North Carolina. The model analyzes weather data and presents pertinent information for airport planning purposes. The model first reads data on the weather center tape and then screens and transfers them to another magnetic tape in a form suitable for manipulation and analysis. Depending on the options the user chooses, the model can produce one or more sets of data on wind, ceiling, and visibility.

Analyzing aircraft operations at airports often requires detailed knowledge of how different weather conditions are distributed over a year. The National Weather Records Center keeps records of weather observations for most major U.S. airports. The PMM&Co. weather model manipulates data from such records to:

- Calculate and tabulate crosswind components on a runway or, in the case of a multiple-runway airport, on both primary and secondary runway orientations. The observations can be tabulated by hour of day and by month of year for specified crosswind velocity ranges.

The crosswind components are computed knowing information on wind direction and speed, and true runway orientation. This information is available by hour of the day and by month of the year and is cross-classified with information on ceiling and visibility.

- Tabulate the occurrence of various ceiling/visibility conditions by time of day and month of year.

- Estimate the number of aircraft that are delayed, diverted, or cancelled during wind conditions which close the airport. The frequency distribution of consecutive hours of specific weather conditions can also be tabulated to help the user in determining delays, diversions, and cancellations.

The number of arrival aircraft delayed, diverted, or cancelled is computed by comparing the weather records of individual days with a schedule of aircraft demand. The number of aircraft demanding service within specified excessive crosswind conditions is then computed and output.

The model logic allocates delays to aircraft which are subject to airport closures of one hour or less. For aircraft subject to airport closures of more than one hour, 20% are considered diverted and 80% cancelled, except for operations in the last hour which are all delayed.

This portion of the model was developed in response to a site-specific airport analysis requirement. In general, the handling of the impacts of airport closures is a complex problem which is best examined in a site-specific manner. Therefore, modifications to this portion of the model may be appropriate for analysis at other airports.

- Print out wind rose tables at a specific airport. This can be performed for any user-specified ceiling and visibility conditions and for any duration in a day (e.g., the 17-hour period between 0700 hours and 2400 hours, or the entire 24-hour day).

Wind rose tables can be developed for any specified sets of wind speed ranges and are presented for 16 points of the compass.

The occurrence of various ceiling and visibility conditions is given for up to seven different sets of conditions.

Three types of input are required to exercise the weather model.

All analyses performed by the weather model require the first type of input, which consists of three elements:

- The years for which weather data will be analyzed
- A header card containing the name of the airport and/or the run description
- Three groups of ceiling and visibility conditions for use in the analysis

The second type of input is a set of weather data for the airport being studied. The weather data are generally stored on magnetic tapes which can be obtained from the National Weather Records Center in Asheville, North Carolina.

The third type of input relates to the kind of analysis to be performed. A total of six options are available for analysis and different inputs are required in each case. The analysis options available are:

1. Data tape screening
2. Delay, diversion, and cancellation
3. Primary runway crosswind component
4. Primary and secondary runway crosswind component
5. Wind rose tables
6. Ceiling and visibility

The output from any individual computer run depends on the options selected for analysis. Output for each of the options is described in the following paragraphs.

Option 1--Data Tape Screening

The output of Option 1 is the screened and processed weather data for use with all other options.

Option 2--Delay, Diversion, and Cancellation

For the specified time period and crosswind speed ranges, the output of Option 2 gives the date, duration, and wind velocity for all occasions with excessive crosswind. In addition, for the specified demand schedule, the number of aircraft delayed, diverted, or cancelled is given for each occasion.

Option 3--Primary Runway Crosswind Components

For the specified runway azimuth and crosswind speed ranges, the output of Option 3 gives the number of weather observations in each crosswind speed range by hour of day and by month. This information is cross-classified with the number of weather observations in three specified ceiling and visibility conditions.

Option 4--Primary and Secondary Runway Crosswind Components

Output of Option 4 is identical to that of Option 3 except that the output is presented for both the primary and secondary runway azimuth, and that there is no classification according to ceiling and visibility conditions.

Option 5--Wind Rose Tables

For the specified wind-speed groups and time of day, the output for Option 5 gives the number of weather observations and percent occurrence of wind by 16 points of the compass. The data are also presented cross-classified by specified ceiling and visibility conditions.

Option 6--Ceiling and Visibility

For the specified ceiling and visibility conditions, the output for Option 6 gives the number of weather observations, by month and by year in each of the ceiling and visibility categories.

Runway Capacity Models

The runway capacity model calculates capacity as the inverse of a weighted average service time of all aircraft being served. The capacity model uses a set of input parameters to determine the minimum time separation (or interval) between operations. The time intervals are computed for different types of aircraft (e.g., Boeing 747 followed by Cessna 150) and for different types of operations (e.g., arrivals and departures), taking into account ATC rules, weather conditions, runway occupancy times, runway configuration, and aircraft operating characteristics. The time intervals are then averaged and inverted to produce the capacity estimates.

Inputs

The inputs required for the runway capacity models include:

1. Ceiling and Visibility. For capacity computation purposes, ceiling and visibility can generally be divided into four sets:
 - VFR1--VFR conditions that allow simultaneous operations on close parallel runways.
 - VFR2--VFR conditions that do not allow simultaneous operations on close parallel runways.
 - IFR1--IFR conditions that allow relief from the two-mile departure-arrival separation rule.
 - IFR2--IFR conditions just above operating minima.

Depending on the extent of information required to meet study objectives, analysis of weather conditions and ATC operating procedures may be required.

2. Runway Use. Runway use is defined in terms of the number, location, and orientation of active runways and involves the directions and kinds of operations using each runway. Analysis of wind conditions and runway constraints (e.g., noise, airspace, obstructions) may be required to select appropriate runway uses.

3. Aircraft Mix. Aircraft mix is defined in terms of four aircraft classes: A, B, C, and D, as shown in the following tabulation:

<u>Aircraft Classi- fication</u>	<u>Types of Aircraft^a</u>
Class A	Small single-engine aircraft weighing 12,500 lb ^b or less (e.g., PA18, PA23, C180, C207)
Class B	Small twin-engine aircraft weighing 12,500 lb ^b or less and Lear jets (e.g., PA31, BE55, BE80, BE99, C310, C402, LR25)
Class C	Large aircraft weighing more than 12,500 lb ^b and up to 300,000 lb ^b (e.g., CV34; CV58; CV88; CV99; DC4; DC6; DC7; L188; L49; DC8-10, 20 series; DC9; B737; B727; B720; B707-120; BA11; S210)
Class D	Heavy aircraft ^c weighing more than 300,000 lb (e.g., L1011; DC8-30, 40, 50, 60 series; DC10; B707-300 series; B737; VC10; A300; Concorde; IL62)

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- a. For aircraft type designators, see FAA Handbook No. 7340.1E with changes.
- b. Weights refer to maximum certificated takeoff weight.
- c. Heavy aircraft are capable of takeoff weights of 300,000 lb or more whether or not they are operating at this weight during a particular phase of flight. (Reference FAA Handbook 7110.65 with changes.)

The proportion of aircraft in each class during the hour for which capacity is to be calculated should be obtained by examination of tower counts, field surveys, etc. If the mix differs between runways because of runway restrictions etc., the mix on each runway should be given.

4. Percent Arrivals. The percent of all aircraft operations that are arrivals. Information can be obtained by examination of tower counts, field surveys, etc.
5. Percent Touch-and-Go. The percent of all aircraft operations that are touch-and-go (training) operations. A touch-and-go operation is counted as two aircraft operations (an arrival and a departure). Information can be obtained by examination of tower counts, field surveys, etc.
6. Exit Configuration. The location and type of each exit taxiway on runways used for arrival aircraft operations. The Airfield Layout Plan or similar sources can be used to obtain the information.
7. Runway Occupancy Times. Arrival, departure, and touch-and-go occupancy times in seconds by aircraft class. Arrival runway occupancy times are required for each exit, together with the percent utilization of each exit by each aircraft class.
8. Aircraft Separations. Consistently achievable minimum separations between aircraft. Separation values are needed by each pair of aircraft classes (e.g., Class A followed by Class B).
9. Common Approach Path Length. The length of the straight-in approach along the extended runway centerline (for which the controller cannot exert speed control) in nautical miles for each aircraft class.
10. Approach Speed. The mean approach speed in knots of each aircraft class over the length of the common approach path.
11. Clearance Time. For airports with intersecting runways, mean arrival and departure intersecting runway clearance times in seconds by aircraft class.

Output

The output from the model is the hourly runway capacity of the runway use under consideration. The capacity computed represents the maximum number of aircraft operations that can take place on the runway(s) under the specific conditions studied.

Appendix B

IMPROVEMENT ITEMS

Source: Miami International Airport Improvement Program
Interim Report

MIAMI INTERNATIONAL AIRPORT IMPROVEMENT PROGRAM

Near-Term Airport Improvements

Summary

The critical near-term airport improvements required to increase the peak hour capacity of MIA are summarized below:

- Improve the taxiway system of runway 9L/27R.
- Install runway centerline lighting and touch down zone lighting on runway 9L. Install dual 250 foot baseline RVR systems on runway 9L/27R.
- Install runway centerline lighting and dual 250 foot baseline RVR systems on runway 9R/27L.
- Install High Intensity Runway Lights, an Instrument Landing System and an Approach Lighting System on runway 30. Provide paved blast protection shoulders on runway 12/30. Implement operational procedures to make greater use of the intersection take-off position on runway 30 and simultaneous use of runway 12 and 9R.

- Upgrade Opa Locka and Tamiami General Aviation Reliever Airports, to encourage low performance general aviation aircraft to relocate out of MIA.
- Study the feasibility of installing a VOR-DME on or in close vicinity to MIA.
- Use two mile in-trail staggered parallel approaches at MIA, to improve capacity without the extra tower staff required for full independent parallel approaches.
- Install Vortex Advisory System (VAS) monitors at both ends of all three runways at MIA.
- Provide overflow aircraft parking positions within the terminal area.
- Complete the interior service road totally around the perimeter of the airfield.
- Ask the airlines to taxi, rather than to tow their aircraft between their bases and their gates, and vice versa, during peak traffic periods.

Implementation of the above recommendations will result in the increases in capacity of MIA shown in Table IV-1.

TABLE IV-1

1985 Hourly Airport Capacity (Assuming 50% Arrivals, 50% Departures)

(1985 Design Hour Demand is Approximately 108 Operations Per Hour)

Weather	East Operations		West Operations	
	No Improvements	With Improvements	No Improvements	With Improvements
Visibility greater than 5 miles; ceiling greater than 1,500 feet	96	106 ⁽¹⁾	110	125 ⁽¹⁾
Visibility between 3 miles ⁽²⁾ and 5 miles; ceiling between 1,000 feet ⁽²⁾ and 1,500 feet	86	102 ⁽²⁾	86	113 ⁽²⁾
Visibility between 2,400 feet RVR and 3 miles ⁽²⁾ ; ceiling between 200 feet and 1,000 feet ⁽²⁾	86	92 ⁽¹⁾	86	92 ⁽¹⁾
Visibility between 1,600 feet/1,800 feet RVR and 2,300 feet RVR	36 depart	76 depart or 38 depart + 30 arriv	36 depart	76 depart
Visibility between 1,200 feet RVR and 1,800 feet RVR	0	76 depart or 38 depart + 30 arriv	0	76 depart
Visibility between 600/700 feet RVR and 1,800 feet RVR	0	76 depart	0	76 depart

(1) Including five more air carrier aircraft per hour.

(2) Minima jet to be finalized. Minima shown are used at Chicago O'Hare for similar procedure.

The following sections discuss each of the above items in a format which identifies:

- a. The present operational problems.
- b. The operational requirements which will solve those problems.
- c. The agency/agencies responsible for implementing those operational requirements. The agency responsible for implementing each operational requirement is noted using the following codes:

AL = Airlines

DCAD = Dade County Aviation Department

FAA = Federal Aviation Administration

RUNWAY 9L/27R

The Problems

Runway 9L/27R is the most heavily used runway on the airport, but the runway's capacity is limited by its poor taxiway system, which should be improved.

The take-off minima on runway 9L/27R urgently need lowering, to reduce outbound delays during winter morning fog conditions. A feasibility study also should be performed to determine if it is possible to upgrade one runway at MIA to Category II minima.

The Operational Requirements

- a. Provide new runway exit taxiways, dual parallel taxiways and an eastern by-pass taxiway to runway 9L/27R. Provide an extension of taxiway "L" to a holding apron on the north side of runway 9L.

Agencies responsible: DCAD and FAA

- b. Install runway centerline lighting on runway 9L/27R. Install touch down zone lighting on runway 9L.

Agencies responsible: DCAD and FAA

- c. Modify the runway 9L Runway Visual Range (RVR) System baseline from 500 to 250 feet. A new 250 foot baseline RVR System should be installed on runway 27R.

Agencies responsible: DCAD and FAA

- d. Determine the feasibility of upgrading runway 9L to Category II landing minima. If it is not technically feasible to upgrade runway 9L, then determine which existing or planned runway (e.g., the extended runway 9R) that would be possible to upgrade to Category II.

Agency responsible: FAA

Implementation of operational requirements b, c, d (centerline lighting, a second RVR and touch down zone lighting) will result

in a 25% improvement in landing minima (from 2,400 feet RVR to 1,800 feet RVR) and a 66% improvement in take-off minima (from 1,800 feet RVR to 700 feet/600 feet RVR) on runway 9L.

RUNWAY 9R/27L

Runway 9R has no RVR System. Take off minima on the RVR equipped runway 27L is 1,600 feet RVR. Runway 9R/27L should be equipped with centerline lighting. A new 250 foot baseline RVR should be installed on runway 9R. The existing runway 27L RVR baseline should be reduced to 250 feet. Take off minima on runways 9R and 27L then would be lowered to 700 feet/600 feet.

RUNWAY 12/30

The Problems

Runway 12/30 plays a vital role in the operation of MIA, as the highest peak-hour capacity of the airport is obtained by completely integrating the use of runway 12 with the use of runways 9L and 9R, when on east operations; and completely integrating the use of runway 30 with the use of runways 27L and 27R, when on west operations. (On east operations: land runway 9R, take off runway 12, land and take off runway 9L. On west operations: land runway 30, take off runway 27L, land and take off runway 27R.) At present, however, runway 30 has no instrument approach. It also is not possible to clear B-747 aircraft to take-off on runway 12/30 as the runway is only 150 feet wide, with no blast protection shoulders.

Although the runway 9L Runway Visual Range (RVR) System is positioned also to serve runway 12, and the runway 27L RVR System is positioned also to serve runway 30, RVR values cannot be provided for runway 12/30, as RVR values are only applicable on runways fitted with High Intensity Runway Edge Lights (HIRL). During winter morning fog conditions, therefore, only one runway is available to handle the morning departure peak, when two runways would more effectively handle the traffic demand and reduce the resulting take-off delays.

The intersection take-off position on runway 30 should be more extensively used, in order to achieve higher utilization of this runway.

The ability for the FAA tower to clear an aircraft to take-off on runway 12, simultaneously with clearing an aircraft to land on runway 9R, and vice versa, would greatly increase the capacity of these runway combinations, which need to be used extensively during east operations.

The Operational Requirements

- a. Install an Instrument Landing System (ILS) and an Approach Lighting System (ALS) on runway 30.

Agencies responsible: DCAD and FAA

- b. Construct paved shoulders on runway 12/30 to enable this runway to be used for B-747 take-offs.

Agencies responsible: DCAD and FAA

- c. Install a High Intensity Runway Lighting System (HIRL) on runway 12/30.

Agencies responsible: DCAD and FAA

- d. Advise the airlines to brief their pilots, and include in their flight manuals, the availability of the intersection take-off position on runway 30. (8,000 feet available.)

Agency responsible: AL

- e. FAA MIA Tower should initiate discussions with FAA region to obtain authority for Miami tower to issue simultaneous clearances for landings on runway 9R, with departures on runway 12 , and vice versa.

Agency responsible: FAA

LOW PERFORMANCE GENERAL AVIATION AIRCRAFT

The Problem

During the winter peak traffic months, up to 200 general aviation aircraft use MIA each day. Over 70% of these aircraft (approximately 150 each day) are single or light twin-engined propeller driven aircraft, with very low airspeeds. The large numbers of these small

low performance general aviation aircraft using MIA during peak hours (often over 20 aircraft an hour) cause extensive delays to the large air carrier aircraft, because of the long ATC separations required between the small low-performance aircraft and the large high-performance airline aircraft. (Present separations required are 6 miles, or 3 minutes between a "heavy" airline aircraft and a small general aviation aircraft.) At the present time, over 40% of the airline operations at MIA during peak hours are by "heavy" or wide-body aircraft. It is forecast that by 1980 over 50% of the airline operations at MIA during peak hours will be "heavy" aircraft. Three minutes of delay to a heavy wide-body aircraft costs that aircraft approximately \$150. If several large air carrier aircraft are delayed for the same three minutes, the delay costs to the airlines by one small general aviation aircraft could rapidly exceed \$1,000. The Dade County Aviation Department receives \$3 for the general aviation aircraft landing fee. Also, when a small low performance general aviation aircraft is using the runway, a large air carrier aircraft cannot be using it and is further delayed.

The Operational Requirements

The conveniently located General Aviation Reliever Airports at Opa Locka and Tamiami should be upgraded, in order to make these airports so attractive to the small low performance general aviation aircraft now using MIA that they will prefer to use Opa Locka or Tamiami instead of MIA.

a. Improvements which should be provided at Opa Locka Airport, and which are shown on the Airport Layout Plan, include:

- (1) Install a full ILS (localizer, glideslope, markers) and Approach Lighting System (ALS) together with an RVR System on runway 9L.
- (2) Upgrade the runway and taxiway system at Opa Locka as shown on the Opa Locka ALP, to enable FAA tower to provide better airport traffic management and improve airfield capacity.

b. Improvements which should be made at Tamiami Airport and which will be shown on the Tamiami ALP now being prepared, include:

- (1) Extend runway 9R, and later runway 9L, to a length of at least 6,500 feet.
- (2) Install an ILS, MALSR, VASI's and RVR on the runway 9R. Also, install VASI's on the present runway 9L.
- (3) Upgrade the taxiway system to provide dual-parallel taxiways to both runways 9L/27R and 9R/27L.

VOR-DME/PROFILE DESCENT PROCEDURES

The Problem

A VOR-DME on, or in the close vicinity of, Miami International Airport will enhance the ability of air carrier aircraft to perform profile-descent procedures. These procedures will provide a reduction in pilot-controller workload, a reduction in aircraft noise impact on the community, and permit significant savings of fuel. Departing aircraft also will be provided with multiple departure tracks, enabling higher departure rates to be maintained, thus reducing departure delays. A considerable number of other air traffic management benefits also would occur within the complete Miami terminal area. Both ATA and FAA tower, therefore, strongly support a VOR-DME on, or in the close vicinity of, Miami International Airport.

The Operational Requirements

- a. Study the feasibility of installing a VOR-DME on, or in close vicinity to, Miami International Airport. (It is recognized that technical implementation of this operational requirement will be difficult, due to the limited availability of suitable land areas on MIA, the cost of land off the airport, and the technical limitations of the existing normal range of VOR-DME equipment. The operational requirement, however, is stated in the hope that FAA technical staff could work closely with DCAD technical staff to implement this urgent operational requirement.)

Agencies responsible: DCAD and FAA

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MIAMI INTERNATIONAL AIRPORT TECHNICAL PLAN. AIRPORT IMPROVEMENT--ETC(U)

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TWO-MILE STAGGERED-PARALLEL APPROACHES

The Problem

Full parallel-runway approaches at MIA result in a very high airfield landing rate and low inbound delays, but require a large FAA tower staff to perform. A fairly high landing rate, however, also can be maintained if two-mile staggered-parallel approaches can be maintained. An arrival on final approach to 9L, for example, could be as close as two miles behind an arrival to 9R; there would then be at least four miles between successive arrivals to 9R. The two-mile staggered-parallel approaches can be performed with a smaller FAA tower staff and thus are highly suited to occasional short periods of high inbound demand.

The Operational Requirement

FAA Miami tower should clear aircraft for two-mile staggered-parallel approaches on runways 9L/27R and 9R/27L at MIA. FAA Miami tower should initiate discussions with FAA regional office to obtain the required approvals.

Agency responsible: FAA

WAKE VORTEX

The Problem

The very limited weather conditions under which wake vortices behind "heavy" aircraft persist are well-known, but in order to positively protect all aircraft all the time, the large wake-vortex separation minima are applied under all weather conditions. At the present time, over 40% of airline aircraft operations at MIA during peak hours are

by "heavy" aircraft. It is forecast that by 1980 over 50% of MIA's peak hour aircraft operations will be by "heavy" aircraft. The delays presently caused by these large separation standards will therefore become even worse by 1980.

The Operational Requirement

Vortex Advisory System (VAS) monitors should be installed at both ends of all three runways at MIA, so that reduced ATC separations and higher airport capacity, resulting in a decrease in aircraft delays, can be achieved at MIA whenever weather conditions permit.

Agencies responsible: DCAD and FAA

OVERFLOW PARKING POSITIONS

The Problem

During peak traffic periods some airlines have more aircraft arriving than there are free gates at which to park them. The overflowing aircraft then have to be held on an adjacent taxiway, until a gate is available. Concourse "G", in particular, is a continuing problem, and an Air Canada B-747, or a United, Continental, or Northwest DC-10 will often have to hold on the adjacent taxiway for up to an hour while waiting for a free gate. The taxiway then is no longer available for the normal passage of arriving and departing aircraft. In some cases this taxiway is the only reasonable route between large area of the airport. Lack of it quickly causes delays and congestion for all aircraft on the airport, as more complex, circuitous and time-consuming alternative routes have to be set up by the FAA tower ground controllers.

The Operational Requirements

The overall utilization of Concourse "G" should be studied, as it is obviously continually overloaded during peak hours during the winter season. Overflow parking positions also must be found for large, wide-body airline aircraft which do not have a parking gate. These overflow parking positions must be within the present terminal area, and not involve the crossing, or recrossing, of the airfield runway system.

Agency responsible: DCAD

VEHICULAR TRAFFIC ON AIRFIELD OPERATIONS AREA

The Problem

The FAA tower has complained and DCAD operations has acknowledged, that there are too many radio-equipped vehicles authorized to drive on the airfield operations area. The constant flow of these vehicles, particularly across runway 9L/27R and along the Route 1 taxiway, causes severe FAA tower ground controller radio-frequency congestion, heavy controller workload, delays to taxiing aircraft, and reduced aircraft safety, as these vehicles occasionally inadvertently cross active runways without clearance. The new FAA procedures requiring each runway crossing to be cleared individually on each occasion between the ground controller and the local controller, also increases the workload on the local controller and reduces his efficiency in controlling aircraft in an expeditious manner.

The Operational Requirement

The interior service road should be completed totally around the perimeter of the airfield operations area. When this interior service road is completed, all vehicles should be ordered to use the roadway, rather than the airfield. All radio certificates then should be withdrawn and replaced only on a case-by-case basis, after the most rigorous examination.

Agency responsible: DCAD

TOWING AIRCRAFT

The Problem

Due to the location of Miami in the airline route network, a large traffic peak occurs between approximately 1200 hours and 1500 hours local time.

Severe taxiway congestion occurs during this period if a stream of inbound or outbound aircraft are held up behind a towed aircraft, with the slow speeds of even a modern tug pulling a large aircraft. A considerable reduction in taxiway congestion and delays and a significant increase in airport capacity would be possible if aircraft positioning between the maintenance areas and the gates, or between the gates and the maintenance areas, could be taxied, rather than towed, during the peak traffic period.

The Operational Requirement

The airlines should be asked to taxi their aircraft between their maintenance areas and their gates, and vice-versa, during the peak hours of airport operations. (Presently 1200 to 1500 hours, local time.)

Agencies responsible: AL and DCAD

Appendix C
INPUT DATA FORMS

LINK DATA

[illegible]

LINK DATA FORM
Miami International Airport
Delay Improvement Study
October 1978

GATE DATA

[illegible]

Figure C-2

C-2 GATE DATA
Miami International Airport
Delay Improvement Study
October 1978

[illegible]

C-3

ROUTE DATA

[illegible]

Figure C-4

ROUTE DATA FORM
Miami International Airport
Delay Improvement Study
October 1978

Airline _____

[illegible]

- Figure C-5

C-5 AIRCRAFT GATE SERVICE TIMES
Miami International Airport
Delay Improvement Study
October 1978

AIRFIELD SIMULATION MODEL RUNWAY/FIX TRAVEL DATA

Fix Number (cc 6-8)	Runway Number (cc 16)	Class Number (cc 24)	Distance (cc 25-32)	Average Speed (cc 33-40)

Figure C-6

C-6

AIRSPACE TRAVEL TIME DATA FORM
Miami International Airport
Delay Improvement Study
October 1978

ARRIVAL AIRCRAFT LATENESS DISTRIBUTION
(Average deviation from schedule, excluding delays
due to destination airport)

Airline _____

Percent of flights late or early (%)	Amount of time Late or early
	More than 30 minutes early
	15 to 30 minutes early
	Less than 15 minutes early
	On time
	Less than 5 minutes late
	5 to 10 minutes late
	10 to 15 minutes late
	15 to 30 minutes late
	30 to 45 minutes late
	45 to 60 minutes late
	More than 60 minutes late

Total 100%

Figure C-7

C-7

ARRIVAL AIRCRAFT LATENESS DISTRIBUTION
Miami International Airport
Delay Improvement Study
October 1978

DEMAND DATA

[illegible]

DEMAND DATA FORM
Miami International Airport
Delay Improvement Study
October 1978

C-2