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OPERATION FREE FLIGHT - AN OPERATIONAL EVALUATION OF RNAV DIREC--ETC(U)
JUL 81 W MINNICK
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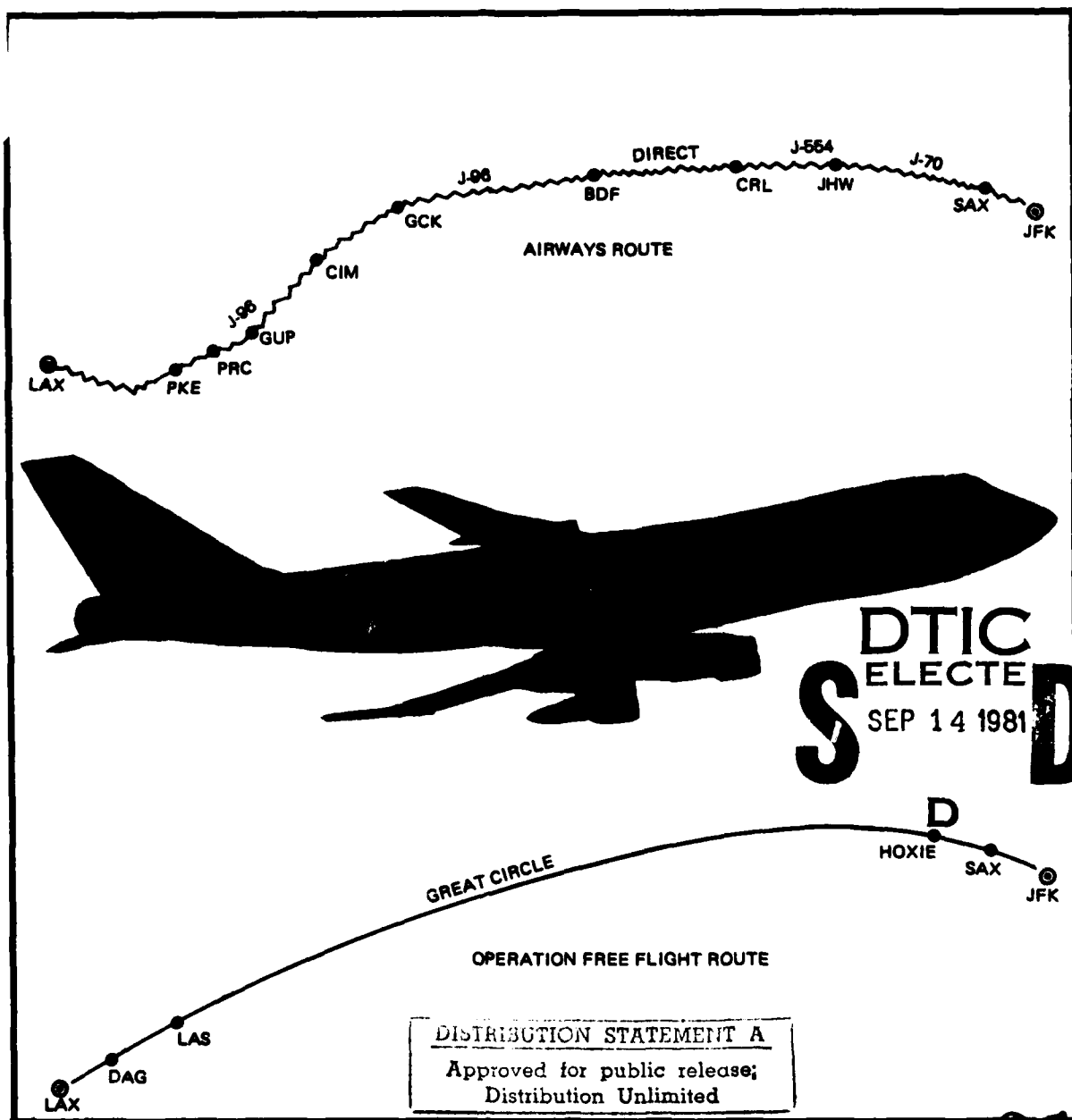
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An operational evaluation
of RNAV direct route flight
plan filing in today's National
Airspace System

Air Traffic Service Procedures
Division

Final Report

July 1981



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16. Abstract This report presents the results of an operational evaluation concerning the feasibility of permitting the filing of direct route flight plans, without route definition, between departure and arrival area fixes serving selected city-pairs. The evaluation was conducted with the voluntary participation of Eastern, United, and Pan American Airlines during the period June 1 through December 31, 1980. Objectives of Operation Free Flight were to obtain factual information about air traffic control (ATC) handling of test aircraft on direct routings, system prohibitions to the concept, general pilot attitude regarding the utility of their RNAV equipment, potential fuel savings, and ATC system impact. The evaluation was conducted throughout the contiguous United States between 27 city-pairs. The primary conclusions were: the operational concept of filing direct, great circle routes between departure and arrival area fixes, at altitudes above Flight Level 290, in a radar environment is feasible; incompatibility with traffic arrival flow at destination airports was determined to be the most significant system prohibition; pilot attitude was skewed in a positive direction; potential fuel savings are projected to be in excess of 40,000,000 gallons per year; and, there was no adverse impact to the ATC system.			
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PREFACE

The Director, Air Traffic Service (AAT-1) of the Federal Aviation Administration (FAA) has sponsored the RNAV direct route flight plan filing, operational evaluation (coded Operation Free Flight) throughout the National Airspace System with the cooperation of Eastern, United, and Pan American World Airlines who volunteered to participate in the test. Primary responsibility for this evaluation was assigned to the FAA's Procedures Division, AAT-300.

The program manager and principal author of this document was Lt. Cmdr. Wayne Minnick, USN, who is assigned to the FAA's En Route Procedures Branch (AAT-330), Washington, D.C. Mr. Baysil Ward of the En Route Procedures Branch helped to develop the evaluation initially and contributed in writing Sections 200 and 400. Messrs. George Weimer and Drex Barksdale of the FAA's Southern Region, Air Traffic Division, coordinated day-to-day operational aspects of the evaluation with all Air Route Traffic Control Centers (ARTCCs) that were affected by the test, and they were primarily responsible for determining and reporting the ATC system impact of the operational evaluation.

The scope of this evaluation included the collection of factual information regarding an informal RNAV direct route practice which had evolved over a period of years between controllers and pilots and a carefully structured set of objectives established to help determine the feasibility of modifications to the National Airspace System for the benefit of all RNAV users and, ultimately, the nation through the development of more efficient relationships between traffic flows, airspace allocations, system capacity, and future air navigation systems.

A critical role in this evaluation was performed by the many unnamed pilots and controllers who provided the data reported herein, and the following members of the participating airlines:

Captain Mike Fenello -----	Former Vice President, System Operations, Eastern Airlines. Current Deputy Administrator, FAA
Mr. Edwin Price -----	ATC Specialist, Eastern Airlines
Captain John Perkinson -----	Manager, Airway Traffic Control, United Airlines
Mr. Des Lennan -----	Flight Dispatch Services Manager, United Airlines
Captain Don Lovern -----	Domestic and Latin America Chief Pilot, Pan American World Airways
Mr. Jerry Murphy -----	Station Chief and Flight Superintendent Miami, Pan American World Airways

The work performed by Messrs. Millard Bohler and Pearlis Johnson, and Ms. Carolyn Edwards of the FAA's Office of Management Systems, in coordinating the automated data management functions was superb and essential to the evaluation's success. Mr. Alan Kaprelian of the Transportation Systems Center, Cambridge, Massachusetts, managed the actual automation of the data and developed the necessary software for its tabulation and analysis.

Finally, Miss SuEllen Gardner tirelessly performed the arduous task of typing the report, assisted by Mrs. Janice Vitko.

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ABBREVIATIONS AND ACRONYMS

ARTCC	-----	Air Route Traffic Control Center
ATC	-----	Air Traffic Control
DME	-----	Distance Measuring Equipment
EA	-----	Eastern Airlines
FL	-----	Flight Level
IFR	-----	Instrument Flight Rules
INS	-----	Inertial Navigation System
NAS	-----	National Airspace System
NAS 9020	-----	ARTCC Computer
OMEGA	-----	A type of area navigation equipment which uses signals transmitted by seven stations located throughout the world.
PA	-----	Pan American World Airways
RNAV	-----	Area Navigation
SID	-----	Standard Instrument Departure
STAR	-----	Standard Terminal Arrival
UA	-----	United Airlines
TACAN	-----	Tactical Air Navigation
VLF	-----	Very Low Frequency (As used herein, refers to signals from communications stations operated by the US Navy which are used by some OMEGA systems.)
VOR	-----	VHF Omni - Directional Range
VOR/DME	-----	VHF Omni - Directional Range/Distance Measuring Equipment
VORTAC	-----	VHF Omni - Directional Range/Tactical Air Navigation

AIRPORT IDENTIFIERS

ATL - Atlanta (Hartsfield) International Airport, GA
BUF - Greater Buffalo International Airport, NY
CLT - Charlotte (Douglas Municipal) Airport, NC
DTW - Detroit (Metropolitan Wayne County) Airport, MI
EWR - Newark International Airport, NJ
IAH - Houston Intercontinental Airport, TX
JFK - John F. Kennedy International Airport, NY
LAX - Los Angeles International Airport, CA
LGA - La Guardia Airport, NY
MIA - Miami International Airport, FL
ORD - Chicago - O'Hare International Airport, IL
PIT - Greater Pittsburgh International Airport, PA
SEA - Seattle - Tacoma International Airport, WA
SFO - San Francisco International Airport, CA

END PAGE

100 EXECUTIVE SUMMARY

An operational evaluation of the feasibility of permitting the filing of direct route flight plans, without route definition, between departure and arrival area fixes serving selected city-pairs was conducted by the Federal Aviation Administration, Procedures Division (AAT-300). The evaluation commenced on June 1, 1980, and continues to date. Data was collected from participating pilots and airlines and air route traffic control centers (ARTCCs) from June 1 through December 31, 1980. Data continues to be collected from ARTCCs. The operational evaluation, which operated under the code words "Operation Free Flight," was designed around four primary and nine secondary objectives, all of which focused on the practical use of area navigation systems in today's environment, resulting benefits, and possible ATC system prohibitions and impacts. The evaluation centered around the en route phase of flight at high altitudes, generally above FL 290. This report addresses the objectives, methodology employed, results, and conclusions.

110 DESCRIPTION OF THE OPERATIONAL EVALUATION

Operation Free Flight involved the voluntary participation of Eastern, United, and National Airlines and Pan American World Airways. City-pairs were selected based upon these participants' scheduled flights which were conducted by aircraft with some type of RNAV avionics. Departure and arrival area fixes were determined through coordination with local ATC facilities in order to avoid disruption of established traffic flows. Latitude and longitude coordinates were used to identify fixes which were not adapted in departure and intermediate ARTCC computers. The resulting route descriptions were provided to the participants and each ARTCC within the contiguous United States. These "routes" were subsequently filed by the participating airlines when their analysis indicated that the Operation Free Flight route would be more economical (considering fuel costs) than normal airway routes. A total of 39 city-pairs were identified in this manner. During the data-collection phase, 27 city-pairs were evaluated.

Data was collected from the airlines and pilots by a questionnaire which was designed to provide information about each flight relative to possible reroutes via airways, the locations and reasons for such reroutes, and data concerning fuel consumption. The questionnaire was designed to satisfy three of the four technical objectives. A total of 529 questionnaires were received from a total of 1,919 actual participants.

Data was collected from each ARTCC in support of the fourth technical objective concerning possible ATC system impacts. The means of collecting this information was also by questionnaire which was designed to elicit subjective responses concerning possible impacts. A total of 49 questionnaires were received. These data were augmented by numerous telephone conversations between ARTCC and project personnel.

120 PROGRAM OBJECTIVES

Operation Free Flight was designed to satisfy four major objectives and nine subobjectives:

1. Determine the feasibility of permitting the filing of direct route flight plans without detailed route definition by examining the rate of success in receiving direct route clearances, i.e., cleared as filed. Included in this objective, were three subobjectives:

- Determine locations of reroutes via the VOR system or via direct, as appropriate.
 - Determine the reasons for reroutes via the VOR system for the purpose of identifying system prohibitions in support of Objective 3.
 - Examine general pilot attitude toward the utility of their RNAV equipment in today's system.
2. Determine the potential fuel savings which may be realized by flying direct. A subobjective was:
 - Determine how successful Operation Free Flight participants were in achieving their estimated fuel savings potential.
 3. Determine ATC system prohibitions to direct route clearances, if any.
 4. Determine ATC system impact of Operation Free Flight in terms of:
 - Controller workload;
 - NAS 9020 computer processing demands;
 - NAS 9020 computer's ability to accurately post flight progress strips within and between ARTCCs;
 - Departure/arrival flow compatibility; and
 - En route airspace conflicts.

130 PRIMARY RESULTS

Primary results are provided in this subsection. Detailed data concerning these findings are contained in Section 600, and a more exhaustive summary of results is contained in Section 700.

- Overall, participants were very successful in being able to conduct their flights via the RNAV great circle routes between departure and arrival area fixes:
 - 80.5% flew 100% of the distance direct.
 - 93.6% of all aircraft flew more than 80% of the distance direct.
 - 88.1% of all aircraft flew more than 90% of the distance direct.
- Based upon the participating airlines analysis of fuel costs, where the Operation Free Flight routes were compared with normal airway routing, the airlines asked for the great circle route for 36% of 5,356 flights; thus, 1,919 flights actually participated over the 6 month period.
- No valid ATC system prohibitions were noted. However, the following "constraints" were identified.
 - Incompatibility with "Traffic Arrival Flow" at destination airports was determined to be a problem area in a few cases. However, all were resolved without difficulty.

- Special Use Airspace, including ATC assigned airspace areas, did not prove to be a significant system prohibition. Major special use airspace complexes which are frequently active may require use of intermediate fixes in the route of flight which will ensure clearance in order to avoid circuitous routing around them in a less fuel efficient manner.
- Controllers frequently, but unintentionally, contributed to system problems and eventual impact to participants by reclearing flights direct to destination without regard for arrival area fixes, or where necessary, arrival flow fixes. In every case identified, this "accommodation" caused problems later in the flight due to arrival flow requirements and associated airspace constraints at the destination ARTCC and, in some cases, the ARTCC adjacent to the destination facility.
- Pilot attitude regarding the utility of their RNAV equipment was strongly skewed in a positive direction.
- Fuel consumption data were received from 12% of the participating flights.
- Documented fuel savings from Operation Free Flight participants amount to 2.03% of the estimated fuel consumption via airways. Under an expanded program, where all users could duplicate the procedure followed during the evaluation, the projected fuel savings for commercial aviation over a 12-month period is 40,000,000+ gallons (projected from CY 1979 fuel consumption data). Fuel savings to general aviation and the military could not be estimated due to lack of detailed data concerning installed RNAV avionics and use in the high altitude structure.
- The marginal difference between direct (great circle) and via airways fuel consumption in nearly all cases was not large. Therefore, significant fuel savings can be achieved only through an increase in the scale of participation on a daily basis.
- Between city-pairs, fuel savings ranged from 0.8% to 4.9% of estimated airway consumption. In gallons, the mean fuel savings range was from 84 gallons to 287 gallons per flight.
- The participating airlines are marginally successful in predicting when fuel savings will accrue by flying the shortest distance, as opposed to an airway route.
 - Most flights saved fuel, based upon the estimates of consumption; however, 21.2% did not.
 - 64.6% achieved 80% or more of their estimated fuel savings, with 14.2% achieving somewhere between 1% and 79%.
 - 21.4% of all flights that flew 100% of the distance direct, as filed, achieved less than 1% of their fuel savings potential. Weather and upper winds were frequently cited by pilots as reasons for not achieving their potential.

- Overall, there was no adverse impact to the ATC system due to Operation Free Flight from the standpoint of controller workload, NAS 9020 computer processing demands, or the 9020 computer's ability to accurately post flight progress strips within and between ARTCCs.
- Relatively minor adjustments to departure or arrival areas fixes were required in order to achieve traffic flow compatibility. These were made within the context of the program and were considered not to be impacts.
- Two types of en route airspace conflicts were identified; one was related to incompatibility with traffic arrival flow and the other to an en route crossing situation with high altitude arrivals into Denver. Neither of these conflicts was considered to be impacts in the strict sense, being resolvable within the context of the program or routine controller actions.

140 CONCLUSIONS

Major conclusions are summarized below and are drawn from the data and analysis contained in Section 600. Section 800 contains all conclusions, organized under each technical objective.

- The operational concept of filing great circle routes between departure and arrival fixes, at altitudes above FL 290, without a series of waypoints between such fixes was determined to be feasible in a radar environment, provided the following are accomplished:
 1. A means for determining and publishing the appropriate departure and arrival area fixes for each terminal area must first be developed and implemented. Additionally, in some cases, turn points to avoid Special Use Airspace and traffic flow points will require identification and subsequent publication.
 2. The handbook for controllers, FAA Order 7110.65B, will require revision to permit and explain procedures for controllers use of latitude/longitude coordinates within the domestic airspace to identify nonadapted fixes in a route of flight.
 3. Development of a new equipment suffix code to identify aircraft with any type of area navigation capability, regardless of the method of certification.
 4. The Airman's Information Manual (AIM) will require revision to explain the operational concept validated herein. This change's scope will be related to #1 above.
- The routes between certain city-pairs which were evaluated by Operation Free Flight are considered to be validated based upon this report's findings. These city-pairs and associated departure/arrival area fixes should be proposed additions to the IFR Preferred Route system, published in the Airport Facility Directory. The following city-pairs are considered validated:

ATL-SEA	MIA-SFO	JFK-IAH	EWR-SFO
ATL-SFO	MIA-ORD	JFK-SFO	EWR-ORD
ATL-LAX	LAX-MIA	JFK-LAX	
ATL-ORD	LAX-ORD	ORD-MIA	
ATL-PIT	LAX-JFK	ORD-LAX	
ATL-BUF	IAH-JFK	ORD-EWR	
MIA-LAX	SFO-JFK	CLT-LGA	

- Frequent but prudent use of great circle routes should result in fuel savings of approximately 2% over airway consumption. This evaluation has shown that achieving fuel savings is a function of more than distance flown. Analysis of other variables, such as upper wind vectors, air temperature, atmospheric pressure, power settings, and gross weight, has to be conducted in conjunction with distance in order to most effectively save fuel on any given flight. Moreover, knowledge of departure and arrival traffic flows, especially for the major hubs, is essential for both obtaining an initial "direct" clearance and avoiding subsequent reroutes which will probably offset fuel savings gained en route.
- Incompatibility with traffic arrival flows was the only significant system prohibition identified. Special Use Airspace was a factor predominately between two city-pairs but can be resolved through minor route modification. ATC Assigned Airspace in the Positive Control Area (PCA) did not prove to be a limiting factor during the test.
- The impact of the foregoing "system prohibitions" was determined to be relatively minor and correctable in each case. However, the fact that some action will be required to negate the system prohibitions is evidence that the National Airspace System, as currently structured, cannot uniformly and continuously accept unrestrained direct route flight without imposing restrictions. The establishment of departure and arrival fixes, turn points, and arrival flow fixes will be required in many cases to achieve compatibility with dense traffic flows and avoid conflict with major Special Use Airspace complexes. These requirements will not necessarily apply in all cases, however, as some great circle routes between cities are very compatible with the flow of traffic.
- There was no adverse impact on controllers with regard to workload.
- There was no adverse impact with regard to the NAS 9020. In order to reduce the use of latitude/longitude coordinates, however, it appears appropriate to examine the feasibility of adapting, in all ARTCCs, the departure/arrival and flow fixes which serve major airports and metroplexes. This would be an enhancement to the controller in terms of machine entry and display, as well as strip perusal.
- Departure and arrival flow compatibility should be achieved once the publication actions identified above are completed and users are cognizant of appropriate fixes to use in their route of flight.

- Potential en route airspace conflicts appear to be reduced in most cases of direct routing. Airspace efficiency, as measured through usage and flexibility, should increase proportionate to the number of users having the navigational capability to deviate from the structured airway system. The relatively small number of areas where an incompatibility exists between direct routing and airspace configurations can be compensated for by the ATC system without adverse impact.

200 INTRODUCTION

In 1970, the FAA established the high altitude RNAV airway structure. Because these airways were generally aligned to avoid all special use airspace and coincide with regional traffic flows, they offered little in mileage savings over the VOR airway structure. Moreover, the RNAV structure did not take into consideration the more subtle center to center arrival and departure preferential traffic flows that have evolved overtime. Since SIDs and STARs and other preferential procedures were usually tied-in to the VOR system, the RNAV route structure proved cumbersome to use, and after a short period of interest in the early 70's (especially by the aircarriers), the RNAV airway structure has never been used to any great degree. As a result, in 1978, after coordination with users, the RNAV airway structure was reduced from 166 routes to 73 routes, from 74,000 route miles to 50,000 route miles. Currently, the FAA is examining the feasibility of eliminating all published RNAV airways with exception of a few in Alaska, as well as the attendant RNAV En Route Chart series.

Although the RNAV airway system proved less than utilitarian, there has been considerable growth in advanced RNAV avionics and a steady increase in the use of those systems by a variety of users. The equipment continued to be used to navigate on oceanic routes and in areas where conventional navigation aids were limited. Demand for special applications in the Northeast Corridor and Gulf Coast areas, predominately by the helicopter community, spurred additional research into certain types of RNAV systems which would meet their specialized requirements. Concurrently, RNAV instrument approaches were established at many locations (384 to date) and additional waypoint information was published on several conventional approaches and STARs for the benefit of RNAV equipped aircraft.

By the end of the previous decade, it was becoming apparent that the potential economy and utility of area navigation would best be realized by random point-to-point routes rather than by any of the several structured routes or grid systems that had been considered. In fact, as more aircraft became RNAV equipped, and as controllers and pilots became more familiar with its capabilities, an informal RNAV direct route technique developed in the National Airspace System. After departing the terminal area, pilots would ask for "RNAV Direct Destination." When traffic permitted and based on an overall knowledge of the route acceptance "upstream", controllers would often clear the aircraft as requested. This generally required controllers to use latitude/longitude coordinates to identify distant navigation aids not adapted in their computer. As this practice became more prevalent, questions were raised as to the propriety of using coordinates to describe domestic routes, the existence of a controller recognizable route, excessive NAS 9020 computer processing demands, and controller workload. In order to answer these questions and to obtain factual information, an operational evaluation was developed. This document describes the detailed results of the evaluation which was coded "Operation Free Flight."

210 BACKGROUND

The direct route flight plan operational evaluation between selected airports (Operation Free Flight) commenced on June 1, 1980, and is still currently active. Data was collected through December 31 from pilots and the participating airlines by means of a questionnaire. A separate questionnaire was used to collect information from Air Route Traffic Control Centers (ARTCCs) relative to ATC system impacts and controller workload.

Data obtained from the pilot questionnaire include date of flight, flight identification, time of departure and arrival, city-pair, success rate in obtaining IFR clearance as filed, subsequent changes en route regarding reroutes of the aircraft, reason for reroute, location of the reroute, pilot viewpoint relative to the utility of his RNAV equipment, and a series of fuel data which pertain to each flight.

Data obtained from the ARTCC questionnaire include ARTCC identification, date, aircraft identification, whether or not the aircraft was rerouted and, if so, where and why, and whether or not an impact to ARTCC operations occurred and, if so, what kind of impact. Instructions to the ARTCCs required execution of the questionnaire only if an impact occurred, unless the facility desired to communicate comments which were broader in scope.

Copies of the questionnaires used during the evaluation are contained in Appendixes A and B.

Data from the pilot questionnaires were collected, evaluated, and analyzed by the FAA Air Traffic Service, En Route Procedures Branch (AAT-330), Operation Free Flight Project Manager. Computer support for data management from the Transportation Systems Center, Cambridge, Massachusetts, was arranged by the FAA Office of Management Systems.

Data from the ARTCC questionnaires were collected, evaluated, and analyzed by the FAA Southern Region, Air Traffic Division (ASO-500).

Throughout the evaluation, close coordination was effected between the Project Manager, ASO-500 staff, participating airline representatives, and ARTCCs. Thus, adjustments were made on several occasions to city-pairs and specific routes, as flight schedule changes were made by the airlines or unforeseen problems developed with a particular route.

220 PURPOSE OF THE EVALUATION

The primary purpose of Operation Free Flight was to obtain factual data relative to the informal random use of RNAV which was previously discussed. Adjunctive to this were several specific objectives which stemmed from the concept of permitting flight plan direct route filing from departure fixes to arrival fixes serving the departure and arrival airports, respectively. Under this concept, the route of flight between the fixes was via great circle, and the route was not otherwise defined to ATC, such as by a series of waypoints along the route of flight.

230 ORGANIZATION OF THE REPORT

The results of the data collected for six months from Operation Free Flight are presented in the remainder of this report. Section 300 provides the operational concept of the evaluation, precautions taken, and responsibilities. A detailed list of technical objectives and discussion of their relationship to the purpose of the evaluation are contained in Section 400. Section 500 explains the methodology employed initially and throughout the test period. Copies of the questionnaires used during the evaluation are contained in Appendixes A and B. Appendix C provides lists of routes used between the selected city-pairs during the test period and currently. Appendix D contains the answers to the pilot questionnaires which formed the data base. A discussion of test results and analysis is presented in Section 600, and Section 700 summarizes the evaluation results. Section 800 offers conclusions.

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300 OPERATIONAL CONCEPT

The operational concept of Operation Free Flight was to permit preselected aircraft with RNAV capability to file direct route flight plans, without pre-coordination, between departure and arrival area fixes (identified by latitude/longitude) for certain paired airports during periods of normal and heavy ATC system demand. The major portion of such direct routes were conducted above FL 290 and totally in a radar environment.

Intrinsic to this concept is the postulation that each Air Route Traffic Control Center's (ARTCC's) NAS 9020 computer can accurately process and track flights utilizing latitude/longitude coordinates and print fix posting data in terms of fix/radial/distance (FRD) on flight progress strips; and that the ARTCC controller's route display feature will depict a route of flight which has been defined by adapted fixes and latitude/longitude coordinates for nonadapted fixes.

310 PRECAUTIONS

Two precautions were taken throughout the evaluation. First, ARTCC radar and computer equipment was required to be operational. If one or both failed, controllers were instructed to reclear Operation Free Flight participants via the VOR system. Secondly, in order to guard against potential adverse system impact, the number of city-pairs and flights permitted to participate were low initially. As more experience was gained, adjustments to both were made.

320 RESPONSIBILITIES

The following responsibilities were developed prior to the test commencing and disseminated to appropriate offices. Controller briefings were conducted and a single point of contact was established at each ARTCC. Each participating airline briefed flight dispatch personnel and disseminated additional written material to all pilots concerned.

321 FAA RESPONSIBILITIES

FAA responsibilities were enumerated as follows:

1. The Chief, Procedures Division (AAT-300) will provide general direction and guidance throughout the test period as necessary.
2. The Southern Region Air Traffic Division (ASO-500) will coordinate all operational aspects of this test with other affected FAA regions and ARTCCs.
3. During the period of the test, all affected facilities shall accept direct route flight plans using coordinates in the route of flight between the airports identified.

4. To the extent possible, controllers shall clear test aircraft as filed via direct routing.
5. ARTCCs shall complete and mail facility evaluation questionnaires, if appropriate, to ASO-500.
6. ASO-500 will collect data from affected facilities/controllers and provide a weekly briefing (telephone) to AAT-300 regarding identifiable problems.
7. ASO-500 shall determine the ATC system impact (Objective 413) and make recommendations to AAT-300.
8. AAT-300 will analyze all data and make a final determination upon completion of the operational evaluation.

322 PARTICIPATING AIRLINE RESPONSIBILITIES

Participating airline responsibilities were enumerated as follows:

1. Airlines which participate in this operational evaluation shall file direct route flight plans for predetermined flights between the selected airports, unless weather or other considerations make this impracticable.
2. Flight crews will be requested to fill out and mail the pilot questionnaire.
3. The last two questions concerning fuel consumption on the questionnaire shall be calculated and answered by the airline prior to flight.
4. Arrival area fixes and any intermediate fixes shall be identified by latitude/longitude coordinates followed by the fix identifier. For example:

	<u>1/</u>	<u>2/</u>	<u>3/</u>	<u>4/</u>	<u>5/</u>
a. ATL	TYS	4229/7912	DKK	SU9	

1/ Departure airport

2/ Departure transition fix

3/ Latitude/longitude coordinates for DKK,
rounded to the nearest minute.

4/ Arrival area fix

5/ Destination airport

b. 1/ 2/ 3/ 4/ 5/ 6/ 7/
MIA SRQ 3157/10616 EWM 3407/11546 TNP LAX

- 1/ Departure airport
- 2/ Departure area fix
- 3/ Latitude/longitude coordinates for EWM,
rounded to the nearest minute.
- 4/ Intermediate fix (turning point)
- 5/ Latitude/longitude coordinates for TNP,
rounded to the nearest minute.
- 6/ Arrival area fix
- 7/ Destination airport

5. Participating flights shall be identified by the interfacility (formerly a clear weather) symbol (O), followed by the statement "Operation Free Flight" in remarks. When a particular flight is not a participant on any given day, the symbol and code words in remarks will not be used.
6. Flight plans via normal routing shall be prepared for participating flight crews. Flight crews shall provide controllers with backup flight plans or necessary portion(s) thereof in the event direct route clearances cannot be issued/must be amended or cancelled.

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400 TECHNICAL OBJECTIVES

The Operation Free Flight operational evaluation was designed to satisfy four major objectives and nine subobjectives. These can be summarized as follows:

410 - Determine the feasibility of permitting the filing of direct route flight plans without detailed route definition by examining the rate of success in receiving direct route clearances, i.e., cleared as filed. Included in this objective, were three subobjectives:

410.1 - Determine locations of reroutes via the VOR system or via direct, as appropriate.

410.2 - Determine the reasons for reroutes via the VOR system for the purpose of identifying system prohibitions in support of Objective 412.

410.3 - Examine general pilot attitude toward the utility of their RNAV equipment in today's system.

411 - Determine the potential fuel savings which may be realized by flying direct. A subobjective was:

411.1 - Determine how successful Operation Free Flight participants were in achieving their estimated fuel savings potential.

412 - Determine ATC system prohibitions to direct route clearances, if any.

413 - Determine ATC system impact of Operation Free Flight in terms of:

413.1 Controller workload;

413.2 NAS 9020 computer processing demands;

413.3 NAS 9020 computer's ability to accurately post flight progress strips within and between ARTCCs;

413.4 Departure/arrival flow compatibility; and

413.5 En route airspace conflicts.

In order to provide a more thorough understanding of each of these objectives, the following paragraphs contain additional background information which influenced the evaluation program.

Geographical location defined by latitude and longitude coordinates is widely used throughout the world in many applications, including aviation. However, this practice has been discouraged and severely limited in the United States domestic airspace system for two predominate reasons. First, other means are available which suffer none of the disadvantages of latitude/longitude coordinates. For air navigation purposes, the United States has developed an extensive network of omnidirectional, very high frequency, navigation stations which have been strategically placed to provide pilots adequate navigation signals for flight between most airports in the country. These omni-stations (VORs) have been augmented with collocated distance measuring equipment (DME) transmitters in some cases and by the military's Tactical Air Navigation (TACAN) systems in others (thus forming VORTAC stations). Most of these are linked by charted airways and jet routes. The development of this network and associated airway/jet route structure had the added effect of also shaping the nation's air traffic control system and providing to air traffic controllers a means for envisioning the three-dimensional air traffic "picture". Aircraft location has been traditionally identified with respect to the network of VORs, VOR/DMEs, or VORTACs because pilots were using these facilities to navigate and controllers had a firm mental picture of where they were in relation to one another. The advent of radar did not significantly alter this situation, although another navigational tool for expediting and separating air traffic became available. Map overlays and video maps of the airway system were developed to complement the controllers' radar presentation, and agreements between ATC facilities invariably describe operations with respect to the airways and associated navigation aids.

Second, although latitude/longitude coordinates are versatile and precise, there are several drawbacks to their use in air traffic control. One of the most significant of these is that in a nonautomated or even semi-automated environment, an air traffic controller's frame of reference cannot be adequately structured. The number of possible combinations of latitude and longitude, for even a small area, are overwhelming. In short, controllers ordinarily cannot relate to latitude/longitude coordinates while envisioning the location of one aircraft with respect to others without going through the time consuming process of plotting the coordinates on a navigation chart. It is much easier and faster to define points with respect to the ground based navigation stations by using a radial and distance from a VORTAC or, less desirably, by intersecting radials from two or more VORs. Another drawback is error, either on the pilots' or controllers' part, or anyone involved with the processing of flight plan data. A small mistake, such as the transposition of two numbers, can cause a large error in location (or expected location) or track (or expected track).

In shaping the operational evaluation, these factors were exhaustively considered while recognizing that many RNAV avionic systems require the use of latitude/longitude coordinates and others operate from navigation signal sources other than VOR, VOR/DME, or VORTAC.

430 STRIP PROCESSING AND AUTOMATED ROUTE DESCRIPTION

Fundamental to en route ATC is the written description of each controlled aircraft's route of flight on a flight progress strip. This information is used by the controller to create a mental, three dimensional picture of the aircraft's flight path and altitude, as well as each aircraft's proximity and altitude in relation to all other aircraft being controlled. Normally, an aircraft's flight path is defined by a combination of airways, VORs/VORTACs or radials and distances from VORTACs. Routes thusly defined are readily recognizable by both the pilot and controller. Prior to automation, flight progress strips were written by hand and each en route sector or position used one or more of these strips to maintain the aircraft separation picture and record aircraft movements.

With the advent of en route automation, the computer was programmed to understand and depict the same aircraft route definitions. Based upon the computer's ability to project the aircraft's route of flight and compare it with the ATC system's sectorization scheme, each sector was provided with required flight progress strips. This degree of automation, however, did not affect the requirement to provide controllers with information necessary to create the three dimensional air traffic picture.

The introduction of computers did, however, provide controllers with the ability to use latitude/longitude coordinates in a much more effective manner than ever before. The 20 en route ARTCC computers that are interfaced within the contiguous United States are uniquely programmed to describe each ARTCC's environment in terms of VORs, airways, and VORTAC defined fixes. Due to capacity limitations for data storage, however, each computer is limited in its geographical coverage to an area generally within 200 miles of each ARTCC boundary for the purpose of adapting data in the computer program and processing radar derived data. However, since all of the computers work on an X/Y coordinate basis, each computer will accept and understand the location of latitude/longitude coordinates even though the coordinates may identify a point well beyond 200 miles of the ARTCC boundary.

440 CURRENT PRACTICES

While the ATC system was developing in terms of automation and more sophisticated radar procedures, a parallel development was occurring in the growth and use of area navigation avionics. By the mid 1970's, many aircraft in the commercial fleet were equipped with different types of RNAV systems. These systems ranged from self contained types (such as INS) to non-VORTAC referenced (such as OMEGA) and several types of VOR/VORTAC referenced systems. Some of these became commonplace in business and personal aircraft, while LORAN C became attractive for certain helicopter operations. Three types of RNAV avionics were used during the evaluation. Eastern Airlines' aircraft were equipped with OMEGA (Litton LTN-211, Mark 2), modified to receive VLF signals, United Airlines' aircraft used INS (Delco Carousel INS C-4), and Pan American/National aircraft used a VOR/VORTAC referenced system (Collins AINS-70 RNAV) which is programmable.

Pilots and controllers started using, informally, these collective advancements in ATC automation and avionics in an effective technique that allowed long-range, high altitude flights to proceed direct between distant points using RNAV. The pilots would use latitude/longitude to describe the destination airport or navigation aid appropriate to the destination airport and navigate direct via RNAV. The ATC system would monitor the flight and separate such direct routes with radar. This practice effectively avoided several technical issues involving RNAV procedures, since radar separation rather than nonradar lateral protected airspace separation procedures was used to maintain proper separation between all IFR aircraft.

To make this innovative practice work, controllers would use the same latitude/longitude coordinates pilots used to describe the direct route and destination. These coordinates, rounded to the nearest minute, would be entered into the computer in lieu of the normal airway/fix/navaid description elements, thereby taking advantage of the aforementioned computer feature to accept and process any set of coordinates. In doing this, controllers overcame the problem associated with the limited adaptation capacity in the computer that normally allowed ARTCCs to adapt only those navigation aids within 200 miles of each ARTCC's boundary.

The practice described above was augmented by the route readout feature of ARTCC computers. This feature gives controllers the capability of having an aircraft's projected route, based upon flight plan entered data, projected visually on their computer enhanced radar presentation. Thusly, the problem of providing a controller recognizable route was partially eliminated.

The foregoing practices were further enhanced during Operation Free Flight by using latitude/longitude coordinates of existing navigation aids, followed immediately thereafter by the standard three letter identifier for the navigation aid. This overcame the problem of nonadapted fixes and navigation aids in the ARTCC computers, allowing computer processing of the flight plan data and data derived from radar as the aircraft proceeded from point to point. It further helped to eliminate ambiguity in the minds of controllers by linking the coordinates to known locations in the airway structure.

450 TECHNICAL ISSUES

For the past two decades in the en route environment, the accepted method of efficiently controlling large volumes of air traffic has been to organize it into manageable preferably one way flows, thereby dictating or controlling the number of conflict points each controller must recognize and cope with. This concept manifests itself in procedures such as preferential airways, preferential arrival and departure routes, segregation of certain types of operations, flow management, and sectorization of airspace. Taking full advantage of the inherent capabilities of RNAV tends to lead toward development of an unstructured system and instantly creates a paradox with respect to integration into our existing structured, proceduralized system.

Existing methods have been, and will probably continue to be, considered valid so long as the controller, rather than a computer, is required to make mental calculations regarding aircraft route projections, conflict points, and required separation actions. It is obvious that a controller can only make these mental computations on a limited number of aircraft. Thus, the thrust has been to separate aircraft procedurally, to keep the number requiring direct controller intervention to a minimum; thereby, increasing the volume of traffic that can be safely handled.

Over the years, the ATC system has grown to reflect a finely tuned model of this methodology. In any attempt to "free up" the system to accommodate the potential of RNAV operations, system components that represent constraints will require rethinking and new methodology.

Nonradar separation procedures and minima which pertain to RNAV are other areas that require review. RNAV route protected airspace definition and resultant separation minima are structured around those types of RNAV equipment which rely upon the VOR/VORTAC system for their navigational signal source. Fundamental to RNAV accuracy are procedures requiring airborne system updates with respect to tangent points which are derived from VOR/VORTAC radial/distance information.

The basic en route RNAV route width is 8 miles; however, under certain combinations of altitude and tangent point to reference facility distance, and tangent point to reference facility and distance along track, the route width must be expanded. This unique method of determining route width makes its determination a necessary cartographic exercise and negates on the spot controller determination of protected airspace in the application of lateral nonradar separation. For this reason, procedures have always required the use of radar separation between aircraft on random RNAV routes. In addition, although not required by procedure, separation between aircraft on approved RNAV airways and routes has generally been considered a function of radar because of its ease of application over the protected airspace criteria associated with nonradar lateral separation minima.

Operation Free Flight was developed within the context of today's National Airspace System and the foregoing technical issues in an attempt to evaluate what appeared to be a positive step with worthwhile benefits. Unlike previous studies, Operation Free Flight was designed to collect "real time" data concerning direct, great circle flight. The remainder of this report explains methodology and results of the operational evaluation.

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500 METHODOLOGY

Given the purpose of the evaluation (described in Section 200), the operational concept (described in Section 300), and the four major objectives (outlined in Section 400), it was determined that several important questions had to be addressed. Among these were:

1. Which city-pairs should be selected?
2. Who will voluntarily participate?
3. How can it be ensured that participants will conduct their flights during the desired normal and heavy traffic periods?
4. What types of RNAV equipment will be needed to participate?
5. How can it be ensured that an adverse impact to the ATC system will not occur?
6. What means should be used to collect information?
7. How much information is needed?
8. What procedure will be most effective in developing the routes of flight?
9. How will fuel savings be quantified?
10. What is the most effective means of coordinating the evaluation?

These questions and others were resolved prior to the evaluation commencing on June 1, 1980. The following paragraphs provide an explanation of the methodology which was selected to answer the stated objectives.

510 CITY-PAIR SELECTION

Twelve city-pairs were initially selected for three reasons. First, there was concern over the impact Operation Free Flight might have on the National Airspace System (NAS). There were unresolved questions regarding traffic flow compatibility, the NAS 9020's ability to accurately post flight progress strips in proper ARTCC sectors, possible controller confusion over the use of latitude/longitude coordinates, and the fact that the aircraft would be flying a great circle route whereas the NAS 9020 computers in most ARTCCs processed flight plan data via rhumb line. Consequently, the first group of city-pairs were linked to Atlanta (Hartsfield) and Miami International and only a few flights per day were selected to participate. Each flight was carefully monitored by ARTCC supervisory personnel until it was determined that the aforementioned concerns did not appear to be limiting factors.

Second, the decision to use scheduled airlines as participants dictated selection of city-pairs which were available; i.e., cities served by the participating airlines. Moreover, since the airlines did not have all of their aircraft equipped with RNAV, the final selection process throughout the evaluation hinged around cities served by "wide body" jets, as these could be consistently counted upon to have the necessary navigation equipment.

Third, the FAA Southern Region Air Traffic Division volunteered to assist in conducting the evaluation and offered numerous constructive suggestions during development of the project. As the principal point of contact for day-to-day operational matters, it was felt that initially confining participants to departures from Atlanta and Miami would give them the opportunity to quickly assess the feasibility of both expanding the number of city-pairs and daily flights.

Over the ensuing six months, city-pairs were added to the list progressively as additional airline flights were increased. Initially, Eastern and National Airlines were the only participants. Later, as National began merging with Pan American World Airways, Pan Am provided additional flights and other city-pairs. In October, United Airlines added B-747 flights to the list and additional city-pairs were identified. By the time United Airlines joined the evaluation, the number of city-pairs had doubled and flights were being conducted coast-to-coast in both directions. Several city-pairs were identified solely for the purpose of obtaining information on relatively short flights and in other than east-west directions. However, it cannot be over stressed that city-pair selection was tied directly to available flights by the participating airlines.

511 ROUTE OF FLIGHT DEVELOPMENT

The primary emphasis throughout the evaluation regarding the routes of flight provided to the participants was that of adhering to the operational concept to the maximum extent possible. From the beginning, however, it was recognized that there were a few unresolvable constraints governing certain city-pairs. These were of two basic types, special use airspace and departure/arrival traffic flows. Two large restricted area complexes, the White Sands Proving Grounds and Edwards AFB area, dictated the insertion of a turn point in the routes serving Miami and San Francisco/Los Angeles. Additionally, in the case of departures and arrivals at Miami to or from the west, special consideration also had to be given its geographical placement and the impact coastal warning areas have on great circle routes. In order to avoid routes through the warning areas, an additional turn point was necessary. Although the operational concept was compromised by such actions, it was felt that the distance involved still made it worthwhile to collect data from these flights. Moreover, given the nature and frequency of operations within the aforementioned special use airspace areas, it was realistic and practical.

The influence of existing departure and arrival traffic flows over route development was less of a compromise of the operational concept than the effect of major special use airspace areas. In fact, the impact was one of degree, rather than principle. In several cases, fixes much closer to the departure or arrival airports would have been preferred over those ultimately selected, but for various reasons, it was decided to use the fix which was most likely to place participating aircraft in the normal departure and arrival flow of traffic. In some cases, this required the use of an intermediate flow fix before the arrival area fix. This later proved to be a prudent decision and is further discussed in Sections 600 and 700.

A deliberate effort was made to use existing Standard Instrument Departure (SID) and Standard Terminal Arrival Route (STAR) fixes to begin and end the en route portion of flight. In most cases, SID and STAR transition fixes were used instead of the basic SID termination fixes or STAR commencement fixes, although the latter would have produced slightly shorter routes. The usual reason for this was related to departure/arrival traffic flows. In all cases, the specific route to be filed was coordinated in advance by the Southern Region with the points of contact at the ARTCCs, and the ARTCC's recommendations regarding the fixes to be used for departures and arrivals were followed. In some cases, minor adjustments were necessary for various unforeseen reasons. These are further discussed in Section 600.

In all cases, routes were defined by the standard identifier for the departure area fix, as well as all other fixes on the route. However, the latitude and longitude of turn points, intermediate fixes, and arrival fixes, rounded off to the nearest minute, were used to compensate for the fact that, generally, these fixes are not adapted in the departure and intermediate ARTCCs' computers and, consequently, the computers would not process the flight plan if only the fix identifier was provided. Since the computer works on an X/Y coordinate basis, however, using a latitude/longitude point very close to the desired fix enabled computer processing of the filed route of flight. The coordinates were immediately succeeded in all cases by the fix identifier for controller recognition purposes.

512 PILOT QUESTIONNAIRE DEVELOPMENT

It was decided that the most efficient means of collecting data, relative to each flight, would be through a questionnaire. Construction of the questionnaire proceeded and was based upon Objectives 410, 411, and 412 and their associated subobjectives. Although several other questions would have been appropriate and were desired, it was decided to limit the questionnaire to a single page, anticipating that pilots would object to a more lengthy questionnaire. The form was designed to be folded and mailed, with postal franking provided, for the same basic reason.

Another consideration in designing the questionnaire was data management. Steps were taken to develop a computer program to tabulate answers to the questions and analyze the data by city-pair and in the aggregate. Arrangements were made so the Project Manager could continuously check results, as indicated by the data, through a time sharing computer terminal which was acoustically coupled to the Transportation Systems Center (TSC) computer in Cambridge, Massachusetts where the data was stored.

Questionnaires were distributed to the participating airlines who took steps to ensure each Operation Free Flight filed aircraft was provided a copy. The airlines also found it necessary to take additional measures to publicize the program in order to inform pilots and encourage execution of the questionnaire.

A copy of the pilot questionnaire is contained in Appendix A.

513 ARTCC QUESTIONNAIRE DEVELOPMENT

The ARTCC questionnaire was developed along the same lines as the pilot questionnaire but was designed to be reviewed individually, rather than through automated means. The structure of the questionnaire was directly related to Objective 413. It was designed to be executed only when an impact occurred or an ARTCC desired to communicate information broader in scope than the exact questions asked.

Each ARTCC within the 48 states was provided copies of the questionnaire and were instructed to forward them to the Southern Region, Air Traffic Division. Throughout the evaluation, ARTCC points of contact were encouraged to amplify questionnaires submitted through telephone conversations with southern region personnel and the Project Manager.

A copy of the ARTCC questionnaire is contained in Appendix B.

514 FLIGHT PLAN SELECTION BY PARTICIPATING AIRLINES

Flight plans are computer selected by each of the participating airlines. Eastern Airlines provided this service to both the former National Airlines and Pan American. Multiple routes of flight between all cities are stored in the United and Eastern computers, and a similar process in selecting the route to file with ATC is followed for every flight.

All airlines do not use the same methodology to select filed flight plan routes. Some are predominately concerned with minimum time tracks, regardless of fuel consumption (to a point). Other airlines seek to consider all variables, ranging from on-schedule performance to airframe, maintenance, crew, and fuel costs, and still others focus mainly on fuel costs. The airlines that participated in Operation Free Flight all shared the same basic methodology, i.e., minimum fuel consumption. Consequently, some of the data will reflect that methodology and not necessarily others.

The working agreement with the participating airlines required the addition of Operation Free Flight routes to the routes already stored in the airline computers. Thus, Operation Free Flight routes were subjected to the same computer analysis as all others. If the computers selected the Operation Free Flight route, it was filed with ATC; if not selected, the flight was not considered to be a participant. Although this arrangement substantially reduced the number of participants and tied the operational concept directly to the quality of airline computer analysis, it would have been unrealistic to expect the airlines to do otherwise, given today's high fuel costs.

515 FLIGHT SELECTION

Initially and throughout the evaluation, exact flight numbers of potential participating flights were predetermined by the Project Manager and the airline representatives. This information was made known only to the Southern Region, Air Traffic Division. This process was followed to ensure participation only during the desired normal to heavy traffic periods which, for evaluation purposes, was generally considered to be between 0800 and 2000 local time. Since flights were conducted nationwide, within four time zones, it was obviously impossible to rigidly conform to these hours. The general procedure followed involved considering the amount of time each flight would be in the system during the desired hours.

516 ADJUSTMENTS

Throughout the evaluation, adjustments to city-pairs, routes, and participating flights were necessary. Most often these were due to schedule changes by the airlines. In some cases, a potential participating flight was moved out of the desired time frame and, in others, the type aircraft was changed to one that did not have RNAV equipment.

Route changes all dealt with refinements to the exact departure or arrival area fixes used or the addition of a "flow" fix in the case of arrivals into the New York area. All route changes were made as soon as a need was identified and were implemented by the airlines shortly thereafter.

DEATH FROM

600 DISCUSSION OF RESULTS AND ANALYSIS

The purpose of this section is to provide the detailed tabular data necessary to support the results, and conclusions. The data was collected by the pilot and ARTCC questionnaires, as well as from the individual participating airlines, during the period June 1 through December 31, 1980. The details presented in this section represent the results of a comprehensive review and analysis of Operation Free Flight data and other data which was available.

To facilitate correlation with the evaluation's objectives, these results are organized according to the four major objectives outlined in Section 400. Individual city-pair data and aggregate data are both discussed, as appropriate. Section 610 is devoted to presentation of the totals of all city-pairs tested, general facts about the operational evaluation, and comparative analysis of the sample data with what was known about all of the potential participants.

610 GENERAL TOTALS AND CHARACTERISTICS OF THE SAMPLE DATA

611 GENERAL TOTALS

Initially, the evaluation was designed to commence with flights conducted between 12 city pairs. As experience was gained and several operational questions were resolved, the number of city-pairs and participating flights were increased. Table 6-1 depicts the original city-pairs and number of flights selected for potential participation. Prior to June 1, three (ATL-LGA, ATL-EWR, and MIA-DTW) were dropped due to schedule changes which resulted in non-RNAV equipped aircraft serving these city-pairs.

TABLE 6-1 INITIAL CITY-PAIRS AND NUMBER OF POTENTIAL FLIGHTS

City-Pair	Potential Flights	City-Pair	Potential Flights
ATL-SEA	1	ATL-LGA	1
ATL-SFO	1	ATL-EWR	2
ATL-LAX	2	MIA-LAX	3
ATL-ORD	1	MIA-SFO	2
ATL-PIT	2	MIA-ORD	2
ATL-BUF	2	MIA-DTW	1

NOTE: All flights were daily, seven days per week.

The above city-pairs were not expanded until late August, although a few additional flights were added to the potential participants list. In July, a firm decision was made to extend the evaluation's time frame and expand the number of city-pairs and flights participating. A need immediately developed to find another airline which would voluntarily participate in order to develop a network of city-pairs that would test routes flown in all directions and enable an increase in volume of participating flights each day. United Airlines filled this need, adding

most city-pairs served by their B-747 fleet and commencing participation on October 7. Both Eastern and Pan American also expanded the number of participating flights, and other city-pairs were added to the evaluation.

As explained in Subsection 516, adjustments to city-pairs and flights were necessary throughout the evaluation. Up to 39 city-pairs were identified and routes developed prior to the end of the data collection phase of the evaluation. However, for reasons which have been discussed, the total number of city-pairs evaluated prior to December 31 was 27. Table 6-2 provides a list of these city-pairs, the total number of flights scheduled during the test period, the total number of times the Operation Free Flight route was actually filed, the percentage selection rate of the Operation Free Flight route, the number of pilot questionnaires received, and the questionnaire percentage return rate.

TABLE 6-2 OVERALL OPERATION FREE FLIGHT DATA

1 City Pair	2 Airline	3 Total Flights During Test Period	4 Operation Free Flight Selected	5 Percent Selection (4 ÷ 3)	6 Number Pilot Questionnaires Received	7 Questionnaire Return Rate (6 ÷ 4)	8 Questionnaires Received with all Fuel Data (Q-19, 20, and 21)	9 Fuel Data Percent Return (8 ÷ 4)
1. ATL-SEA	EA	181	78	43%	20	26%	9	12%
2. ATL-SFO	EA	36	22	61%	3	14%	1	5%
3. ATL-LAX	EA	248	160	65%	20	13%	5	3%
4. ATL-ORD	EA	19	14	74%	1	7%	0	
5. ATL-PIT	EA	212	57	27%	19	33%	8	14%
6. ATL-BUF	EA	424	197	46%	34	17%	15	8%
7. MIA-LAX	PA	838	302	36%	68	23%	33	11%
8. MIA-SFO	EA	212	97	46%	40	41%	15	15%
	PA	612	280	46%	56	20%	29	10%
	TOTAL	824	377	46%	96	25%	44	12%
9. MIA-ORD	EA	212	130	61%	53	41%	15	12%
10. SEA-ATL	EA	36	3	8%	2	67%	0	
11. LAX-MIA	PA	92	33	36%	1	3%	0	
12. LAX-ATL	EA	72	0	0%	8		6	
13. LAX-ORD	UA	83	45	54%	15	33%	4	9%
14. LAX-JFK	EA	119	0	0%	1		0	
	UA	281	67	24%	42	63%	11	16%
	TOTAL	400	67	24%	43	64%	11	16%
15. LAX-JFK	EA	60	34	57%	12	35%	7	21%
	PA	92	52	57%	11	21%	6	12%
	TOTAL	152	86	57%	23	27%	13	15%
16. SFO-JFK	EA	119	14	12%	5	36%	4	29%
	UA	81	30	37%	14	47%	7	23%
	TOTAL	200	44	22%	19	43%	11	25%
17. JFK-LAX	EA	59	20	34%	0			
	PA	92	31	34%	1	3%	0	
	TOTAL	151	51	34%	1	2%	0	
18. JFK-SFO	EA	119	13	11%	1	8%	1	8%
	UA	83	21	25%	18	86%	9	43%
	TOTAL	202	34	17%	19	56%	10	29%
19. JFK-LAX	EA	119	11	9%	5	45%	1	9%
	UA	287	25	9%	10	40%	1	4%
	TOTAL	406	36	9%	15	42%	2	6%
20. ORD-MIA	EA	60	18	30%	1	6%	1	6%
21. ORD-LAX	UA	84	13	15%	8	62%	4	31%
22. ORD-EWR	UA	49	20	41%	4	20%	1	5%
23. PIT-ATL	EA	59	4	7%	2	50%	1	25%
24. BUF-ATL	EA	120	0	0%	1		0	
25. CLT-LGA	EA	88	65	74%	14	22%	7	11%
26. EWR-SFO	UA	85	51	60%	38	75%	25	49%
27. EWR-ORD	UA	23	12	52%	1	8%	0	
ALL CITY PAIRS	EA	2574	937	36%	242	26%	95	10%
	UA	1056	284	27%	150	53%	62	22%
	PA	1726	698	40%	137	20%	68	10%
	TOTAL	5356	1919	36%	529	28%	226	12%

NOTE: All data from the former National Airlines has been combined and tabulated with Pan American data.

Three anomalies are readily apparent with the data in Table 6-2. These occur with city-pairs LAX-ATL, LAX-JFK (Eastern Airlines), and BUF-ATL. In these cases, the Operation Free Flight route was not filed a single time, yet pilot questionnaires were received. Investigation revealed that Eastern Airlines had retained three previously developed great circle routes between LAX-ATL in their computer in addition to the Operation Free Flight route and each of these was a few miles shorter than the evaluation's route. Consequently, their computer never selected and filed under Operation Free Flight, instead one of the shorter great circle routes was filed when one appeared to be the most economical. By the time this situation was discovered, it was too late to determine the total number of times one of these other great circle routes was selected. The data received from these pilot questionnaires were retained in the data base, given the fact that the reporting flights were obviously flying a direct routing which was in most respects the same as the Operation Free Flight route. Because of the different method of describing the route of flight, however, specific analysis of this city-pair has been excluded and the data used only in considering the aggregate data collected.

In the case of BUF-ATL, investigation revealed that the normal airway routing length was within four miles of the Operation Free Flight route and, evidently for this reason, Eastern's computer failed to select the evaluation's route of flight. Review of the single pilot questionnaire received established that the flight was "cleared as filed," was not rerouted via the VOR system, and the pilot thought that his RNAV equipment was extremely useful on the flight. Although no explanation of this disparity could be provided, the pilot questionnaire data was retained in the data base since the flight apparently participated in the test. The same situation applies to the single questionnaire received (from Eastern) between LAX-JFK.

Table 6-2 establishes that during the test period, the participating airlines had an opportunity to file the Operation Free Flight route a total of 5356 times between 27 city-pairs and that the test route was actually filed for 36% (1,919 flights) of the total flights.

Specific data concerning these participants were received from 529 flights for a 28% rate of return of the questionnaires overall. Columns 8 and 9 reveal that data concerning fuel consumption were only received from 12% (226 flights) of the participants. Most often, this was due to the airlines not answering questions 20 and 21 on the questionnaire, rather than the pilots' failure to answer question 19. Unfortunately, it was not possible to validly compute the estimates of fuel consumption after the fact. Consequently, numerous questionnaires which were received were limited to the data obtained from questions 1 through 18. As a result, most of the analysis of the fuel data has been limited to the aggregate data received from all city-pairs.

Table 6-2 also reveals that between several of the city-pairs, very few pilot questionnaires were received, although there may have been a considerable number of participating flights, and that between a few city-pairs, there were very few participating flights conducted. In both cases, no attempt has been made to draw conclusions from the pilot questionnaires alone.

612 CHARACTERISTICS OF THE SAMPLE DATA

The 529 pilot questionnaires which make up the Operation Free Flight data base constitute a nonrandom sample of all the participating flights which totaled 1,919. Since no attempt was made to influence the sample, except through general encouragements to pilots to fill-out the questionnaires, there is very little that can be said about the sample size, and there arises an immediate question over how representative the data derived from the sample (529) is to the total population (1,919). In order to gain insight into this question, several comparisons of the sample data were made with known characteristics of the total number of participants.

One comparison examined the distribution of departure times between the scheduled times of departure for all flights known to have participated and the actual times of departure reported by the 529 flights in the sample. The scheduled departure times were used for all known participants, in lieu of actual departure times, primarily as a matter of convenience since the former data was readily available. Additionally, use of the scheduled times was considered to be justified given the on-time performance records of the participating airlines.

Table 6-3 presents the results of the comparison.

TABLE 6-3 SCHEDULED DEPARTURE TIMES - ALL PARTICIPANTS
COMPARED WITH ACTUAL TIMES OF DEPARTURE - SAMPLE

Time of Departure (Local)	1 Scheduled Departure Times - All Parti- cipating Flights	2 Number and Percent Between 0801-2000 All Participants	3 Actual Departure Times - Sample Data	4 Number and Percent Between 0801-2000 Sample
0001-0100			5	
0101-0200			5	
0201-0300				
0301-0400				
0401-0500			1	
0501-0600				
0601-0700	10			
0701-0800			4	
0801-0900	227		37	
0901-1000	165		53	
1001-1100	34		26	
1101-1200	118		41	
1201-1300	71		20	
1301-1400	289	1,847	39	481
1401-1500	57	96.3%	19	90.9%
1501-1600	13		9	
1601-1700	44		7	
1701-1800	565		69	
1801-1900	167		84	
1901-2000	97		77	
2001-2100	10		8	
2101-2200			8	
2201-2300	52		6	
2301-2400			11	
TOTALS	1,919		529	

Table 6-3 shows that a high percentage (96.3%) of the participating flights were scheduled for departure during the desired hours of 0801 to 2000. A similar high percentage (90.9%) of the 529 flights which make up the sample reported actual departure times between the same twelve hour period. The scattering which is evident in Column 3 prior to 0801 is suspected to be due to delayed departures by the 52 participating flights scheduled for takeoff between 2201-2300. Part of the 11 actual departures between 2301-2400 in column 3 may also be attributed to the same reason. Spot checks of these flights indicate that bad weather accounted for most of these delays.

A similar comparison was made with the distribution of arrival times between the scheduled times of arrival for all flights known to have participated and the actual times of arrival of the 529 flights in the sample. Scheduled times of arrival in lieu of actual times were used for the same reason stated in the foregoing discussion. Table 6-4 presents the results of the comparison.

TABLE 6-4 SCHEDULED ARRIVAL TIMES - ALL PARTICIPANTS
COMPARED WITH ACTUAL TIMES OF ARRIVAL - SAMPLE

Time of Arrival (Local)	1 Scheduled Arrival Times - All Participating Flights	2 Number and Percent Between 1001-2300 All Participants	3 Actual Arrival Times - Sample Data	4 Number and Percent Between 1001-2300 Sample
0001-0100			1	
0101-0200			1	
0201-0300			4	
0301-0400	45		6	
0401-0500			7	
0501-0600			10	
0601-0700	7		1	
0701-0800			1	
0801-0900			2	
0901-1000	39		3	
1001-1100	94		25	
1101-1200	88		27	
1201-1300	69		22	
1301-1400	90		35	
1401-1500	91	1,818	15	491
1501-1600	111	94.7%	17	92.8%
1601-1700	286		37	
1701-1800	65		25	
1801-1900	266		36	
1901-2000	234		61	
2001-2100	290		97	
2101-2200	37		61	
2201-2300	97		33	
2301-2400	10		2	
TOTALS	1,919		529	

Table 6-4 shows that a high percentage (94.7%) of the participating flights were scheduled to arrive during the hours 1001-2300. A similar high percentage (92.8%) of the 529 flights in the sample reported actual arrival times between the same thirteen hour period. Scattering of the actual arrival times in Column 3 over a 24-hour period was expected since scheduled departure times were used, predominately, to determine which flights should be added to the potential participants list. The 45 scheduled arrivals between 0301-0400 in Column 1 reflect this fact.

As revealed by Tables 6-3 and 6-4, the flights which make up the sample appear to be representative of the entire population of participants as far as overall departure and arrival times are concerned. Other comparisons, however, do not indicate consistently clear trends. Columns 4 and 6 of Table 6-2, for example, show the total number of times the Operation Free Flight routes were filed and the number of questionnaires received from participating flights. In general, as the number of participating flights increased, so did the number of questionnaires received. However, there are several exceptions to this generality which suggest that there is not a direct relationship between the two. Moreover, it was noted over the six month data collection period that the quantity of questionnaires received was related to each airline's latest publicity about the evaluation to their pilots. After each such re-emphasis, the number of questionnaires increased, then tapered off until the next time "reminders" were sent out. A notable exception to this trend was United Airlines, which is evident from the fact that, overall, 53% of their participating flights provided questionnaires.

A final comparison of the sample data to the number of participants was made in an indirect fashion. The method used was primarily subjective and interpretational in nature but, more than any other, it strongly suggests that the sample data is, in general, representative of the entire population of participating flights. This comparison consisted of reviewing, in detail, the ARTCC questionnaires received and relating them to the pilot questionnaire data. In nearly every case, there was an exact correlation between the two sets of data. This finding was reinforced through numerous telephone conversations and meetings between the Project Manager, Southern Region staff, and ARTCC points of contact. Consequently, there are no discernable reasons to suspect that the overall sample data and the trends they reflect are biased in any particular fashion. With respect to individual city-pairs, however, there were some which produced such a paucity of data that no conclusions were possible. Succeeding paragraphs of this section elaborate extensively on the results of the evaluation and analysis of the data.

620 OPERATION FREE FLIGHT SUCCESS RATE AND SYSTEM PROHIBITIONS

Objective 410: Determine the feasibility of permitting the filing of direct route flight plans without detailed route definition by examining the rate of success in receiving direct route clearances, i.e., cleared as filed.

Subobjectives:

- 410.1 - Determine locations of reroutes via the VOR system or via direct, as appropriate.
- 410.2 - Determine the reasons for reroutes via the VOR system for the purpose of identifying system prohibitions in support of Objective 412.
- 410.3 - Examine general pilot attitude toward the utility of their RNAV equipment in today's system.

Objective 412: Determine ATC system prohibitions to direct route clearances, if any.

621 ALL CITY-PAIRS

621.1 SUCCESS RATE

Overall, the data indicate that the participants were very successful in conducting their entire flight via direct routing, as filed. Depending upon how questions 6 through 17 were answered on the pilot questionnaire, six possible routing combinations can be identified. For example, answering question 6 "yes" and question 7 "no" indicates that the flight flew 100% of its distance direct, as filed. Tracking the patterns of possible responses to the questions, will establish the following possibilities:

1. Direct all the way, no reroutes. Note that radar vectors en route were not considered reroutes via the VOR system.
2. Direct initially, but subsequently rerouted via airways to arrival fix.
3. Direct initially, rerouted via airways, but subsequently cleared direct to arrival fix.
4. VOR system all the way, i.e., not cleared as filed.
5. VOR system initially, but subsequently cleared direct to arrival fix.
6. VOR system initially, recleared direct, but subsequently rerouted via airways to arrival fix.

Table 6-5 presents the routing combinations of all flights in the pilot questionnaire data base between all 27 city-pairs.

TABLE 6-5 ROUTING COMBINATIONS- ALL CITY-PAIRS

1 DIRECT Σ (n)	2 DIRECT/VOR Σ (n)	3 DIRECT/VOR/DIRECT Σ (n)	4 VOR Σ (n)	5 VOR/DIRECT Σ (n)	6 VOR/DIRECT/VOR Σ (n)	TOTAL Σ (n)
80.5 (426)	7.8 (41)	6.2 (33)	0.6 (3)	3.6 (19)	1.3 (7)	100 (529)

621.2 LOCATIONS OF REROUTES

Table 6-5 shows that a significant majority (80.5%) of the participants were able to conduct their flights as filed, without being rerouted. The very low percentages under routing combinations 4 (VOR) and 6 (VOR/DIRECT/VOR) lead to a more thorough examination of the 100 flights under combinations 2, 3, 5, and 6 to determine how many of these aircraft flew a significant portion of the distance direct. The results were that 69 of the 100 flights flew more than 80% of the distance between fixes direct, although a portion of their flights were conducted on airways. Further analysis revealed that 40 of these 69 flights were able to fly direct over more than 90% of the distance between fixes. When these figures are added to the number of aircraft that flew 100% of the distance direct, the "success rate" climbs even higher. Table 6-6 presents these results.

TABLE 6-6 AIRCRAFT FLYING A SIGNIFICANT PORTION OF ROUTES DIRECT BETWEEN ALL CITIES

> 80% DIRECT Σ (n)	> 90% DIRECT Σ (n)
93.6 (495)	88.1 (466)

With exception of the foregoing analysis, locations of the reroutes, as they pertain to the all city-pair aggregate data, are not further discussed in this subsection.

621.3 REASONS FOR REROUTES (SYSTEM PROHIBITIONS)

Reasons for reroutes via airways or inability to obtain an initial direct routing fall predominately into two categories: (1) Traffic; and (2) Weather. Table 6-7 presents the results of all answers to questions 8, 12, and 16 on the pilot questionnaire given by the 110 pilots responding to them.

TABLE 6-7 DISTRIBUTION OF FLIGHTS BETWEEN ALL CITY-PAIRS BY REASON FOR REROUTING VIA VOR SYSTEM

Question	Weather Σ (n)	Upper Winds Σ (n)	Traffic Σ (n)	Special Use Airspace Σ (n)	ATC System Outage Σ (n)	Aircraft Equipment Σ (n)	Other Σ (n)	Total Σ (n)
8	16.2 (12)	0 (0)	41.9 (31)	23.0 (17)	5.4 (4)	1.4 (1)	12.2 (9)	100.0 (74)
12	48.3 (14)	3.4 (1)	13.8 (4)	.0 (0)	.0 (0)	.0 (0)	34.5 (10)	100.0 (29)
16	42.9 (3)	.0 (0)	57.1 (4)	.0 (0)	.0 (0)	.0 (0)	.0 (0)	100.0 (7)
TOTAL	26.4 (29)	0.9 (1)	35.4 (39)	15.5 (17)	3.6 (4)	0.9 (1)	17.3 (19)	100.0 (110)

Keeping in mind that answers to question 8 were only potentially appropriate for those flights which were initially successful in receiving a direct route clearance and that answers to questions 12 and 16 were only appropriate for those flights which were not initially successful, the data in Table 6-7 reveal that "Traffic" was most often cited as the reason for being rerouted via airways after either initially (question 8) or subsequently (question 16) being cleared direct and that "Weather" was most often cited as the reason for not being initially successful (question 12). Overall, "Traffic" was most often cited (35.4%) with "Weather" running not too far behind.

It should be noted that "Weather" was most often cited in question 12 as the reason flights were not cleared as filed. Review of the 10 "Other" responses indicate that one belonged in the "Traffic" category and the other nine most often indicated a flight plan filing or processing problem not related to the evaluation.

During analysis of individual city-pairs, two facts became evident, and these findings help to further clarify the major reasons for flights being rerouted. First, several respondents who stated "Other" as the reason for reroute were actually saying "Traffic." The term "traffic" has several meanings, depending upon its application. During this evaluation, "traffic" fell into two categories, i.e., "traffic," as in separation or "traffic" as in arrival flow. Both are obviously interrelated when volume or density is a factor, but, often, separation from other traffic operated independently of arrival flow as a reason for rerouting aircraft. While this was apparently not evident to all the pilots responding, it does become evident when several of the "Other" responses are analyzed in conjunction with the ARTCC questionnaires. Several of these pilot responses elaborated on "Other" with such phrases as "New York ARTCC will not accept direct" or "Rerouted by Cleveland ARTCC." It was determined that such responses were indicating "Traffic Arrival Flow" as the reason for reroute in these cases. Therefore, when "Traffic Arrival Flow" is added to the "Traffic" responses, the percentage of respondents in this category become very significant.

Second, the relatively low number of respondents citing "Special Use Airspace" could have been further reduced through very slight modifications to the routes. Twelve of the 17 respondents in this category came from the MIA-LAX and SFO-JFK city-pairs. All of these reroutes were due to major restricted area complexes which were in use at the time the flights were conducted. Route modification, however, raises the question of impact from both the pilot and controller points of view. This question is extensively discussed in Subsection 640.

The data from Table 6-7 was modified to reflect the foregoing information by shifting the responses under "Other" to "Traffic" when it could be determined through pilot comments that "Traffic Arrival Flow" was the reason for reroute, by deleting the 12 "Special Use Airspace" responses derived from MIA-LAX and SFO-JFK, and by recomputing percentages. This data is presented in Table 6-8.

TABLE 6-8 DISTRIBUTION OF FLIGHTS BETWEEN ALL CITY-PAIRS BY REASON FOR REROUTE VIA VOR SYSTEM (MODIFIED)

Question	Weather % (n)	Upper Winds % (n)	Traffic % (n)	Special Use Airspace % (n)	ATC System Outage % (n)	Aircraft Equipment % (n)	Other % (n)	Total % (n)
8	19.4 (12)	0 (0)	64.5 (40)	8.1 (5)	6.5 (4)	1.6 (1)	0 (0)	100.0 (62)
12	48.3 (14)	3.4 (1)	17.2 (5)	0 (0)	0 (0)	0 (0)	31.0 (9)	100.0 (29)
16	42.9 (3)	0 (0)	57.1 (4)	0 (0)	0 (0)	0 (0)	0 (0)	100.0 (7)
TOTAL	29.6 (29)	1.0 (1)	50.0 (49)	5.1 (5)	4.1 (4)	1.0 (1)	9.2 (9)	100.0 (98)

Table 6-8 strongly suggests that the only widespread ATC system constraint to uninterrupted direct route flight is "Traffic;" either as applicable for separation or for arrival flow. Weather is definitely a factor but falls into the same category as "Upper Winds, ATC System Outage, and Aircraft Equipment;" namely, not controllable or subject to manipulation. "Special Use Airspace" appears to be a factor only with respect to a few specific locations. Among all respondents answering "Other," ten out of 19 were linked to "Traffic."

Further refinement of the results with respect to the variable "Traffic" was not possible due to lack of information in a high number of cases. A sufficient number of questionnaires did, however, contain enough amplifying information to strongly indicate that incompatibility with "Traffic Arrival Flow" was a major reason for reroutes. Since the operational concept of Operation Free Flight required the identification of departure and arrival area fixes in order to avoid incompatible traffic flows, this finding was seemingly nonsensical until the data was interrelated with ARTCC questionnaires and reviewed on an individual city-pair basis. In nearly all cases, the causative factor was, ironically, traced to "controller accommodation" of two distinct types. One, a participant would require vectoring off the initial direct route which was filed and being flown. Later, when the pilot was able to resume normal navigation, the controller would reclear the aircraft to the destination airport without regard for the arrival area fix. Two, the scenario would be identical to one, above, or a controller would become aware that a special use airspace area was not active and, to help the pilot out by shortening his filed route, would reclear the aircraft to the arrival area fix or destination airport, irrespective of any intermediate fixes which had been filed. In both situations, the track of the aircraft would be sufficiently altered to cause arrival conflicts as the flight neared the destination airport. Consequently, the arrival area ARTCC would instruct the adjacent ARTCC to reroute the aircraft. When this occurred, the coordination between ARTCCs was invariably conducted with respect to the controller recognizable, VOR airway structure and resulted in a reroute via the VOR system to the flight.

621.4 PILOT ATTITUDE

The pilot questionnaire contained one question (#18) which was inserted to obtain a rough idea of how pilots felt about the utility of their RNAV equipment on each flight. Obviously, one question does not qualify, rigorously, as a means for describing the attitude of any given population, and this evaluation does not purport to do so. For a variety of reasons, however, some indication of the direction of pilots' attitude regarding the utility of RNAV equipment in today's system was desired. Consequently, one question was considered sufficient to satisfy this subobjective. The distribution of responses overall seem to indicate a positive skewness. Table 6-9 presents this data.

TABLE 6-9 DISTRIBUTION OF FLIGHTS BETWEEN ALL CITY-PAIRS BY PILOT VIEWPOINT ABOUT RNAV

Extremely Advantageous X (n)	Very Advantageous X (n)	Moderately Advantageous X (n)	Slightly Advantageous X (n)	Not At All Advantageous X (n)	Total X (n)
46.7 (247)	29.3 (155)	13.6 (72)	8.7 (46)	1.7 (9)	100.0 (529)

It was noted that most of the United Airlines' pilots chose "moderately" or "very" to describe the advantage of RNAV on their flights. Several, in fact, questioned the acronym "RNAV" in the question. Review of comments provided on the questionnaires revealed that many of these pilots did not consider their INS system to be RNAV equipment, and they did not consider the test program to be all that different from routine flights. Typical comments were: "RNAV? We have INS" or "This program is not new. We frequently ask for INS direct to destination after reaching cruise altitude - and get it." The latter comment is indicative of the informal, direct routing procedure which was discussed in Section 200 and both undoubtedly provide some insight into these pilots' tendency to be less positive in answering the question. They further point out the fact that "advantageous" is viewed from several perspectives, other than pure utility.

The distribution of pilots' viewpoint was arranged in accordance with the various routing combinations which were described previously. The results are presented in Table 6-10.

TABLE 6-10 PILOTS' VIEWPOINT BY ROUTING COMBINATION - ALL CITY-PAIRS

Viewpoint	Direct X (n)	Direct/VOR X (n)	Direct/VOR Direct X (n)	VOR X (n)	VOR/ Direct X (n)	VOR/Direct/ VOR X (n)
Extremely ADV	51.6 (220)	19.5 (8)	33.3 (11)	66.7 (2)	31.6 (6)	.0 (0)
Very ADV	28.6 (122)	31.7 (13)	24.2 (8)	.0 (0)	42.1 (8)	57.1 (4)
Moderately ADV	11.7 (50)	24.4 (10)	18.2 (6)	33.3 (1)	21.1 (4)	14.3 (1)
Slightly ADV	7.3 (31)	12.2 (5)	21.2 (7)	.0 (0)	5.3 (1)	28.6 (2)
Not At All ADV	0.7 (3)	12.5 (5)	3.0 (1)	.0 (0)	.0 (0)	.0 (0)
TOTAL	100.0 (426)	100.0 (41)	100.0 (33)	100.0 (3)	100.0 (19)	100.0 (7)

The data in Table 6-10 indicate the same positive skewness under each routing combination. The fact that most flights were able to fly significant portions of their routes via direct probably accounts for some of this apparent polarization, but the fact that several flights which were severely limited in opportunity to primarily navigate with their RNAV equipment, yet still expressed a very positive attitude toward RNAV, is evidence that other factors need to be taken into account. This seems to be reinforced by the data under Combinations 1 and 4. In the latter case, two flights reported "Extremely Advantageous" and the third "Moderately Advantageous," yet all three conducted their flights via airways. Under Combination 1, the data shows three flights reporting "Not At All Advantageous," yet 100% of their flight en route was conducted via great circle, using RNAV equipment.

When the distribution of pilots' viewpoint is arranged according to percentage of fuel savings potential realized (see Subsection 630 for an explanation of this term), the same positive direction is sustained. This data is presented in Table 6-11.

TABLE 6-11 PILOTS' VIEWPOINT BY PERCENTAGE OF FUEL SAVINGS POTENTIAL
REALIZED - ALL CITY-PAIRS

Viewpoint	>100 % (n)	100-80% % (n)	79-60% % (n)	59-40% % (n)	39-1% % (n)	<1% % (n)
Extremely ADV	45.1 (46)	50.0 (22)	50.0 (6)	54.5 (6)	44.5 (4)	45.8 (22)
Very ADV	39.2 (40)	34.1 (15)	25.0 (3)	18.2 (2)	33.3 (3)	29.2 (14)
Moderately ADV	8.8 (9)	15.9 (7)	8.3 (1)	27.3 (3)	11.1 (1)	18.8 (9)
Slightly ADV	4.9 (5)	.0 (0)	16.7 (2)	.0 (0)	.0 (0)	6.2 (3)
Not At All ADV	2.0 (2)	.0 (0)	.0 (0)	.0 (0)	11.1 (1)	.0 (0)
TOTAL	100.0 (102)	100.0 (44)	100.0 (12)	100.0 (11)	100.0 (9)	100.0 (48)

NOTE: The data in Table 6-11, above, are from the 226 flights that provided fully completed questionnaires.

The data in Table 6-11 seem to strongly indicate no correlation between the pilots' attitude toward RNAV and fuel savings. In each category of fuel savings potential realized, there is a very strong, positive skew on the attitude continuum, poignantly accentuated by the fact that 75% of the pilots who achieved less than 1% of their potential fuel savings ranked the utility of RNAV as "Very" or "Extremely" advantageous.

622 INDIVIDUAL CITY-PAIRS

Due to an insufficient quantity of pilot questionnaires between 12 of the 27 city-pairs, this subsection will provide results and analysis of data collected from flights between the remaining 15 city-pairs only.

622.1 SUCCESS RATE

With three exceptions, the success rate between each city-pair approximated the same pattern found for all flights between all city-pairs that was discussed in the preceding subsection. Table 6-12 presents the distribution of these flights between each city-pair by routing combination.

TABLE 6-12 DISTRIBUTION OF FLIGHTS BY CITY-PAIR
BY ROUTING COMBINATION

CITY-PAIR	DIRECT % (n)	DIRECT/ VOR % (n)	DIRECT/ VOR/ DIRECT % (n)	VOR % (n)	VOR/ DIRECT % (n)	VOR/ DIRECT/ VOR % (n)	TOTAL
ATL-SEA	80.0 (16)	5.0 (1)	10.0 (2)	.0 (0)	5.0 (1)	.0 (0)	100.0 (20)
ATL-LAX	90.0 (18)	.0 (0)	.0 (0)	.0 (0)	5.0 (1)	.0 (0)	100.0 (20)
ATL-PIT	57.9 (11)	31.6 (6)	5.3 (1)	.0 (0)	.0 (0)	5.3 (1)	100.0 (19)
ATL-BUF	85.3 (29)	5.9 (2)	2.9 (1)	.0 (0)	2.9 (1)	2.9 (1)	100.0 (34)
MIA-LAX	82.4 (56)	5.9 (4)	10.3 (7)	.0 (0)	1.5 (1)	.0 (0)	100.0 (68)
MIA-SFO	82.3 (79)	4.2 (4)	3.1 (3)	1.0 (1)	9.4 (9)	.0 (0)	100.0 (96)
MIA-ORD	79.2 (42)	7.5 (4)	3.8 (2)	1.9 (1)	.0 (0)	7.5 (4)	100.0 (53)
LAX-ORD	86.7 (13)	.0 (0)	6.7 (1)	.0 (0)	6.7 (1)	.0 (0)	100.0 (15)
LAX-JFK	83.7 (36)	11.6 (5)	2.3 (1)	.0 (0)	.0 (0)	2.3 (1)	100.0 (43)
LAX-JFK	87.0 (20)	8.7 (2)	.0 (0)	.0 (0)	4.3 (1)	.0 (0)	100.0 (23)
SFO-JFK	36.8 (7)	42.1 (8)	21.1 (4)	.0 (0)	.0 (0)	.0 (0)	100.0 (19)
JFK-SFO	78.9 (15)	5.3 (1)	15.8 (3)	.0 (0)	.0 (0)	.0 (0)	100.0 (19)
JFK-LAX	93.3 (14)	.0 (0)	.0 (0)	.0 (0)	6.7 (1)	.0 (0)	100.0 (15)
EWR-SFO	89.5 (34)	2.6 (1)	2.6 (1)	.0 (0)	2.6 (1)	.0 (0)	100.0 (38)
CLT-LGA	71.4 (10)	14.3 (2)	14.3 (2)	.0 (0)	7.1 (1)	.0 (0)	100.0 (14)
ALL CITY-PAIRS	80.5 (426)	6.2 (33)	6.2 (33)	.6 (3)	3.6 (19)	1.2 (7)	100.0 (529)

NOTE: Totals in the all city-pairs columns reflect the totals over 27 city-pairs and have been reprinted in this table for comparison purposes only.

The data from city-pairs ATL-PIT, SFO-JFK, and CLT-LGA deviate substantially from the pattern displayed for "All City-Pairs." A further analysis of the data from these city-pairs was conducted to determine the total distance flights were able to fly direct, even though some were rerouted. The results are presented in Table 6-13.

TABLE 6-13 AIRCRAFT FLYING A SIGNIFICANT PORTION OF ROUTES DIRECT BETWEEN SELECTED CITIES

CITY-PAIR	>80% DIRECT		>90% DIRECT	
	%	(n)	%	(n)
ATL-PIT	78.9	(15)	68.4	(13)
SFO-JFK	84.2	(16)	63.2	(12)
CLT-LGA	92.9	(13)	85.7	(12)
All City-Pairs	93.6	(495)	88.1	(466)

Table 6-13 reveals that the data from CLT-LGA does not substantially deviate from that found for all city-pairs, although flights were rerouted with more frequency than was found overall. The other two city-pairs still show a marked difference with the overall data; thus, indicating there may be significant problems affecting their flight. To explore this possibility, a further analysis of the reasons for reroute was conducted. The results are presented in Table 6-14.

TABLE 6-14 REASON FOR REROUTING VIA VOR SYSTEM - SELECTED CITIES

CITY-PAIR	WEATHER		UPPER WINDS		TRAFFIC		SPECIAL USE AIRSPACE		ATC SYSTEM OUTAGE		AIRCRAFT EQUIPMENT		OTHER	
	%	(n)	%	(n)	%	(n)	%	(n)	%	(n)	%	(n)	%	(n)
ATL-PIT	-	-	-	-	55.6	(5)	-	-	-	-	-	-	44.4	(4)
SFO-JFK	-	-	-	-	33.3	(4)	41.7	(5)	-	-	-	-	25.0	(3)
CLT-LGA	50.0	(2)	-	-	25.0	(1)	25.0	(1)	-	-	-	-	-	-

The data from Table 6-14 augment the findings in Table 6-13 above, for CLT-LGA by indicating that the success rate is not only substantial but diminished primarily by a noncontrollable variable, i.e., weather. The ARTCC questionnaires were reviewed and no impacts were reported for this city-pair.

The data in Table 6-14 for ATL-PIT and SFO-JFK show several "Other" responses. These were checked individually to determine what comments, if any, may have been provided. The results were that three out of four "Other" responses for ATL-PIT and all three responses for SFO-JFK actually fell into the "Traffic" category since pilot comments indicated that traffic arrival flow was the reason for reroute. Thus, if the data for these two city-pairs are rearranged in Table 6-14, "Traffic" becomes an apparent system prohibition to the direct route between ATL-PIT and both "Traffic" and "Special Use Airspace" are indicated as a system constraint between SFO-JFK.

A review of the ARTCC questionnaires did not reveal any significant impacts for ATL-PIT even though the pilot questionnaire data seem to indicate a low success rate. In the case of SFO-JFK, however, the ARTCC questionnaires did provide insight into the apparent system constraints. A joint-use restricted area west of Salt Lake City (R-6405) required several reroutes of participating flights. Usually these reroutes were over the Delta, Utah (DTA) VORTAC which lies southeast of R-6405. Based upon reports from Cleveland ARTCC, these flights were apparently recleared direct to the Sparta, New Jersey (SAX) VORTAC which is 49 miles from JFK without regard for the Hoxie intermediate fix which had been preidentified (and filed in the route of flight) as a fix essential to the flow of arrivals into JFK. The consequence of this action was borne by Cleveland ARTCC since the flights' tracks were sufficiently altered to place them in conflict with westbound traffic out of the New York area, as well as near the boundaries of Cleveland ARTCC's sectors which increased controller coordination requirements.

622.2 LOCATIONS OF REROUTES

Table 6-12 indicates that most flights were very successful in conducting their entire flight via direct routing, as filed, with exception of the three city-pairs previously discussed. In order to further refine the success rate between each city-pair, location of all reroutes were reviewed and tabulated in terms of significant portions of routes flown direct. Two distance percentages were selected for comparison purposes to the aggregate data findings. The results are presented in Table 6-15.

TABLE 6-15 AIRCRAFT FLYING A SIGNIFICANT PORTION OF ROUTES DIRECT BETWEEN SELECTED CITIES

CITY-PAIR	>80% DIRECT		>90% DIRECT	
	%	(n)	%	(n)
ATL-SEA	95	(19)	90	(18)
ATL-LAX	100	(20)	100	(20)
ATL-PIT	79	(15)	68	(13)
ATL-BUF	97	(33)	85	(29)
MIA-LAX	96	(65)	87	(59)
MIA-SFO	95	(91)	93	(89)
MIA-ORD	85	(45)	81	(43)
LAX-ORD	100	(15)	100	(15)
LAX-JFK	100	(43)	93	(40)
IAH-JFK	91	(21)	87	(20)
SFO-JFK	84	(16)	63	(12)
JFK-SFO	95	(18)	89	(17)
JFK-LAX	100	(15)	100	(15)
EWB-SFO	95	(36)	89	(34)
CLT-LGA	93	(13)	86	(12)
ALL CITY-PAIRS	93.6	(495)	88.1	(466)

NOTE: Totals in the All City-Pairs columns reflect the totals over 27 city-pairs and have been reprinted in this table for comparison purposes only.

With exception of the three city-pairs previously discussed, the data in Table 6-15 closely approximates the findings between all city-pairs. It is interesting to note that the data for ATL-LAX, LAX-ORD, and JFK-LAX show that 100% of the flights flew more than 90% of the total distance direct, even though several flights were rerouted. In general, all of the city-pairs with high percentages in both columns reflect the findings in Subsection 621 concerning "Traffic Arrival Flow"; albeit, the relative impact, as far as distance is concerned, was not substantial.

622.3 REASONS FOR REROUTES (SYSTEM PROHIBITIONS)

Reasons for reroutes provided by the pilot questionnaires were tabulated for each city-pair by totaling the answers to questions 8, 12, and 16. The results are presented in Table 6-16.

TABLE 6-16 DISTRIBUTION OF FLIGHTS BY CITY-PAIR BY REASON
FOR REROUTING VIA VOR SYSTEM - SELECTED CITIES

CITY-PAIR	WEATHER % (n)	UPPER WINDS % (n)	TRAFFIC % (n)	SPECIAL USE AIRSPACE % (n)	ATC SYSTEM OUTAGE % (n)	AIRCRAFT EQUIPMENT % (n)	OTHER % (n)	TOTAL (n)
ATL-SEA	75.0 (3)	-	25.0 (1)	-	-	-	-	(4)
ATL-LAX	50.0 (1)	-	50.0 (1)	-	-	-	-	(2)
ATL-PIT	-	-	55.6 (5)	-	-	-	44.4 (4)	(9)
ATL-BUF	33.3 (2)	-	50.0 (3)	-	-	-	16.7 (1)	(6)
MIA-LAX	8.3 (1)	-	25.0 (3)	58.3 (7)	8.3 (1)	-	-	(12)
MIA-SFO	41.2 (7)	-	41.2 (7)	5.9 (1)	-	5.9 (1)	5.9 (1)	(17)
MIA-ORD	66.7 (10)	-	26.7 (4)	-	-	-	6.7 (1)	(15)
LAX-ORD	100.0 (1)	-	-	-	-	-	-	(1)
LAX-JFK	-	-	50.0 (4)	-	-	-	50.0 (4)	(8)
IAH-JFK	-	-	66.7 (2)	-	-	-	33.3 (1)	(3)
SFO-JFK	-	-	33.3 (4)	41.7 (5)	-	-	25.0 (3)	(12)
JFK-SFO	-	-	25.0 (1)	25.0 (1)	50.0 (2)	-	-	(4)
JFK-LAX	-	100.0 (1)	-	-	-	-	-	(1)
EWR-SFO	-	-	25.0 (1)	25.0 (1)	25.0 (1)	-	25.0 (1)	(4)
CLT-LGA	50.0 (2)	-	25.0 (1)	25.0 (1)	-	-	-	(4)
ALL CITY-PAIRS	26.4 (29)	0.9 (1)	35.4 (39)	15.5 (17)	3.6 (4)	0.9 (1)	17.3 (19)	(110)

NOTE: Totals in the All City-Pairs columns reflect the totals over 27 city-pairs and have been reprinted in this table for comparison purposes only.

Table 6-16 reveals some variability between the individual city-pairs. "Traffic" was cited as a reason for reroute between all but two of the city-pairs and, in general, as the number of responses increased, so does the frequency of "Traffic." "Weather" seemed to affect flights between MIA-SFO and MIA-ORD much more than the other city-pairs. However, the relatively low frequency of "Weather" between MIA-LAX may indicate that the data are somewhat misleading in this regard. Overall, the low number of responses between each city-pair contraindicate further analysis of this data.

The ARTCC questionnaires were reviewed in conjunction with the responses pilots cited as reasons for reroutes. The results were as follows:

ATL-SEA. Minneapolis ARTCC submitted three questionnaires and Memphis ARTCC submitted one. All were classified as nonimpacts but did result in increased controller workload through radar vectoring. Each of the questionnaires submitted by Minneapolis indicated that Operation Free Flight participants were conflicting with the high altitude arrivals into Denver. Apparently, the Operational Free Flight participants were vectored in lieu of rerouted, given the low number of pilot questionnaires indicating reroutes.

ATL-LAX. Fort Worth ARTCC submitted one questionnaire which indicated that one flight required rerouting due to restricted area R-5601. This was classified as a nonimpact, as only one report was received. No pilot reports citing "Special Use Airspace" were received.

ATL-PIT. Two ARTCC questionnaires were received. Indianapolis ARTCC cited one situation where the flight was in conflict with the flow of other traffic and Atlanta ARTCC cited a case of a similar nature. Both were classified as nonimpacts, evidently being isolated cases. It was established that the flight reported by Atlanta had been "controller accommodated" by being cleared to destination airport instead of the arrival area fix. The pilot questionnaires reflect several instances where reroutes were required due to "Traffic."

ATL-BUF. Cleveland ARTCC submitted eight questionnaires, two of which were traced to incorrect flight plan entries by Atlanta ARTCC. One cited the need to reroute aircraft by the preferential routing after the arrival area fix (Note: Preferential routing (other than STAR's) from arrival area fixes to the destination airports were added to the filed routes on January 5, 1981. During the data collection of the evaluation, only STAR's were included in the route of flight.) and 5 cited traffic (for spacing or separation) or weather. These were classified as impacts and will be discussed further under Subsection 650. One other report was received. Indianapolis ARTCC cited a traffic flow conflict, but it was determined that the causative factor was an incorrect coordinate being entered by Atlanta ARTCC. The pilot questionnaires indicated reroutes for "Traffic" and "Weather."

MIA-SFO. Four reports were received from Los Angeles ARTCC. Three described reroutes to participants due to the restricted area, R-4808, complex northwest of Las Vegas, Nevada. The other involved traffic arrival flow and weather. Apparently, vectors were used predominantly to route the aircraft around these restricted areas when flight could not be conducted through them. The pilot questionnaires cite "Traffic" and "Weather" as the major reasons for reroutes.

MIA-ORD One questionnaire was submitted by Atlanta ARTCC which described a reroute due to weather which was impacting arrivals into the Chicago area. "Weather" was most often cited by the pilot questionnaires for this city-pair.

LAX-ORD No ARTCC reports were received. The pilot questionnaires indicate 100% success.

LAX-JFK Three reports were received from Cleveland ARTCC, all indicating a need to reroute aircraft to get them into the arrival flow for New York. The pilot questionnaires indicated the same trend. One report from Minneapolis and one from New York cited traffic separation and an attendant need to vector the flights. "Traffic" was cited several times in the pilot questionnaires.

IAH-JFK. No ARTCC reports were received. The pilot questionnaires do not indicate any significant patterns.

SFO-JFK. Sixteen ARTCC reports were received from Salt Lake and Cleveland ARTCC's concerning these flights. The impact was as described in Subsection 622.1. The pilot questionnaires indicate the same patterns.

JFK-SFO. Two ARTCC reports were received. One involved a breakdown in coordinating the Operation Free Flight route and has been discounted. The other was received from Denver ARTCC and cited an en route traffic flow conflict with arrivals in the Denver area. The pilot questionnaires do not indicate any particular pattern, except a high success rate.

JFK-LAX. No ARTCC reports were received. The pilot questionnaires indicate a 100% success rate.

EWR-SFO. One questionnaire from Denver ARTCC and two from Minneapolis ARTCC indicated an en route traffic flow conflict with arrivals into Denver. All reflect the same pattern as found with ATL-SEA and JFK-SFO. New York ARTCC submitted four reports. One cited Radar Data Processor failure which resulted in rerouting one participant. The others described the need to vector participants for separation from other departures due to a slight incompatibility with the departure flow while the Operation Free Flight aircraft were proceeding on a direct route before reaching cruise altitude. The pilot questionnaires indicate a high success rate for this city-pair.

CLT-LGA. No ARTCC reports were received. The pilot questionnaires indicate a high success rate when total distance direct is considered.

622.4 PILOT ATTITUDE

The distribution of responses by city-pair to the single question regarding pilots' viewpoint on the advantage of RNAV is presented in Table 6-17.

TABLE 6-17 DISTRIBUTION OF FLIGHTS BETWEEN CITY-PAIRS
BY PILOT VIEWPOINT ABOUT RNAV

CITY-PAIR	EXTREMELY ADVANTAGEOUS % (n)	VERY ADVANTAGEOUS % (n)	MODERATELY ADVANTAGEOUS % (n)	SLIGHTLY ADVANTAGEOUS % (n)	NOT AT ALL ADVANTAGEOUS % (n)	TOTAL % (n)
ATL-SEA	45.0 (9)	50.0 (10)	5.0 (1)	.0 (0)	.0 (0)	100.0 (20)
ATL-LAX	60.0 (12)	35.0 (7)	5.0 (1)	.0 (0)	.0 (0)	100.0 (20)
ATL-PIT	10.5 (2)	47.4 (9)	26.3 (5)	10.5 (2)	5.3 (1)	100.0 (19)
ATL-BUF	29.4 (10)	26.5 (9)	17.6 (6)	26.5 (9)	.0 (0)	100.0 (34)
MIA-LAX	52.9 (36)	22.1 (15)	14.7 (10)	10.3 (7)	.0 (0)	100.0 (68)
MIA-SFO	74.0 (71)	17.7 (17)	7.3 (7)	.0 (0)	1.0 (1)	100.0 (96)
MIA-ORD	39.6 (21)	24.5 (13)	17.0 (9)	15.1 (8)	3.8 (2)	100.0 (53)
LAX-ORD	53.3 (8)	20.0 (3)	20.0 (3)	6.7 (1)	.0 (0)	100.0 (15)
LAX-JFK	30.2 (13)	32.6 (14)	18.6 (8)	14.0 (6)	4.7 (2)	100.0 (43)
IAH-JFK	43.5 (10)	34.8 (8)	17.4 (4)	4.3 (1)	.0 (0)	100.0 (23)
SFO-JFK	31.6 (6)	26.3 (5)	26.3 (5)	10.5 (2)	5.3 (1)	100.0 (19)
JFK-SFO	26.3 (5)	26.3 (5)	15.8 (3)	26.3 (5)	5.3 (1)	100.0 (19)
JFK-LAX	33.3 (5)	33.3 (5)	13.3 (2)	20.0 (30)	.0 (0)	100.0 (15)
EWR-SFO	39.5 (15)	50.0 (19)	10.5 (4)	.0 (0)	.0 (0)	100.0 (38)
CLT-LGA	57.1 (8)	35.7 (5)	.0 (0)	7.1 (1)	.0 (0)	100.0 (14)
ALL CITY- PAIRS	46.7 (247)	29.3 (155)	13.6 (72)	8.7 (46)	1.7 (9)	100.0 (529)

NOTE: Totals for All City-Pairs reflect the totals over 27 city-pairs and have been reprinted in this table for comparison purposes only.

The data in Table 6-17 above, show several deviations from the pattern established overall. These occur in both directions, i.e., positive and negative. To show these with greater clarity, the categories "Extremely" and "Very" and "Slightly" and "Not at All" were combined. The significant results are presented in Table 6-18.

TABLE 6-18 DISTRIBUTION OF FLIGHTS BETWEEN CITY-PAIRS BY
PILOT VIEWPOINT ABOUT RNAV (MODIFIED)

CITY-PAIR	EXTREMELY OR VERY ADVANTAGEOUS	MODERATELY ADVANTAGEOUS	SLIGHTLY OR NOT AT ALL ADVANTAGEOUS	TOTAL
	% (n)	% (n)	% (n)	% (n)
ATL-SEA	95.0 (19)	5.0 (1)	.0 (0)	100.0 (20)
ATL-LAX	95.0 (19)	5.0 (1)	.0 (0)	100.0 (20)
MIA-SFO	91.7 (88)	7.3 (7)	1.0 (1)	100.0 (96)
EWR-SFO	89.5 (34)	10.5 (4)	.0 (0)	100.0 (38)
CLT-LGA	92.8 (13)	.0 (0)	7.1 (0)	100.0 (14)
ATL-PIT	57.9 (11)	26.3 (5)	15.8 (3)	100.0 (19)
ATL-BUF	55.9 (19)	17.6 (6)	26.5 (9)	100.0 (34)
MIA-ORD	64.1 (34)	17.0 (9)	18.9 (10)	100.0 (53)
LAX-JFK	62.8 (27)	18.6 (8)	18.7 (8)	100.0 (43)
SFO-JFK	57.9 (11)	26.3 (5)	15.8 (3)	100.0 (19)
JFK-LAX	66.6 (10)	13.3 (2)	20.0 (3)	100.0 (15)
JFK-SFO	52.6 (10)	15.8 (3)	31.6 (6)	100.0 (19)
ALL CITY- PAIRS	76.0 (402)	13.6 (72)	10.4 (55)	100.0 (529)

The data from three city-pairs (MIA-LAX, LAX-ORD, and IAH-JFK) followed approximately the same pattern as found in the aggregate and have not been included in Table 6-18. The first five city-pairs listed in the above table show a significantly more positive attitude toward RNAV than the remaining seven city-pairs. When this information is compared to the data reported by Table 6-15, there seems to be some correlation between "success rate" and pilot attitude toward RNAV. The data from Tables 6-15 and 6-18 have been combined and modified to show this relationship and are presented in Table 6-19.

TABLE 6-19 SUCCESS RATE AND PILOT VIEWPOINT COMPARED

CITY-PAIR	>90% DIRECT	EXTREMELY OR VERY ADVANTAGEOUS
	% (n)	% (n)
ATL-SEA	90 (18)	95 (19)
ATL-LAX	100 (20)	95 (19)
MIA-SFO	93 (89)	92 (88)
EWR-SFO	89 (34)	90 (34)
CLT-LGA	86 (12)	93 (13)
ATL-PIT	68 (13)	58 (11)
ATL-BUF	85 (29)	56 (19)
MIA-ORD	81 (43)	64 (34)
LAX-JFK	93 (40)	63 (27)
SFO-JFK	63 (12)	58 (11)
JFK-LAX	100 (15)	67 (10)
JFK-SFO	89 (17)	53 (10)
ALL CITY- PAIRS	88 (466)	76 (402)

There are sufficient variations in Table 6-19, however, to strongly suggest that other factors are influential in shaping pilot attitude. The data for CLT-LGA, ATL-BUF, LAX-JFK, JFK-LAX, and JFK-SFO support this contention. The perspective of the United Airlines' pilots, which was discussed in Subsection 621.4, accounts for some of the variation but certainly not all since many of the reports were from Eastern Airlines' pilots. Further exploration of this area was considered to be beyond the program's scope.

An examination of pilot attitude and success in achieving estimated fuel savings potential was severely hampered by the small quantity of fully completed questionnaires between individual city-pairs. Only the city-pairs of MIA-LAX, MIA-SFO, and EWR-SFO produced a fair number of responses, and these have been selected for reporting the distribution of pilot attitude with respect to percentage of fuel savings actually realized. This data is presented in Tables 6-20A, B, and C.

TABLE 6-20A PILOTS' VIEWPOINT BY PERCENTAGE OF FUEL SAVINGS
REALIZED - MIA-LAX

VIEWPOINT	>100% Z (n)	100-80% Z (n)	79-60% Z (n)	59-40% Z (n)	39-1% Z (n)	<1% Z (n)
EXTREMELY ADVANTAGEOUS	40.0 (8)	.0 (0)	100.0 (1)	50.0 (1)	100.0 (2)	33.3 (2)
VERY ADVANTAGEOUS	40.0 (8)	50.0 (1)	.0 (0)	.0 (0)	.0 (0)	16.7 (1)
MODERATELY ADVANTAGEOUS	15.0 (3)	50.0 (1)	.0 (0)	50.0 (1)	.0 (0)	33.3 (2)
SLIGHTLY ADVANTAGEOUS	5.0 (1)	.0 (0)	.0 (0)	.0 (0)	.0 (0)	16.7 (1)
NOT AT ALL ADVANTAGEOUS	.0 (0)	.0 (0)	.0 (0)	.0 (0)	.0 (0)	.0 (0)
TOTAL	100.0 (20)	100.0 (2)	100.0 (1)	100.0 (2)	100.0 (2)	100.0 (6)

TABLE 6-20B PILOTS' VIEWPOINT BY PERCENTAGE OF FUEL SAVINGS
REALIZED - MIA-SFO

VIEWPOINT	>100% Z (n)	100-80% Z (n)	79-60% Z (n)	59-40% Z (n)	39-1% Z (n)	<1% Z (n)
EXTREMELY ADVANTAGEOUS	80.0 (12)	71.4 (5)	100.0 (5)	60.0 (3)	100.0 (2)	80.0 (8)
VERY ADVANTAGEOUS	20.0 (3)	28.6 (2)	.0 (0)	.0 (0)	.0 (0)	20.0 (2)
MODERATELY ADVANTAGEOUS	.0 (0)	.0 (0)	.0 (0)	40.0 (2)	.0 (0)	.0 (0)
SLIGHTLY ADVANTAGEOUS	.0 (0)	.0 (0)	.0 (0)	.0 (0)	.0 (0)	.0 (0)
NOT AT ALL ADVANTAGEOUS	.0 (0)	.0 (0)	.0 (0)	.0 (0)	.0 (0)	.0 (0)
TOTAL	100.0 (15)	100.0 (7)	100.0 (5)	100.0 (5)	100.0 (2)	100.0 (10)

TABLE 6-20C PILOTS' VIEWPOINT BY PERCENTAGE OF FUEL SAVINGS
REALIZED - EWR-SFO

VIEWPOINT	>100% Z (n)	100-80% Z (n)	79-60% Z (n)	59-40% Z (n)	39-1% Z (n)	<1% Z (n)
EXTREMELY ADVANTAGEOUS	37.5 (6)	25.0 (1)	.0 (0)	.0 (0)	.0 (0)	40.0 (2)
VERY ADVANTAGEOUS	50.0 (8)	75.0 (3)	.0 (0)	.0 (0)	.0 (0)	40.0 (2)
MODERATELY ADVANTAGEOUS	12.5 (2)	.0 (0)	.0 (0)	.0 (0)	.0 (0)	20.0 (1)
SLIGHTLY ADVANTAGEOUS	.0 (0)	.0 (0)	.0 (0)	.0 (0)	.0 (0)	.0 (0)
NOT AT ALL ADVANTAGEOUS	.0 (0)	.0 (0)	.0 (0)	.0 (0)	.0 (0)	.0 (0)
TOTAL	100.0 (16)	100.0 (4)	.0 (0)	.0 (0)	.0 (0)	100.0 (5)

The data in Tables 6-20A, B, and C reveal the same pattern as found for all city-pairs depicted in Table 6-11; namely, a strong positive skew on the attitude continuum with several respondents expressing "Very" or "Extremely" advantageous even though less than 1% of their fuel savings potential was realized.

630 OPERATION FREE FLIGHT FUEL SAVINGS

Objective 411 - Determine the potential fuel savings which may be realized by flying direct. Subobjective 411.1 - Determine how successful Operation Free Flight participants were in achieving their fuel savings potential.

631 ALL CITY-PAIRS

Overall, the data indicate that when fuel is saved by flying direct (great circle), the en route fuel savings is relatively small but significant when accumulated. Table 6-21 depicts the results of the 226 participants' answers to questions 19, 20, and 21. (Note: Question 19a proved to be not useful and has been excluded from this report.)

TABLE 6-21 DISTRIBUTION OF FLIGHTS BETWEEN ALL CITY-PAIRS BY GALLONS OF FUEL CONSUMED BETWEEN DEPARTURE AND ARRIVAL FIXES

Gallons Actually Consumed	Estimated Consumption Via Direct Routing	Estimated Consumption Via Airways
2,013,760 gals.	2,016,738 gals.	2,055,521 gals.

The fuel data presented in Table 6-21 above, considered the estimated and actual fuel consumption between departure and arrival area fixes. Fuel consumed prior to departure, on the departure routing, and during the arrival phase of flight, together with any delays at either end, have been excluded. The data was derived from different types of aircraft, with different fuel consumption characteristics. Types of aircraft were A-300, L-1011, DC-10, and B-747.

Overall, the data reflect a fuel savings of 41,761 gallons for 226 flights; averaging 185 gallons per flight. However, the fuel saved amounts to 2.03% of the estimated fuel consumption via airways.

Analysis revealed that there was considerable variation in the amount of fuel saved, ranging from a negative 1,216 gallons to a high of 1,433 gallons. Most flights saved fuel, based upon the estimates of consumption; however, forty-eight flights did not.

The data indicate that the participating airlines are marginally successful in predicting when fuel savings will accrue by flying the shortest distance, as opposed to an airways route. The data in Table 6-22 is from the 226 flights and depicts their relative success in achieving their fuel savings potential. (Fuel savings potential was determined by subtracting estimated consumption via direct from estimated consumption via airways. Actual consumption of fuel en route, which was reported by pilots, was subtracted from the estimate via airways to determine actual savings.)

TABLE 6-22 PERCENTAGE OF POTENTIAL FUEL SAVINGS ACTUALLY REALIZED BETWEEN ALL CITY-PAIRS

>100% % (n)	100-80% % (n)	79-60% % (n)	59-40% % (n)	39-1% % (n)	<1% % (n)
45.1 (102)	19.5 (44)	5.3 (12)	4.9 (11)	4.0 (9)	21.2 (48)

The data in Table 6-22, above, show that 64.6% of the flights reporting achieved 80% or more of their estimated fuel savings, with 14.2% achieving somewhere between 1% and 79%. An interesting aspect of this data is that 21.2% achieved less than 1% of their estimated potential.

To further explore the data in Table 6-22, the data was arranged by flight pattern combination. The results are presented in Table 6-23.

TABLE 6-23 PERCENTAGE OF FUEL SAVINGS POTENTIAL REALIZED BY ROUTING COMBINATION

Percentage Realized	Direct % (n)	Direct/VOR % (n)	Direct/VOR/ Direct % (n)	VOR % (n)	VOR/Direct % (n)	Direct/VOR/ Direct % (n)
> 100%	46.3 (84)	50.0 (8)	43.8 (7)	.0 (0)	37.5 (3)	.0 (0)
100-80%	19.2 (35)	25.0 (4)	12.5 (2)	100.0 (1)	25.0 (2)	33.3 (1)
79-60%	4.9 (9)	6.3 (1)	6.3 (1)	.0 (0)	.0 (0)	33.3 (1)
59-40%	4.4 (8)	.0 (0)	6.3 (1)	.0 (0)	12.5 (1)	.0 (0)
39-1%	3.8 (7)	6.3 (1)	6.3 (1)	.0 (0)	.0 (0)	.0 (0)
< 1%	21.4 (39)	12.5 (2)	25.0 (4)	.0 (0)	25.0 (2)	33.3 (1)
TOTAL	100.0 (182)	100.0 (16)	100.0 (16)	100.0 (1)	100.0 (8)	100.0 (3)

Percentage of fuel savings potential realized when distributed by routing combination, reveals that the majority of flights were able to achieve more than 80% of their fuel savings potential regardless of routing combination. Presumably, this occurred because of the high percentage of aircraft that were able to fly more than 80% of the distance direct, even though they were rerouted via airways at some point along the route (reported in Table 6-6).

The extreme cases (< 1%) in Table 6-23 do not appear to favor any particular combination. Indeed, most such cases also reported that they flew 100% of the distance direct. Various factors explain why a higher percentage did not achieve their potential, such as upper winds being stronger than forecast, vectors required around weather, heavy traffic and associated altitude/speed changes, and reroutes via airways for, usually, weather or traffic. Pilot comments on the questionnaires frequently pointed to these reasons for consuming more fuel than expected.

It also must be recognized that in nearly all cases, the marginal difference between direct and via airways estimated fuel consumption was not large. In fact, in many cases the estimated difference was less than 500 pounds (75 gallons). This occurred most frequently between those city-pairs which are linked by the VOR airway structure in such a way as to approximate a great circle.

632 INDIVIDUAL CITY-PAIRS

In most cases, too few questionnaires with fuel data were received between individual city-pairs to credibly report findings, conduct analysis, and offer conclusions. Accordingly, this subsection has been limited in scope and will present data from city-pairs between which ten or more fully completed questionnaires were received. Table 6-24 lists these city-pairs and tabulates the gallons of fuel actually consumed plus the estimated consumption via direct and airways.

TABLE 6-24 DISTRIBUTION OF FLIGHTS BETWEEN SELECTED CITY-PAIRS
BY GALLONS OF FUEL CONSUMED BETWEEN DEPARTURE AND
ARRIVAL FIXES

City-Pair	Gallons Actually Consumed	Estimated Consumption Via Direct Routing	Estimated Consumption Via Airways
ATL-BUF	39,845	39,515	41,216
MIA-LAX	366,612	370,433	374,343
MIA-SFO	400,557	397,994	410,526
MIA-ORD	65,628	65,015	66,881
LAX-JFK	125,955	127,858	129,112
IAH-JFK	62,810	62,482	66,049
SFO-JFK	131,343	132,448	134,119
JFK-SFO	149,209	149,433	150,388
EWB-SFO	387,881	391,343	394,262

The data from Table 6-24, above, were used to calculate fuel savings as a percentage of the airway estimate and the average savings per aircraft. Table 6-25 presents the results.

TABLE 6-25 FUEL SAVINGS BETWEEN SELECTED CITY-PAIRS

City-Pair	Gallons of Fuel Saved	Fuel Savings as a Percentage of Estimated Airway Consumption	Average Fuel Savings per Flight (gallons)	Number of Flights Reporting
ATL-BUF	1,371	3.3%	91 gals.	15
MIA-LAX	7,731	2.1%	234 gals.	33
MIA-SFO	9,969	2.4%	227 gals.	44
MIA-ORD	1,253	1.9%	84 gals.	15
LAX-JFK	3,157	2.4%	287 gals.	11
IAH-JFK	3,239	4.9%	249 gals.	13
SFO-JFK	2,776	2.1%	252 gals.	11
JFK-SFO	1,179	0.8%	118 gals.	10
EWB-SFO	6,381	1.6%	255 gals.	25
ALL CITY PAIRS	41,761	2.03%	185 gals.	226

NOTE: Data provided for all city-pairs are from 226 flights and are shown for comparison purposes only.

Table 6-25, above, shows the wide range of average fuel savings per flight between the selected city-pairs and places this data into perspective when expressed as a percentage of estimated airway consumption. Since in many cases, several types of aircraft with different fuel consumption characteristics generated the data, the percentage figures and average savings per flight should be viewed with this in mind. Predictably, the percentage figures reflect the fact that airway distance is very close to great circle distance in many cases.

With exception of IAH-JFK and LAX-JFK, several flights between these nine city-pairs saved less than 1% of their estimated potential fuel savings, and there were notable exceptions to the overall trend presented in Table 6-22 as far as success in achieving potential fuel savings was concerned. Table 6-26 presents this data by city-pair.

TABLE 6-26 PERCENTAGE OF POTENTIAL FUEL SAVINGS ACTUALLY
REALIZED BETWEEN SELECTED CITY-PAIRS

City-Pair	>100% % (n)	100-80% % (n)	79-60% % (n)	59-40% % (n)	39-1% % (n)	< 1% % (n)	TOTAL % (n)
ATL-BUF	40.0 (6)	26.7 (4)	.0 (0)	.0 (0)	6.7 (1)	26.7 (4)	100.0 (15)
MIA-LAX	60.6 (20)	6.1 (2)	3.0 (1)	6.1 (2)	6.1 (2)	18.2 (6)	100.0 (33)
MIA-SFO	34.1 (15)	15.9 (7)	11.4 (5)	11.4 (5)	4.5 (2)	22.7 (10)	100.0 (44)
MIA-ORD	33.3 (5)	20.0 (3)	13.3 (2)	.0 (0)	.0 (0)	33.3 (5)	100.0 (15)
LAX-JFK	54.5 (6)	18.2 (2)	9.1 (1)	9.1 (1)	.0 (0)	9.1 (1)	100.0 (11)
IAH-JFK	15.4 (2)	69.2 (9)	7.7 (1)	.0 (0)	7.7 (1)	.0 (0)	100.0 (13)
SFO-JFK	45.5 (5)	18.2 (2)	.0 (0)	9.1 (1)	.0 (0)	27.3 (3)	100.0 (11)
JFK-SFO	70.0 (7)	.0 (0)	.0 (0)	.0 (0)	.0 (0)	30.0 (3)	100.0 (10)
EWK-SFO	64.0 (16)	16.0 (4)	.0 (0)	.0 (0)	.0 (0)	20.0 (5)	100.0 (25)
ALL CITY PAIRS	45.1 (102)	19.5 (44)	5.3 (12)	4.9 (11)	4.0 (9)	21.2 (48)	100.0 (226)

NOTE: Data provided for all city-pairs are from 226 flights and are provided for comparison purposes only.

The data in Table 6-26, above, show a significantly higher success rate in achieving 80% or more of estimated fuel savings potential, compared to the all city-pair trend, for LAX-JFK (72.7%), IAH-JFK (84.6%), JFK-SFO (70.0%), and EWR-SFO (80.0%). These findings, when compared to the data in Table 6-25, reveal that these four city-pairs also include both the lowest and highest fuel savings when expressed as a percentage of estimated airway consumption - JFK-SFO and IAH-JFK.

Further analysis of the data between individual city-pairs was severely hampered by the low number of fully completed questionnaires. Only between three city-pairs was the response rate of fair quantity - MIA-LAX (33), MIA-SFO (44), and EWR-SFO (25). When the distribution of potential fuel savings realized was arranged according to the routing combinations, an interesting pattern emerged. This data is presented in Tables 6-27, 6-28, and 6-29.

TABLE 6-27 PERCENTAGE OF POTENTIAL FUEL SAVINGS REALIZED BY ROUTING COMBINATION - MIA-LAX

Percentage Realized	Direct % (n)	Direct/VOR % (n)	Direct/VOR/ Direct % (n)	VOR % (n)	VOR/DIRECT % (n)	VOR/DIRECT/ VOR % (n)
> 100%	63.0 (17)	100.0 (2)	25.0 (1)	.0 (0)	.0 (0)	.0 (0)
100-80%	3.7 (1)	.0 (0)	25.0 (1)	.0 (0)	.0 (0)	.0 (0)
79-60%	3.7 (1)	.0 (0)	.0 (0)	.0 (0)	.0 (0)	.0 (0)
59-40%	3.7 (1)	.0 (0)	25.0 (1)	.0 (0)	.0 (0)	.0 (0)
39-1%	7.4 (2)	.0 (0)	.0 (0)	.0 (0)	.0 (0)	.0 (0)
< 1%	18.5 (5)	.0 (0)	25.0 (1)	.0 (0)	.0 (0)	.0 (0)
TOTAL	100.0 (27)	100.0 (2)	100.0 (4)	.0 (0)	.0 (0)	.0 (0)

TABLE 6-28 PERCENTAGE OF POTENTIAL FUEL SAVINGS REALIZED BY ROUTING COMBINATION - MIA-SFO

Percentage Realized	Direct % (n)	Direct/VOR % (n)	Direct/VOR/ Direct % (n)	VOR % (n)	VOR/DIRECT % (n)	VOR/DIRECT/ VOR % (n)
> 100%	35.3 (12)	.0 (0)	.0 (0)	.0 (0)	42.9 (3)	.0 (0)
100-80%	11.8 (4)	.0 (0)	50.0 (1)	.0 (0)	28.6 (2)	.0 (0)
79-60%	11.8 (4)	.0 (0)	50.0 (1)	.0 (0)	.0 (0)	.0 (0)
59-40%	11.8 (4)	.0 (0)	.0 (0)	.0 (0)	14.3 (1)	.0 (0)
39-1%	5.9 (2)	.0 (0)	.0 (0)	.0 (0)	.0 (0)	.0 (0)
< 1%	23.5 (8)	100.0 (1)	.0 (0)	.0 (0)	14.3 (1)	.0 (0)
TOTAL	100.0 (34)	100.0 (1)	100.0 (2)	.0 (0)	100.0 (7)	.0 (0)

TABLE 6-29 PERCENTAGE OF POTENTIAL FUEL SAVINGS REALIZED BY ROUTING COMBINATION - EWR-SFO

Percentage Realized	Direct % (n)	Direct/VOR % (n)	Direct/VOR/ Direct % (n)	VOR % (n)	VOR/DIRECT % (n)	VOR/DIRECT/ VOR % (n)
> 100%	59.1 (13)	100.0 (2)	100.0 (1)	.0 (0)	.0 (0)	.0 (0)
100-80%	18.2 (4)	.0 (0)	.0 (0)	.0 (0)	.0 (0)	.0 (0)
79-60%	.0 (0)	.0 (0)	.0 (0)	.0 (0)	.0 (0)	.0 (0)
59-40%	.0 (0)	.0 (0)	.0 (0)	.0 (0)	.0 (0)	.0 (0)
39-1%	.0 (0)	.0 (0)	.0 (0)	.0 (0)	.0 (0)	.0 (0)
< 1%	22.7 (5)	.0 (0)	.0 (0)	.0 (0)	.0 (0)	.0 (0)
TOTAL	100.0 (22)	100.0 (2)	100.0 (1)	.0 (0)	.0 (0)	.0 (0)

In each of the above tables, the data is clustered under the "Direct" routing combination; thus, indicating the aircraft flew 100% of the distance direct, as filed. Yet, in each case a significant percentage of these flights achieved less than 1% of their estimated fuel savings potential. This pattern was also evident for the other city-pairs; albeit, the low number of responses may be misleading. Nonetheless, the data strongly suggests that this pattern, as reported by Table 6-23 for all city-pairs, is consistent between each, rather than the result of a few city-pairs distorting the totals.

640 ATC SYSTEM IMPACT

Objective 413 - Determine ATC system impact of Operation Free Flight in terms of:

- 413.1 - Controller workload;
- 413.2 - NAS 9020 computer processing demands;
- 413.3 - NAS 9020 computer's ability to accurately post flight progress strips within and between ARTCCs;
- 413.4 - Departure/arrival flow compatibility; and
- 413.5 - En route airspace conflicts.

641 CONTROLLER WORKLOAD

It is important to establish a point that qualifies this category. While the controller questionnaire addressed concern for, or interest in, the workload imposed upon the controller as a result of Operation Free Flight's direct route concept, the true analysis should be made on any "additional" controller workload. This is an important qualifier because there were a number of statements reflecting an "impact" on controller workload which subsequently described the nature of this workload as "vectors around weather" or "vectors for traffic." While these are, of course, workload factors, they were never found to be "additional" workload as a result of Operation Free Flight, or the direct route concept of flying.

The same held true for those questionnaires reflecting an impact in the category of "computer." The statements which followed alluded to the fact that whenever a controller had to make a computer entry, there was an impact. This, too, needs clarification. First of all, there was absolutely no reported impact on the computer. Secondly, the controller workload impact which was identified was, once again, no additional workload to that normally found when a controller updates the computer as a result of a vector or reroute.

642 NAS 9020 COMPUTER PROCESSING DEMANDS

There were no adverse responses from any ARTCC regarding impacts in this area.

643 NAS 9020 COMPUTER'S ABILITY TO ACCURATELY POST FLIGHT PROGRESS STRIPS

There were no adverse responses from any ARTCC regarding impacts in this area.

644 DEPARTURE/ARRIVAL FLOW COMPATIBILITY

In the early stages of Operation Free Flight's development, it seemed quite apparent that the establishment of certain ground rules, aimed at satisfying departure and arrival flow, would be necessary. As a result of this assumption, those air traffic control facilities whose operation would be impacted were involved in the flight planning. Arrival and departure transition areas were considered, and routings were established with the express purpose of delivering to those points, and not the airport proper.

With very few exceptions, the fixes which were established initially remained. In those cases where it was necessary to make an adjustment, it became even more obvious that such fixes, or transition areas, were of major importance in achieving a smooth and efficient flow.

The coordination required in meeting the needs of the facility was handled directly between ASO-530 and the affected facility, with problem resolution quick and simple, with no adverse impact upon the user or the test. This is important to note for several reasons. They are: (1) the initial theory that delivery to departure and arrival fixes to satisfy specific flow requirements was validated; (2) thorough planning is needed when initially establishing these fixes; (3) during the normal course of events, an adjustment may be necessary to satisfy flow requirements; and (4) these changes are not difficult to make within the framework of the ATC system.

645 EN ROUTE AIRSPACE CONFLICTS

In assessing system impact in this category, two other categories came into play. Those categories are controller workload and flow compatibility.

Bearing in mind, the earlier qualifying statement that "additional" controller workload is what needs to be identified, and not simply those workload factors found in the existing system on a day-to-day basis, consider the following: (1) crossing traffic in the en route environment will exist whether on airways or random routes; (2) crossing and converging situations at a common navigational aid, with its spiderweb effect, is less "airspace efficient," often calling for altitude changes for cross-out; (3) vectors in a less congested area are simpler with no "additional" workload; (4) having all traffic along established routes may provide uniformity but adds to the potential for overtakes and head-on situations while reducing some of the flexibility for pilot discretion descents. All-in-all, potential en route airspace conflicts appear to lessen in most cases of direct routing.

However, there will be areas where an incompatibility exists between direct routing and traffic flow. This kind of situation appears to be rare, and may call for action ranging from a dog-leg route around such a traffic flow, to altitude restrictions which top the traffic queuing-up for arrival. During the test, only two traffic flows were encountered which required the action described above. As stated previously, none of the problems identified during the course of the test were unresolvable.

700 SUMMARY OF RESULTS

This section compiles the significant results discussed in, and derived from, the analysis presented in Section 600. For ease of correlation with the objectives, discussion of results and analysis, the summary is divided into three major subsections which directly relate to each technical objective. Within each subsection, the summary is divided into aggregate, all city-pair findings, and individual city-pair results.

710 OPERATION FREE FLIGHT SUCCESS RATE AND SYSTEM PROHIBITIONS

711 ALL CITY-PAIRS

- Twenty-seven city-pairs were tested during the period June 1 to December 31, 1980. A total of 5,356 flights potentially could have participated; 1,919 flights were selected by airline computers for the Operation Free Flight route. This amounts to a selection rate of 36% overall, with parameters of 27% and 40% making up the minimum and maximum selection rates by participating airlines.
- Data was collected by pilot questionnaire from 529 flights for an overall 28% rate of return from participants; minimum and maximum rates of return for the participating airlines were 20% and 53% respectively.
- The 529 pilot questionnaires represent a nonrandom sample of all participating flights which totaled 1,919. It was determined that there are no discernable reasons to suspect that the overall sample data and the trends they reflect are biased in any particular fashion. A paucity of data between some city-pairs, however, limited the degree of analysis and prevented conclusions from the sample data alone.
- Overall, participants were very successful in being able to conduct their flights via the RNAV great circle routes between departure and arrival area fixes with 80.5% flying 100% of the distance direct. Even those that were rerouted via airways were able to fly direct for most of the distance. When these flights are added to those that were 100% successful, the data reflect that 93.6% of all flights flew more than 80% of the distance direct and 88.1% flew more than 90% of the distance direct.
- "Traffic" and "Weather" were most often cited as reasons for being rerouted via airways.
- "Weather" was most often the reason for not being "cleared as filed" initially.
- Many respondents who listed "Other" were determined to fall into the "Traffic" category.

- Most often, when "Traffic" was cited, the more accurate reason was incompatibility with "Traffic Arrival Flow" at the destination airports.
- Special Use Airspace, including ATC assigned airspace areas, did not prove to be a significant system prohibition under this program. The relatively few number of cases where "Special Use Airspace" was cited can be easily accommodated through minor route modifications. Most responses in this category were isolated to the city-pairs of MIA-LAX and SFO-JFK.
- Controllers frequently, but unintentionally, contributed to system problems and eventual impact to participants by reclearing flights direct to destination without regard for arrival area fixes or, where necessary, arrival flow fixes. In every case identified, this "accommodation" caused problems later in the flight due to arrival flow requirements and associated airspace constraints at the destination ARTCC and, in some cases, the ARTCC adjacent to the destination facility.
- Overall, pilot attitude regarding the utility of their RNAV equipment was strongly skewed in a positive direction.
- The positive attitude toward RNAV expressed by pilots appears to be influenced by their opportunity to use the equipment in flying direct. However, the data indicate that other factors are involved in shaping this attitude.
- The positive attitude toward RNAV expressed by pilots did not appear to be influenced by their ability to save fuel.

712 INDIVIDUAL CITY-PAIRS

- Insufficient data from 12 of the 27 city-pairs limited detailed analysis to 15 city-pairs.
- With three exceptions, the success rate between each city-pair approximated the same pattern found for all city-pairs. These exceptions were ATL-PIT, SFO-JFK, and CLT-LGA. It was determined that even though flights between CLT-LGA were rerouted with more frequency than flights between other city-pairs, they were still able to fly most of the distance direct. No system impacts could be identified for ATL-PIT, yet this city-pair had a low success rate. With SFO-JFK, two system prohibitions were identified. One was the joint-use restricted area (R-6405) west of Salt Lake City, Utah, and the other involved incompatibility with traffic arrival flow into New York. The latter problem was tracked to "controller accommodation," however, and does not appear to be a limiting factor.
- Results for each city-pair are summarized as follows:

ATL-SEA - Success rate was high; 95% flew more than 80% of the distance direct. No system prohibitions were noted. However, reports from Minneapolis ARTCC indicating conflicts with high altitude arrivals into Denver warrant further investigation.

ATL-LAX - Success rate was very high; 100% flew more than 80% of the distance direct. No system prohibitions were noted.

ATL-PIT - Success rate was lower than overall; 79% flew more than 80% of the distance direct. "Traffic" appears to be a system prohibition. Further investigation is warranted.

ATL-BUF - Success rate was very high; 97% flew more than 80% of the distance direct. "Traffic" was identified as a system prohibition during the test period, but this may have been resolved subsequently. Further investigation is warranted.

MIA-SFO - Success rate was high; 95% flew more than 80% of the distance direct. No system prohibitions were noted.

MIA-LAX - Success rate was high; 96% flew more than 80% of the distance direct. "Special Use Airspace" was initially identified as a system prohibition, but was later resolved through route modification.

MIA-ORD - Success rate was lower than overall; 85% flew more than 80% of the distance direct. "Weather" seemed to affect this city-pair more than others. No system prohibitions were noted.

LAX-ORD - Success rate was very high; 100% flew more than 80% of the distance direct. No system prohibitions were noted.

LAX-JFK - Success rate was very high; 100% flew more than 80% of the distance direct. "Traffic" was identified as a system prohibition. However, it was determined that this prohibition was generated through "controller accommodation" and is resolvable.

IAH-JFK - Success rate was slightly lower than overall; 91% flew more than 80% of the distance direct. No system prohibitions were identified.

SFO-JFK - Success rate was lower than overall; 84% flew more than 80% of the distance direct. "Special Use Airspace" and "Traffic" were identified as system prohibitions. Further investigation is warranted.

JFK-SFO - Success rate was high; 95% flew more than 80% of the distance direct. No system prohibitions were noted.

JFK-LAX - Success rate was very high; 100% flew more than 80% of the distance direct. No system prohibitions were noted.

EWB-SFO - Success rate was high; 95% flew more than 80% of the distance direct. No system prohibitions were noted. However, reports from Minneapolis ARTCC indicating conflicts with high altitude arrivals into Denver warrant further investigation.

CLT-LGA - Success rate was high; 93% flew more than 80% of the distance direct even though many flights were rerouted. No system prohibitions were noted. Further investigation is warranted.

- Pilot altitude toward RNAV for each city-pair was generally positive, with variations in degree apparent for those city-pairs with a low success rate in flying direct. However, this pattern was inconsistent, and the data strongly suggest that other factors are involved in shaping pilot attitude.
- Available data for each city-pair appeared to indicate that saving fuel did not influence pilot attitude.

720 OPERATION FREE FLIGHT FUEL SAVINGS

721 ALL CITY-PAIRS

- Out of the 529 questionnaires, 226 contained all requested fuel information for an overall rate of return of 12% of the participating flights; minimum and maximum values by participating airlines were 10% and 22% respectively. As a result, most of the analysis of the fuel data was confined to the aggregate data received from all city-pairs.
- When fuel is saved by flying direct (great circle), the en route fuel savings is relatively small but significant when accumulated.
- The arithmetic mean fuel savings was 185 gallons per flight. The minimum and maximum values were - 1,216 gallons and +1,433 gallons.
- The documented fuel savings from Operation Free Flight participants amount to 2.03% of the estimated fuel consumption via airways.
- The participating airlines are marginally successful in predicting when fuel savings will accrue by flying the shortest distance, as opposed to an airway route.
 - Most flights saved fuel, based upon the estimates of consumption; however, 21.2% did not.
 - 64.6% achieved 80% or more of their estimated fuel savings, with 14.2% achieving somewhere between 1% and 79%.
 - 21.4% of all flights that flew 100% of the distance direct, as filed, achieved less than 1% of their fuel savings potential. Weather and upper winds were frequently cited by pilots as reasons for not achieving their potential.
- The marginal difference between direct and via airways fuel consumption in nearly all cases was not large. In many cases, the difference was less than 500 pounds (75 gallons).

722 INDIVIDUAL CITY-PAIRS

- Too few questionnaires with fuel data limited detailed analysis to three city-pairs. More general data was available between nine city-pairs.
- Average fuel savings per flight was wide-ranging between the nine city-pairs listed below. Minimum and maximum values were 84 gallons and 287 gallons per flight; expressed as a percentage of estimated airway consumption, the values were 0.8% and 4.9%.
- Fuel savings data indicate that, in many cases, airway distance is very close to great circle distance.
- Results for each city-pair are summarized as follows:

ATL-BUF - 3.3% of estimated airway fuel consumption was saved; averaging 91 gallons per flight. 66.7% achieved 80% or more of their estimated fuel savings potential, with 26.7% achieving less than 1%.

MIA-LAX - 2.1% of estimated airway consumption was saved; averaging 234 gallons per flight. 66.7% achieved 80% or more of their estimated fuel savings potential, with 18.2% achieving less than 1%.

MIA-SFO - 2.4% of estimated airway fuel consumption was saved; averaging 227 gallons per flight. 50% achieved 80% or more of their estimated fuel savings potential, with 22.7% achieving less than 1%.

MIA-ORD - 1.9% of estimated airway fuel consumption was saved; averaging 84 gallons per flight. 53.3% achieved 80% or more of their estimated fuel savings potential, with 33.3% achieving less than 1%.

LAX-JFK - 2.4% of estimated airway fuel consumption was saved; averaging 287 gallons per flight. 72.7% achieved 80% or more of their estimated fuel savings potential, with 9.1% achieving less than 1%.

IAH-JFK - 4.9% of estimated airway fuel consumption was saved; averaging 249 gallons per flight. 84.6% achieved 80% or more of their estimated fuel savings potential, with none achieving less than 1%.

SFO-JFK - 2.1% of estimated airway fuel consumption was saved; averaging 252 gallons per flight. 63.7% achieved 80% or more of their estimated fuel savings potential, with 27.3% achieving less than 1%.

JFK-SFO - 0.8% of estimated airway fuel consumption was saved; averaging 118 gallons per flight. 70% achieved 80% or more of their estimated fuel savings potential, with 30% achieving less than 1%.

EWR-SFO - 1.6% of estimated airway fuel consumption was saved; averaging 255 gallons per flight. 80% achieved 80% or more than their estimated fuel savings potential, with 20% achieving less than 1%.

- The data for MIA-LAX, MIA-SFO, and EWR-SFO show the same pattern as found for "all city-pairs" when fuel savings is interrelated with the various routing combinations. This strongly suggests that the pattern indicated by the aggregate data is consistent between each city-pair.

730 ATC SYSTEM IMPACT

731 ALL CITY-PAIRS

- Overall, there was no adverse impact to the ATC system due to Operation Free Flight from the standpoint of controller workload, NAS 9020 computer processing demands, or the 9020 computer's ability to accurately post flight progress strips within and between ARTCCs.
- In order to achieve departure/arrival flow compatibility, relatively minor adjustments to departure or arrival area fixes were required in a few cases. The need for adjustments did not impact the ATC system.
- During the evaluation, two types of en route airspace conflict were identified, but neither was considered to be an impact.

732 INDIVIDUAL CITY-PAIRS

- Results for each city-pair are summarized as follows:

ATL-SEA - An en route airspace conflict with high altitude arrivals into Denver was reported but not classified as an impact.

ATL-LAX - No ATC system impact.

ATL-PIT - No ATC system impact.

ATL-BUF - No ATC system impact.

MIA-SFO - No ATC system impact.

MIA-LAX - No ATC system impact.

MIA-ORD - No ATC system impact.

LAX-ORD - No ATC system impact.

LAX-JFK - An en route airspace conflict with departures from the New York area and traffic flow in Cleveland ARTCC was identified. This conflict was resolved through establishment of a "flow" fix to augment the arrival area fix. All subsequent conflicts were not the result of Operation Free Flight; therefore, no ATC system impact was identified.

IAH-JFK - No ATC system impact.

SFO-JFK - The same type of en route airspace conflict as with LAX-JFK was identified. Additionally, conflict with Special Use Airspace was occasionally reported. Both are considered resolvable; therefore, no ATC system impact was identified.

JFK-SFO - No ATC system impact.

JFK-LAX - No ATC system impact.

EWR-SFO - The same type of en route airspace conflict as with ATL-SEA was identified but not classified as an impact.

CLT-LGA - No ATC system impact.

ATL-SFO - No ATC system impact.

ATL-ORD - No ATC system impact.

SEA-ATL - No ATC system impact. However, the low participation rate negates conclusive evaluation.

LAX-MIA - No ATC system impact.

LAX-ATL - No ATC system impact. However, the low participation rate negates conclusive evaluation.

JFK-IAH - No ATC system impact.

ORD-MIA - No ATC system impact.

ORD-LAX - No ATC system impact.

ORD-EWR - No ATC system impact.

PIT-ATL - No ATC system impact. However, the low participation rate negates conclusive evaluation.

BUF-ATL - No ATC system impact. However, the low participation rate negates conclusive evaluation.

EWR-ORD - No ATC system impact.

800 CONCLUSIONS

The major conclusions from Operation Free Flight are summarized in this section. The data and analysis which support these conclusions are presented in Section 600 and summarized in Section 700. Conclusions are organized under each major objective from Section 400.

Objective 410 - Determine the feasibility of permitting the filing of direct route flight plans without detailed route definition by examining the rate of success in receiving direct route clearances (i.e., cleared as filed), system prohibitions, and pilot altitude toward use of RNAV in today's system.

- A. The operational concept of filing great circle routes between departure and arrival area fixes, at altitudes above FL 290, without a series of waypoints between such fixes was determined to be feasible in a radar environment, providing the following are accomplished:
1. A means for determining and publishing the appropriate departure and arrival area fixes for each terminal area must first be developed and implemented. Additionally, in some cases, turn points to avoid special use airspace and traffic flow points will require identification and subsequent publication.
 2. The handbook for controllers, FAA Order 7110.65B, will require revision to permit and explain procedures for controllers use of latitude/longitude coordinates within the domestic airspace to identify nonadapted fixes in a route of flight.
 3. Development of a new equipment suffix code to identify aircraft with any type of area navigation capability, regardless of the method of certification.
 4. The Airman's Information Manual (AIM) will require revision to explain the operational concept validated herein. This change's scope will be related to #1 above.
- B. The routes between certain city-pairs which were evaluated by Operation Free Flight are considered to be validated based upon this report's findings. These city-pairs and associated departure/arrival area fixes should be proposed additions to the IFR Preferred Route system, published in the Airport/Facility Directory. The following city-pairs are considered validated:

ATL-SEA	MIA-SFO	JFK-IAH	EWR-SFO
ATL-SFO	MIA-ORD	JFK-SFO	EWR-ORD
ATL-LAX	LAX-MIA	JFK-LAX	
ATL-ORD	LAX-ORD	ORD-MIA	
ATL-PIT	LAX-JFK	ORD-LAX	
ATL-BUF	IAH-JFK	ORD-EWR	
MIA-LAX	SFO-JFK	CLT-LGA	

Objective 411 - Determine the potential fuel savings which may be realized by flying direct.

- A. Frequent but prudent use of great circle routes should result in fuel savings of approximately 2% over airway consumption. This evaluation has shown that achieving fuel savings is a function of more than

distance flown. Analysis of other variables, such as upper wind vectors, air temperature, atmospheric pressure, power settings, and gross weight, has to be conducted in conjunction with distance in order to most effectively save fuel on any given flight. Moreover, knowledge of departure and arrival traffic flows, especially for the major hubs is essential for both obtaining an initial "direct" clearance and avoiding subsequent reroutes which will probably offset fuel savings gained en route.

- B. Subject to A above, expanded application of the Operation Free Flight operational concept has the potential to result in the following fuel savings over airway consumption:

1. Commercial Aviation - 39,098,000+ gallons.

This estimate is based upon fuel consumed in CY 1979 by commercial air carriers and does not include fuel consumed by other elements of the industry, such as cargo carriers. It assumes that the direct route selection rate of 36% which was determined by Operation Free Flight data will continue to be representative. The basis for this calculation is the finding that 2.03% of airway fuel consumption can be saved through frequent use of the Operation Free Flight concept.

2. General Aviation and Military - Due to lack of data concerning the number of flights conducted at high altitude and their share of total fuel consumption, it was not possible to estimate fuel savings potential.

Objective 412 - Determine ATC system prohibitions to direct route clearances, if any.

- A. Incompatibility with traffic arrival flows was the only significant system prohibition identified. Special Use Airspace was a factor predominately between two city-pairs but can be resolved through minor route modification. ATC Assigned Airspace in the Positive Control Area (PCA) did not prove to be a limiting factor during the test.
- B. The impact of the foregoing "system prohibitions" was determined to be relatively minor and correctable in each case. However, the fact that some action will be required to negate the system prohibitions is evidence that the National Airspace System, as currently structured, cannot uniformly and continuously accept unrestrained direct route flight without imposing restrictions. The establishment of departure and arrival fixes, turn points, and arrival flow fixes will be required in many cases to achieve compatibility with dense traffic flows and avoid conflict with major Special Use Airspace complexes. These requirements will not necessarily apply in all cases, however, as some great circle routes between cities are very compatible with the flow of traffic and in some cases, such as with STOL aircraft and helicopters, traffic flow compatibility is frequently not desired.

Objective 413 - Determine ATC system impact of Operation Free Flight in terms of:

413.1 - Controller workload;

413.2 - NAS 9020 computer processing demands;

413.3 - NAS 9020 computer's ability to accurately post flight progress strips within and between ARTCCs;

413.4 - Departure/arrival flow compatibility; and

413.5 - En route airspace conflicts.

- A. There was no adverse impact on controllers with regard to workload.
- B. There was no adverse impact with regard to the NAS 9020. In order to reduce the use of latitude/longitude coordinates, however, it appears appropriate to examine the feasibility of adapting in all ARTCCs, the departure/arrival and flow fixes which serve major airports and metroplexes. This would be an enhancement to the controller in terms of machine entry and display, as well as strip perusal.
- C. Departure and arrival flow compatibility should be achieved once the publication actions identified above are completed and users are cognizant of appropriate fixes to use in their route of flight.
- D. Potential en route airspace conflicts appear to be reduced in most cases of direct routing. Airspace efficiency, as measured through usage and flexibility, should increase proportionate to the number of users having the navigational capability to deviate from the structured airway system. The relatively small number of areas where an incompatibility exists between direct routings and airspace configurations can be compensated for by the ATC system without adverse impact.

APPENDIX A

DEPARTMENT OF TRANSPORTATION - FEDERAL AVIATION ADMINISTRATION OPERATION FREE FLIGHT (OPERATIONAL EVALUATION BETWEEN SELECTED AIRPORTS)		1. Date (Month & Day)	3. Actual Departure Time
		2. Flight ID	2
5. From - To (Use Three Letter Identifier)		4. Actual Arrival Time	
6. Did you initially receive a direct route clearance as filed?		2	
a. Departure Airport _____ b. Destination Airport _____		☐ a. Yes (Go to No. 7) ☐ b. No (Skip to No. 12)	
7. Were you subsequently rerouted via the VOR/VORTAC system?		12. Why? ("x" one)	
☐ a. Yes ☐ b. No (Skip to No. 18)		☐ a. Weather ☐ c. Traffic ☐ e. ATC system outage ☐ b. Upper winds ☐ d. Special use airspace ☐ f. Aircraft equipment ☐ g. Other (specify) : _____	
8. Why? ("x" one)		13. Were you subsequently rerouted direct to destination fix via area navigation?	
☐ a. Weather ☐ c. Traffic ☐ e. ATC system outage ☐ b. Upper winds ☐ d. Special use airspace ☐ f. Aircraft equipment ☐ g. Other (specify) : _____		☐ a. Yes ☐ b. No (Skip to No. 18)	
9. How far from destination fix were you rerouted via the VOR/VORTAC system?		14. How far from destination fix were you subsequently rerouted direct?	
☐ a. Yes ☐ b. No (Skip to No. 18)		☐ a. Yes ☐ b. No (Skip to No. 18)	
10. Were you subsequently rerouted direct to destination fix via area navigation?		15. Were you subsequently rerouted via the VOR/VORTAC system?	
☐ a. Yes ☐ b. No (Skip to No. 18)		☐ a. Yes ☐ b. No (Skip to No. 18)	
11. How far from destination fix were you subsequently rerouted direct?		16. Why? ("x" one)	
☐ a. Yes ☐ b. No (Skip to No. 18)		☐ a. Weather ☐ d. Special use airspace ☐ b. Upper winds ☐ e. ATC system outage ☐ c. Traffic ☐ f. Aircraft equipment ☐ g. Other (specify) : _____	
18. On THIS FLIGHT and from your viewpoint, how advantageous was the use of your area navigation equipment?		13. Actual fuel consumed on this flight between departure area fix and arrival area fix (as determined by first and last fix in route of flight of filed flight plan) was _____ lbs.	
☐ a. Extremely ☐ b. Very ☐ c. Moderately ☐ d. Slightly ☐ e. Not at all			
19a. How much fuel do you believe was saved on this flight by using this direct routing? _____ lbs.		17. How far from destination fix were you subsequently rerouted via the VOR/VORTAC system?	
		☐ a. Yes ☐ b. No (Skip to No. 18)	
19b. How much fuel do you believe was saved on this flight by using this direct routing? _____ lbs.			
20. Estimated fuel consumption between above fixes (question 19) assuming direct routing on this flight is _____ lbs.			
21. Estimated fuel consumption between above fixes (question 19) assuming normal airway routing on this flight is _____ lbs.			
COMPANY QUESTIONS			
20. Estimated fuel consumption between above fixes (question 19) assuming direct routing on this flight is _____ lbs. 21. Estimated fuel consumption between above fixes (question 19) assuming normal airway routing on this flight is _____ lbs.			

APPENDIX B

DIRECT ROUTE FLIGHT PLAN OPERATIONAL EVALUATION
FACILITY QUESTIONNAIRE

1. Facility _____ 2. Date _____
3. Aircraft Identification _____
4. Was Aircraft Rerouted?
 - a. yes
 - b. no — Skip to Question 7
5. Where was Aircraft Rerouted? _____
6. Why was Aircraft Rerouted? _____
 - a. weather
 - b. traffic
 - c. special-use airspace
 - d. system outage
 - e. pilot request
 - f. other _____

Explain _____

7. Was there any impact?
 - a. yes
 - b. no — Skip to Question 9
8. What kind of impact?
 - a. computer
 - b. workload
 - c. procedural
 - d. airspace
 - e. traffic flow
 - f. other _____

Explain _____

9. Comments _____
- _____
- _____
- _____

APPENDIX C

AIRPORTS AND ROUTES

1. ATL CHA 4713/11919 MWH SEA
- * 2. ATL VUZ 3815/11424 ILC 3800/11746 OAL.MOD3 SFO, or
ATL VUZ 3600/11452 BLD 3728/12057 MOD.MOD3 SFO
3. ATL VUZ 3407/11546 TNP.DOWNE1 LAX
4. ATL HCH 4033/8704 BVT BVT337 CGT CGT356 BEBEE ORD
5. ATL TYS 4001/8049 AIR V117 WISKE PIT
6. ATL TYS 4229/7916 DKK DKK020 WELLA BUF
7. ATL SPA 3940/7537 EWT.HARRY1 EWR
8. ATL AHN 3456/8118 2QH CLT
9. ATL 2626/8135 LEILA.LEILA2 MIA
10. MIA SRQ 3157/10616 EWM 3407/11546 TNP.DOWNE1 LAX
- *11. MIA SRQ 2837/8738 NEPTA 3600/11452 BLD 3738/12057 MOD.MOD3 SFO
12. MIA ORL 4033/8704 BVT BVT337 CGT CGT356 BEBEE ORD
13. SEA WIRTT 3538/11958 AVE.MOOR4 LAX
14. SEA RADDY 3503/8959 MEM.RMG1 ATL
15. LAX BFL 4700/12223 WIRTT SEA (0930-1800L)
LAX SBA SNS 4700/12223 WIRTT SEA (1800-0930L)
16. LAX TRM 3335/11445 BLH 3157/10616 EWM 2836/8738 NEPTA 2724/8233 SRQ.LEILA2 MIA or
LAX TRM 3406/11441 PKE 3157/10616 EWM 2836/8738 NEPTA 2724/8233 SRQ.LEILA2 MIA
17. LAX TRM 3504/8959 MEM.RMG1 ATL
18. LAX DAG 3604/11509 LAS 4109/8935 BDF BDF052 ORD235 VAINS ORD
19. LAX DAG 3604/11509 LAS 4154/7751 HOXIE 4104/7432 SAX V-36 ELLIS JFK
20. IAH LFK 3857/7521 TWIGG.KENY2 JFK
21. IAH JCT 3424/10544 CEARA 3800/11746 OAL.MOD3 SFO
22. SFO LIN 3833/11801 MVA 2836/8738 NEPTA 2724/8233 SRQ.LEILA2 MIA
23. SFO LIN 3833/11801 MVA 3503/8959 MEM.RMG1 ATL
24. SFO LIN 3833/11801 MVA 4154/7751 HOXIE 4104/7432 SAX V-36 ELLIS JFK
25. SFO LIN 3833/11801 MVA 4130/7758 SLT.SLT1 EWR
26. SFO LIN 3833/11801 MVA 3424/10544 CEARA 3036/9625 CLL IAH

- 27. JFK RBV FLYPI 3011/9438 DAS IAH
- 28. JFK RBV 4113/10446 CYS 3800/11746 OAL.MOD3 SFO or
JFK RBV 4113/10446 CYS 3728/12057 MOD.MOD3 SFO
- 29. JFK RBV BOGGE 3359/11451 BLD 3447/11627 HEC.DOWNEL LAX
- 30. ORD COVIE 2626/8135 LEILA.LEILA2 MIA
- 31. ORD WHETT 4014/7701 HAR V-210 BUCKS PHL
- 32. ORD IOW 3559/11451 BLD 3447/11627 HEC LAX
- 33. ORD ELX 4130/7758 SLT.SLT1 EWR
- 34. PIT BURG 3442/8318 TOC.MACEY2 ATL or
PIT HACKS 3442/8318 TOC.MACEY2 ATL
- 35. BUF JHW 3442/8318 TOC.MACEY2 ATL
- 36. PHL PTW FLOAT 4058/8511 FWA FWA311 GCT097 CGT CGT356 BEBBE ORD
- 37. CLT 3559/8031 CAVAD 3940/7537 EWT.PROUD1 LGA or
CLT 3559/8031 CAVAD 3938/7518 OOD.PROUD1 LGA
- 38. EWR SBJ ETX 4113/10446 CYS 3800/11746 OAL.MOD3 SFO or
EWR SBJ ETX 4113/10446 CYS 3728/12057 MOD.MOD3 SFO
- 39. EWR SBJ ETX 4058/8511 FWA FWA311 GCT097 CGT CGT356 BEBBE ORD

* Indicates change this revision.

Revised 7/20/81

D-1

LIST OF ALL PILOTS SURVEY RESPONDENTS SORTED BY CITY_PAIR																							18:57 MONDAY, APRIL 27, 1981	
CP	RID	DATE	FLTD	DEP	ARR	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	G1	G2	AFUEL	DFUEL	MFUEL	
ATL-BUF	7	725	E9962	2225	53	A	B		0	0	0			0				C			13000	12999	13000	
ATL-BUF	114	723	E9962	1948	1738	A	B		0	0	0			0				D			0	0	0	
ATL-BUF	128	723	E9962	2322	57	A	B		0	0	0			0				D			16000	11800	12200	
ATL-BUF	137	726	E9962	30	213	A	B		0	0	0			0				B			12700	13000	13500	
ATL-BUF	149	730	E9962	103	173	A	B		0	0	0			0				D			0	0	0	
ATL-BUF	154	731	E9962	1613	1803	A	B		0	0	0			0				D			0	0	0	
ATL-BUF	156		E9962	2325	103	A	B		0	0	0			0				D			0	0	0	
ATL-BUF	166		E9962	2500	58	A	B		0	0	0			0				D			0	0	0	
ATL-BUF	172		E9962	2500	58	A	B		0	0	0			0				D			12100	12200	13700	
ATL-BUF	179		E9962	1448	1738	A	B		0	0	0			0				C			0	0	0	
ATL-BUF	190	818	E9962	2204	102	B	B		0	0	0			0				D			14110	11500	12200	
ATL-BUF	199	817	E9962	1613	1751	A	B		0	0	0			0				C			28600	28600	29050	
ATL-BUF	201	818	E9962	1615	1805	A	B		0	0	0			0				C			0	0	0	
ATL-BUF	204	820	E9962	2500	58	A	B		0	0	0			0				A			0	0	0	
ATL-BUF	205	822	E9962	1754	1754	A	B		0	0	0			0				D			26200	26800	29200	
ATL-BUF	214	825	E9962	3124	1132	B	B		0	0	0			0				B			0	0	0	
ATL-BUF	215	826	E9962	3124	1132	B	B		0	0	0			0				B			0	0	0	
ATL-BUF	219	826	E9962	3124	1132	B	B		0	0	0			0				B			0	0	0	
ATL-BUF	220	826	E9962	3124	1132	B	B		0	0	0			0				B			0	0	0	
ATL-BUF	221	826	E9962	3124	1132	B	B		0	0	0			0				B			0	0	0	
ATL-BUF	231	826	E9962	3124	1132	B	B		0	0	0			0				B			0	0	0	
ATL-BUF	232	826	E9962	3124	1132	B	B		0	0	0			0				B			0	0	0	
ATL-BUF	234		E9962	2200	179	A	B		0	0	0			0				B			13000	16500	17800	
ATL-BUF	235		E9962	2200	179	A	B		0	0	0			0				B			13500	13500	15800	
ATL-BUF	244		E9962	2200	179	A	B		0	0	0			0				B			24000	24500	24500	
ATL-BUF	247		E9962	2226	124	A	B		0	0	0			0				B			0	0	0	
ATL-BUF	253	915	E9962	1000	1768	A	B		0	0	0			0				D			12500	12000	12500	
ATL-BUF	259	919	E9962	2508	106	A	A		0	0	0			0				D			13450	13450	15000	
ATL-BUF	260	919	E9962	1548	1768	A	A		0	0	0			0				D			0	0	0	
ATL-BUF	262	920	E9962	13	211	A	B		0	0	0			0				D			0	0	0	
ATL-BUF	372	1114	E9962	1720	1858	A	B		0	0	0			0				D			10000	10000	105000	
ATL-BUF	475	1215	E9962	30	203	A	B		0	0	0			0				A			0	0	0	
ATL-BUF	475	1215	E9962	1707	1857	A	B		0	0	0			0				A			27000	28939	29000	
ATL-BUF	486	1121	E9962	1720	1915	A	B		0	0	0			0				B			28000	28000	29000	
ATL-BUF	526	1226	E9962	2300	58	A	B		0	0	0			0				C			28000	28000	29000	
ATL-LAX	106	717	E9962	453	806	A	A		0	0	0			0				B			0	0	0	
ATL-LAX	138	730	E9962	2335	2000	A	B		0	0	0			0				B			0	0	0	
ATL-LAX	167		E9962	2335	2000	A	B		0	0	0			0				B			0	0	0	
ATL-LAX	167		E9962	2335	2000	A	B		0	0	0			0				B			0	0	0	
ATL-LAX	233		E9962	1420	1738	A	B		0	0	0			0				B			0	0	0	
ATL-LAX	233		E9962	1420	1738	A	B		0	0	0			0				B			0	0	0	
ATL-LAX	239		E9962	1420	1738	A	B		0	0	0			0				B			0	0	0	
ATL-LAX	241	914	E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	244	912	E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	246		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	251	914	E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	251	914	E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	252	920	E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	256	918	E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	274	1011	E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	364	1110	E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	364	1110	E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	365		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	376		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0	0	0	
ATL-LAX	472		E9962	1720	1738	A	B		0	0	0			0				A			0			

18:57 MONDAY, APRIL 27, 1981

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LIST OF ALL PILOTS SURVEY RESPONDENTS SORTED BY CITY PAIR 18:57 MONDAY, APRIL 27, 1981

CP	RID	DATE	FLTD	DEP	ARR	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	G1	G2	AFUEL	DFUEL	MFUEL
EMR-ORD	522	1214	UA111	1836	2036	A	B														0	0	0
EMR-SFO	296	1013	UA 35	1422	2011	A	B														0	0	0
EMR-SFO	302	1014	UA 35	1422	1955	A	B														0	0	0
EMR-SFO	307	1014	UA 35	1420	1916	A	B														0	0	0
EMR-SFO	308	1012	UA 35	1423	1958	B															0	0	0
EMR-SFO	312	1024	UA 35	1411	1932	A	B														0	0	0
EMR-SFO	331	1023	UA 35	1546	2113	A	B														0	0	0
EMR-SFO	334	1021	UA 35	1507	2029	A	B														0	0	0
EMR-SFO	338	1025	UA 35	1416	2000	A	B														0	0	0
EMR-SFO	343	1025	UA 35	1508	2063	A	B														0	0	0
EMR-SFO	345	1025	UA 35	1416	2003	A	B														0	0	0
EMR-SFO	362	1114	UA 35	1501	2036	A	B														0	0	0
EMR-SFO	362	1114	UA 35	1514	2203	A	B														0	0	0
EMR-SFO	383	1114	UA 35	1624	2220	A	B														0	0	0
EMR-SFO	385	1117	UA 35	1413	1948	A	B														0	0	0
EMR-SFO	396	1122	UA 35	1535	2104	A	B														0	0	0
EMR-SFO	411	1123	UA 35	1511	2066	A	B														0	0	0
EMR-SFO	413	1123	UA 35	1513	2031	A	B														0	0	0
EMR-SFO	420	1126	UA 35	1524	2049	A	B														0	0	0
EMR-SFO	421	1121	UA 35	1524	2049	A	B														0	0	0
EMR-SFO	442	1127	UA 35	1500	2017	A	B														0	0	0
EMR-SFO	442	1127	UA 35	1526	2103	A	B														0	0	0
EMR-SFO	455	1127	UA 35	1512	2103	A	B														0	0	0
EMR-SFO	455	1127	UA 35	1512	2103	A	B														0	0	0
EMR-SFO	462	1127	UA 35	1512	2103	A	B														0	0	0
EMR-SFO	462	1127	UA 35	1512	2103	A	B														0	0	0
EMR-SFO	486	1221	UA 35	1503	2238	A	B														0	0	0
EMR-SFO	486	1221	UA 35	1517	2238	A	B														0	0	0
EMR-SFO	499	1220	UA 35	1514	2049	A	B														0	0	0
EMR-SFO	499	1220	UA 35	1514	2049	A	B														0	0	0
EMR-SFO	501	1229	UA 35	1528	2131	A	B														0	0	0
EMR-SFO	502	1231	UA 35	1512	2047	A	B														0	0	0
EMR-SFO	504	1224	UA 35	1501	2005	A	B														0	0	0
EMR-SFO	506	1214	UA 35	1512	2035	A	B														0	0	0
EMR-SFO	509	1213	UA 35	1511	2041	A	B														0	0	0
EMR-SFO	515	1210	UA 35	1500	2035	A	B														0	0	0
EMR-SFO	516	129	UA 35	1509	2045	A	B														0	0	0
EMR-SFO	520	1211	UA 35	1514	2058	A	B														0	0	0
EMR-SFO	521	1326	UA 35	1541	2058	A	B														0	0	0
IAH-JFK	282	1017	PA 26	1935	2250	B															0	0	0
IAH-JFK	282	1017	PA 26	1935	2250	B															0	0	0
IAH-JFK	283	1017	PA 26	1907	2252	A	B														0	0	0
IAH-JFK	283	1017	PA 26	1907	2252	A	B														0	0	0
IAH-JFK	325	1022	PA 26	1902	2217	A	B														0	0	0
IAH-JFK	325	1022	PA 26	1902	2217	A	B														0	0	0
IAH-JFK	354	1029	PA 26	1924	2219	A	B														0	0	0
IAH-JFK	354	1029	PA 26	1924	2219	A	B														0	0	0
IAH-JFK	356	1114	EA 64	1715	2051	A	B														0	0	0
IAH-JFK	356	1114	EA 64	1715	2051	A	B														0	0	0
IAH-JFK	370	1114	EA 64	1806	2141	A	B														0	0	0
IAH-JFK	370	1114	EA 64	1806	2141	A	B														0	0	0
IAH-JFK	371	1110	EA 64	1803	2053	A	B														0	0	0
IAH-JFK	371	1110	EA 64	1803	2053	A	B														0	0	0
IAH-JFK	375	1115	EA 64	1735	2053	A	B														0	0	0
IAH-JFK	375	1115	EA 64	1735	2053	A	B														0	0	0
IAH-JFK	376	1116	EA 64	1822	2055	A	B														0	0	0
IAH-JFK	376	1116	EA 64	1822	2055	A	B														0	0	0
IAH-JFK	400	1121	EA 64	1726	2014	A	B														0	0	0
IAH-JFK	400	1121	EA 64	1726	2014	A	B														0	0	0
IAH-JFK	402	1111	PA 26	1920	2207	A	B														0	0	0
IAH-JFK	402	1111	PA 26	1920	2207	A	B														0	0	0
IAH-JFK	408	1116	EA 64	1810	2200	A	B														0	0	0
IAH-JFK	408	1116	EA 64	1810	2200	A	B														0	0	0
IAH-JFK	425	1120	PA 26	1913	2203	A	B														0	0	0
IAH-JFK	425	1120	PA 26	1913	2203	A	B														0	0	0

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LIST OF ALL PILOTS SURVEY RESPONDENTS SORTED BY CITY_PAIR 18:57 MONDAY, APRIL 27, 1981

CP	RID	DATE	FLYID	DEP	ARR	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	G1	G2	AFUEL	DFUEL	MFUEL
MIA-LAX	5		NA442	1722	2230	A	B											A					
MIA-LAX	8		NA 51	2206	302	A	B											A					
MIA-LAX	14		NA 51	2157	357	A	B											A					
MIA-LAX	20		NA442	1734	2227	A	B											A					
MIA-LAX	22		NA442	1730	2239	A	B											A					
MIA-LAX	24		NA440	1252	1727	A	B											B					
MIA-LAX	25		NA 51	2200	315	A	B											A					
MIA-LAX	27		NA 51	2115	236	A	B											A					
MIA-LAX	38	614	NA440	1109	1807	A	B											A					
MIA-LAX	47	618	NA442	1705	2218	A	B											A					
MIA-LAX	47	619	NA440	1232	1610	A	B											A					
MIA-LAX	50	621	NA367	1638	2118	A	B											A					
MIA-LAX	50	621	NA367	1638	2118	A	B											A					
MIA-LAX	57	622	NA440	1254	1824	A	B											D					
MIA-LAX	57	623	NA440	1254	1730	A	B											D					
MIA-LAX	60	624	NA440	1254	1805	A	B											D					
MIA-LAX	61	625	NA 51	2224	1805	A	B											D					
MIA-LAX	64	626	NA 51	2224	258	A	B											D					
MIA-LAX	65	628	NA442	1715	2202	A	B											D					
MIA-LAX	66	628	NA440	1346	1835	A	B											D					
MIA-LAX	72	629	NA440	1256	1805	A	B											D					
MIA-LAX	73	629	NA367	1700	2152	A	B											D					
MIA-LAX	77		NA440	1153	1915	A	B											D					
MIA-LAX	86		NA440	1254	1842	A	B											D					
MIA-LAX	86		NA440	1254	1842	A	B											D					
MIA-LAX	97	719	NA440	1254	1815	A	B											D					
MIA-LAX	97	719	NA440	1254	1815	A	B											D					
MIA-LAX	107	717	NA373	2215	316	A	B											D					
MIA-LAX	108	721	NA373	2215	316	A	B											D					
MIA-LAX	110	720	NA440	1254	1805	A	B											D					
MIA-LAX	116	722	NA440	1254	1805	A	B											D					
MIA-LAX	120	721	NA440	1350	1754	A	B											D					
MIA-LAX	126	724	NA440	1252	1743	A	B											D					
MIA-LAX	133	725	NA440	1351	1911	A	B											D					
MIA-LAX	148	730	NA440	1302	1740	A	B											D					
MIA-LAX	150		NA440	1252	1725	A	B											D					
MIA-LAX	152		NA440	1254	1731	A	B											D					
MIA-LAX	153	729	NA 49	2235	323	A	B											D					
MIA-LAX	171		NA373	2235	330	A	B											D					
MIA-LAX	181	812	NA440	1254	1733	A	B											D					
MIA-LAX	188	816	NA440	1254	1733	A	B											D					
MIA-LAX	192	818	NA440	1254	1817	A	B											D					
MIA-LAX	218	829	NA440	1254	1805	A	B											D					
MIA-LAX	236	912	NA373	2216	314	A	B											D					
MIA-LAX	237		NA373	2216	314	A	B											D					
MIA-LAX	238	910	NA440	1353	1913	A	B											D					
MIA-LAX	254	918	NA440	1254	1724	A	B											D					
MIA-LAX	255	919	NA440	1254	1805	A	B											D					
MIA-LAX	266	922	NA440	1256	1816	A	B											D					
MIA-LAX	267	924	NA440	1256	1816	A	B											D					
MIA-LAX	268		NA440	1301	1821	A	B											D					
MIA-LAX	273		NA440	1258	1764	A	B											D					
MIA-LAX	275	1012	NA440	1258	1764	A	B											D					
MIA-LAX	276	1013	NA440	1258	1808	A	B											D					
MIA-LAX	277	1014	NA440	1258	1808	A	B											D					
MIA-LAX	278	1015	NA440	1258	1808	A	B											D					
MIA-LAX	280	1016	NA440	1258	1808	A	B											D					
MIA-LAX	346	1110	NA440	1258	1808	A	B											D					

LIST OF ALL PILOTS SURVEY RESPONDENTS SORTED BY CITY_PAIR																								
CP	RID	DATE	FLTID	DEP	ARR	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	G1	G2	AFUEL	DUUEL	NFUEL	
MIA-LAX	168	1113	PA440	1345	1830	A	A	D	515	A	330										75500	77800	78300	7
MIA-LAX	169		PA440	1245	1805	A	B														80500	81500	81900	
MIA-LAX	170		PA440	1350	1810	A	B														79100	81100	81600	
MIA-LAX	171		PA440	1355	1805	A	B														87600	84900	85500	
MIA-LAX	172		PA440	1345	1803	A	B														81500	83800	85500	
MIA-LAX	173		PA440	1418	1903	A	B	D	220	B											72300	77700	78400	
MIA-LAX	174	1212	PA440	1345	1905	A	B														87000	87300	87500	
MIA-LAX	175	1229	EA 78	2225	59	A	B																	
MIA-LAX	176		EA 78	2305	143	A	B																	
MIA-LAX	177		EA 78	2152	30	A	B																	
MIA-LAX	178		EA 78	2202	43	A	B																	
MIA-LAX	179		EA 78	2152	20	A	B																	
MIA-LAX	180		EA 78	2305	158	A	B																	
MIA-LAX	181		EA 78	2249	126	A	B																	
MIA-LAX	182		EA 78	2210	38	A	B																	
MIA-LAX	183		EA 78	2130	53	A	B																	
MIA-LAX	184		EA 78	1949	53	A	B																	
MIA-LAX	185		EA 78	2225	115	A	B	C	500	A	400													
MIA-LAX	186		EA 78	2225	53	A	B																	
MIA-LAX	187		EA 78	2213	107	A	B																	
MIA-LAX	188		EA 78	2159	45	A	B																	
MIA-LAX	189		EA 78	2202	106	A	B																	
MIA-LAX	190		EA 78	2153	23	A	B																	
MIA-LAX	191		EA 78	2108	20	A	B																	
MIA-LAX	192		EA 78	2154	20	A	B																	
MIA-LAX	193		EA 78	2108	2359	A	B																	
MIA-LAX	194		EA 78	2224	107	A	B																	
MIA-LAX	195		EA 78	2110	36	A	B																	
MIA-LAX	196		EA 78	2201	53	A	B																	
MIA-LAX	197		EA 78	2108	2900	A	B																	
MIA-LAX	198		EA 78	2204	116	A	B																	
MIA-LAX	199		EA 78	2204	116	A	B																	
MIA-LAX	200		EA 78	2305	132	A	B																	
MIA-LAX	201		EA 78	2240	41	A	B																	
MIA-LAX	202		EA 78	2149	37	A	B																	
MIA-LAX	203		EA 78	2153	2900	A	B																	
MIA-LAX	204		EA 78	2108	2900	A	B																	
MIA-LAX	205		EA 78	2108	2900	A	B																	
MIA-LAX	206		EA 78	2108	2900	A	B																	
MIA-LAX	207		EA 78	2108	2900	A	B																	
MIA-LAX	208		EA 78	2108	2900	A	B																	
MIA-LAX	209		EA 78	2108	2900	A	B																	
MIA-LAX	210		EA 78	2108	2900	A	B																	
MIA-LAX	211		EA 78	2108	2900	A	B																	
MIA-LAX	212		EA 78	2108	2900	A	B																	
MIA-LAX	213		EA 78	2108	2900	A	B																	
MIA-LAX	214		EA 78	2108	2900	A	B																	
MIA-LAX	215		EA 78	2108	2900	A	B																	
MIA-LAX	216		EA 78	2108	2900	A	B																	
MIA-LAX	217		EA 78	2108	2900	A	B																	
MIA-LAX	218		EA 78	2108	2900	A	B																	
MIA-LAX	219		EA 78	2108	2900	A	B																	
MIA-LAX	220		EA 78	2108	2900	A	B																	
MIA-LAX	221		EA 78	2108	2900	A	B																	
MIA-LAX	222		EA 78	2108	2900	A	B																	
MIA-LAX	223		EA 78	2108	2900	A	B																	
MIA-LAX	224		EA 78	2108	2900	A	B																	
MIA-LAX	225		EA 78	2108	2900	A	B																	
MIA-LAX	226		EA 78	2108	2900	A	B																	
MIA-LAX	227		EA 78	2108	2900	A	B																	
MIA-LAX	228		EA 78	2108	2900	A	B																	
MIA-LAX	229		EA 78	2108	2900	A	B																	
MIA-LAX	230		EA 78	2108	2900	A	B																	
MIA-LAX	231		EA 78	2108	2900	A	B																	
MIA-LAX	232		EA 78	2108	2900	A	B																	
MIA-LAX	233		EA 78	2108	2900	A	B																	
MIA-LAX	234		EA 78	2108	2900	A	B																	
MIA-LAX	235		EA 78	2108	2900	A	B																	
MIA-LAX	236		EA 78	2108	2900	A	B																	
MIA-LAX	237		EA 78	2108	2900	A	B																	
MIA-LAX	238		EA 78	2108	2900	A	B																	
MIA-LAX	239		EA 78	2108	2900	A	B																	
MIA-LAX	240		EA 78	2108	2900	A	B																	
MIA-LAX	241		EA 78	2108	2900	A	B																	
MIA-LAX	242		EA 78	2108	2900	A	B																	
MIA-LAX	243		EA 78	2108	2900	A	B																	
MIA-LAX	244		EA 78	2108	2900	A	B																	
MIA-LAX	245		EA 78	2108	2900	A	B																	
MIA-LAX	246		EA 78	2108	2900	A	B																	
MIA-LAX	247		EA 78	2108	2900	A	B																	
MIA-LAX	248		EA 78	2108	2900	A	B																	
MIA-LAX	249		EA 78	2108	2900	A	B																	
MIA-LAX	250		EA 78	2108	2900	A	B																	
MIA-LAX	251		EA 78	2108	2900	A	B																	
MIA-LAX	252		EA 78	2108	2900	A	B																	
MIA-LAX	253		EA 78	2108	2900	A	B																	
MIA-LAX	254		EA 78	2108	2900	A	B																	
MIA-LAX	255		EA 78	2108	2900	A	B																	
MIA-LAX	256		EA 78	2108	2900	A	B																	
MIA-LAX	257		EA 78	2108	2900	A	B																	
MIA-LAX	258																							

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18:57 MONDAY, APRIL 27, 1981

57800	62000	64800	77000	78300	80600	82900	85200	87500	89800	92100	94400	96700	99000	101300	103600	105900	108200	110500	112800	115100	117400	119700	122000	124300	126600	128900	131200	133500	135800	138100	140400	142700	145000	147300	149600	151900	154200	156500	158800	161100	163400	165700	168000	170300	172600	174900	177200	179500	181800	184100	186400	188700	191000	193300	195600	197900	200200	202500	204800	207100	209400	211700	214000	216300	218600	220900	223200	225500	227800	230100	232400	234700	237000	239300	241600	243900	246200	248500	250800	253100	255400	257700	260000	262300	264600	266900	269200	271500	273800	276100	278400	280700	283000	285300	287600	289900	292200	294500	296800	299100	301400	303700	306000	308300	310600	312900	315200	317500	319800	322100	324400	326700	329000	331300	333600	335900	338200	340500	342800	345100	347400	349700	352000	354300	356600	358900	361200	363500	365800	368100	370400	372700	375000	377300	379600	381900	384200	386500	388800	391100	393400	395700	398000	400300	402600	404900	407200	409500	411800	414100	416400	418700	421000	423300	425600	427900	430200	432500	434800	437100	439400	441700	444000	446300	448600	450900	453200	455500	457800	460100	462400	464700	467000	469300	471600	473900	476200	478500	480800	483100	485400	487700	490000	492300	494600	496900	499200	501500	503800	506100	508400	510700	513000	515300	517600	519900	522200	524500	526800	529100	531400	533700	536000	538300	540600	542900	545200	547500	549800	552100	554400	556700	559000	561300	563600	565900	568200	570500	572800	575100	577400	579700	582000	584300	586600	588900	591200	593500	595800	598100	600400	602700	605000	607300	609600	611900	614200	616500	618800	621100	623400	625700	628000	630300	632600	634900	637200	639500	641800	644100	646400	648700	651000	653300	655600	657900	660200	662500	664800	667100	669400	671700	674000	676300	678600	680900	683200	685500	687800	690100	692400	694700	697000	699300	701600	703900	706200	708500	710800	713100	715400	717700	720000	722300	724600	726900	729200	731500	733800	736100	738400	740700	743000	745300	747600	749900	752200	754500	756800	759100	761400	763700	766000	768300	770600	772900	775200	777500	779800	782100	784400	786700	789000	791300	793600	795900	798200	800500	802800	805100	807400	809700	812000	814300	816600	818900	821200	823500	825800	828100	830400	832700	835000	837300	839600	841900	844200	846500	848800	851100	853400	855700	858000	860300	862600	864900	867200	869500	871800	874100	876400	878700	881000	883300	885600	887900	890200	892500	894800	897100	899400	901700	904000	906300	908600	910900	913200	915500	917800	920100	922400	924700	927000	929300	931600	933900	936200	938500	940800	943100	945400	947700	950000	952300	954600	956900	959200	961500	963800	966100	968400	970700	973000	975300	977600	979900	982200	984500	986800	989100	991400	993700	996000	998300	1000600	1002900	1005200	1007500	1009800	1012100	1014400	1016700	1019000	1021300	1023600	1025900	1028200	1030500	1032800	1035100	1037400	1039700	1042000	1044300	1046600	1048900	1051200	1053500	1055800	1058100	1060400	1062700	1065000	1067300	1069600	1071900	1074200	1076500	1078800	1081100	1083400	1085700	1088000	1090300	1092600	1094900	1097200	1099500	1101800	1104100	1106400	1108700	1111000	1113300	1115600	1117900	1120200	1122500	1124800	1127100	1129400	1131700	1134000	1136300	1138600	1140900	1143200	1145500	1147800	1150100	1152400	1154700	1157000	1159300	1161600	1163900	1166200	1168500	1170800	1173100	1175400	1177700	1180000	1182300	1184600	1186900	1189200	1191500	1193800	1196100	1198400	1200700	1203000	1205300	1207600	1209900	1212200	1214500	1216800	1219100	1221400	1223700	1226000	1228300	1230600	1232900	1235200	1237500	1239800	1242100	1244400	1246700	1249000	1251300	1253600	1255900	1258200	1260500	1262800	1265100	1267400	1269700	1272000	1274300	1276600	1278900	1281200	1283500	1285800	1288100	1290400	1292700	1295000	1297300	1299600	1301900	1304200	1306500	1308800	1311100	1313400	1315700	1318000	1320300	1322600	1324900	1327200	1329500	1331800	1334100	1336400	1338700	1341000	1343300	1345600	1347900	1350200	1352500	1354800	1357100	1359400	1361700	1364000	1366300	1368600	1370900	1373200	1375500	1377800	1380100	1382400	1384700	1387000	1389300	1391600	1393900	1396200	1398500	1400800	1403100	1405400	1407700	1410000	1412300	1414600	1416900	1419200	1421500	1423800	1426100	1428400	1430700	1433000	1435300	1437600	1439900	1442200	1444500	1446800	1449100	1451400	1453700	1456000	1458300	1460600	1462900	1465200	1467500	1469800	1472100	1474400	1476700	1479000	1481300	1483600	1485900	1488200	1490500	1492800	1495100	1497400	1499700	1502000	1504300	1506600	1508900	1511200	1513500	1515800	1518100	1520400	1522700	1525000	1527300	1529600	1531900	1534200	1536500	1538800	1541100	1543400	1545700	1548000	1550300	1552600	1554900	1557200	1559500	1561800	1564100	1566400	1568700	1571000	1573300	1575600	1577900	1580200	1582500	1584800	1587100	1589400	1591700	1594000	1596300	1598600	1600900	1603200	1605500	1607800	1610100	1612400	1614700	1617000	1619300	1621600	1623900	162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LIST OF ALL PILOTS SURVEY RESPONDENTS SORTED BY CITY PAIR																									
CP	RID	DATE	FLYID	DEP	ARR	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	G1	G2	AFUEL	DFUEL	NFUEL		
ORD-LAX	450	1126	UA111	2145	139	A	B		0		0			0		0	B				22300	22300	22600	0	
ORD-MIA	360		EA71	1519	1744	A	B		0		0			0		0	A				0	0	0	0	
PIT-ATL	369		EA137	2235	11	A	B		0		0			0		0	C				0	0	0	0	
PIT-ATL	480		EA137	2235	11	A	B		0		0			0		0	C				5800	5899	5900	0	
SEA-ATL	433	1125	EA85	1704	2135	A	B		0		0			0		0	C				0	0	0	0	
SEA-ATL	441	1128	EA85	1650	2121	A	B		0		0			0		0	C				0	0	0	0	
SFO-JFK	292	1020	UA22	1601	2121	A	B		625	B	0			0		0	B				93650	94100	94700	0	
SFO-JFK	304	1013	UA22	1521	2121	A	B		0		0			0		0	B				73500	73700	75000	0	
SFO-JFK	306	1012	UA22	1545	2040	A	B		0		0			0		0	B				0	0	0	0	
SFO-JFK	311	1012	UA22	1550	2030	A	A		200	A	1800			0		0	A				0	0	0	0	
SFO-JFK	315	1025	UA136	1536	2128	A	A		1855	A	1596			0		0	D				0	0	0	0	
SFO-JFK	318	1023	UA22	1547	2041	A	A		275	B	0			0		0	C				0	0	0	0	
SFO-JFK	332	1022	UA22	1552	2112	A	A		643	B	0			0		0	C				90700	87800	88400	0	
SFO-JFK	335	1011	EA724	2121	2041	A	B		0		0			0		0	B				98100	97500	98100	0	
SFO-JFK	355		EA724	2121	153	A	B		0		0			0		0	C				63000	63000	63750	0	
SFO-JFK	359		EA722	1639	2100	A	B		0		0			0		0	A				58000	57500	56500	0	
SFO-JFK	364	1111	UA22	1630	2150	A	B		0		0			0		0	B				0	0	0	0	
SFO-JFK	368	1120	EA724	2120	205	A	B		0		0			0		0	A				75600	75600	80000	0	
SFO-JFK	401	1118	EA722	1645	2115	A	A		350	B	0			0		0	A				72700	76200	76900	0	
SFO-JFK	403	1122	EA722	1654	2112	A	A		150	B	0			0		0	E				0	0	0	0	
SFO-JFK	436	1129	UA22	1630	2112	A	A		0		0			0		0	A				0	0	0	0	
SFO-JFK	437	1129	UA22	1642	2119	A	B		348	B	0			0		0	B				84400	88100	88500	0	
SFO-JFK	458	1130	UA22	1644	2106	A	A		2000	B	0			0		0	A				82500	87050	87450	0	
SFO-JFK	466		UA22	1639	2204	A	A		0		0			0		0	C				86050	87050	87300	0	
SFO-JFK	514	1212	UA22	1650	2210	A	A		1880	A	1750			0		0	D				0	0	0	0	

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