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THE INTERNATIONAL AIR ANALYSIS MODEL

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I. INTRODUCTION

This report documents the work performed by the Transportation Systems Center of the United States Department of Transportation (DOT) in Fiscal Year 1979, for the Office of Air Transportation (P-63) in the Office of the Secretary of Transportation, initiating the development of a computer-assisted methodology (model) for analyzing alternative proposals for air economic regulations. While it is expected that the model described in this report will ultimately be useful for analysis of a wide range of aviation policy issues of importance to the DOT (including the effects of proposed air carrier mergers), the first phase of development is focused on the task of evaluating the traffic and financial consequences, on US and foreign carriers, of alternative regulatory proposals in the context of international bilateral negotiations.

The remainder of this chapter contains three sections as follows: Section I.1, summarizing the current overall U.S. policy toward international aviation, as announced by President Carter in August 1978, and describing the interagency process by which U.S. positions in specific bilateral talks emerge; Section I.2, describing an analytical framework for the analysis of bilateral proposals including an introduction to the proposed role of the model documented in this report;

and finally Section I.3, containing a brief description of the most noteworthy previous models for analyzing alternative proposals for the economic regulation of aviation.

The second chapter describes, in some detail, the data sources available for international air analysis. Chapter III describes the algorithms and general structure of the International Air Analysis model, followed by computer program information covering model inputs, outputs and operations. The fifth chapter contains the French bilateral test case analysis. At this point only the manual analysis is complete, the computer scenario analysis will be provided at a later date. The last chapter presents recommendations for continuing development of the International Air Analysis model system. Finally, the appendix consists of commuted listings of all computer programs which comprise the model system.

I.1 U.S. Bilateral Negotiations - Policy and Process

U.S. Policy Goals

In August 1978, President Carter announced the United States policy for the conduct of international air transportation negotiations. The policy called for the maintenance and continued development of safe, convenient, efficient; affordable, and environmentally acceptable air services to be achieved through the preservation and extension of competition among airlines in a fair market place. This policy is designed to provide the greatest possible benefits to travelers and shippers. In order to carry out U.S. international aviation policy, the President established a set of general objectives, designed particularly for major international air markets, from which specific negotiating strategies were to be developed.

In negotiating bilateral agreements the policy calls for, first, the trading of competitive opportunities, rather than restrictions. Second, the negotiators are to aggressively pursue U.S. interests in expanded air transportation and reduced prices instead of protectionism. Third, the U.S. will give liberal concessions in return for progress toward competitive objectives. And fourth, the negotiations will not sign, without Presidential approval, bilateral agreements that do not meet the minimum U.S. competitive objectives. Within the context of these four general goals, seven specific negotiating objectives were developed:

- o Create new and greater opportunities for innovative and competitive pricing that will encourage and permit the use of new price and service options to meet the needs of different travelers and shippers.

- o Liberalize the rules governing charter operations of supplemental and scheduled carriers. Limitations and restrictions on the volume, frequency or regularity of charter operations should be eliminated and requirements for approval of flights should be prohibited.

- o Reduce or remove restrictions on capacity, frequency, and route and operating rights of scheduled carriers, in order to promote more efficient airline operations and greater consumer traveling and shipping convenience.

- o Eliminate discrimination and unfair competitive practices faced by U.S. airlines in international transportation.

- o Allow flexibility to designate multiple U.S. airlines in international air markets.

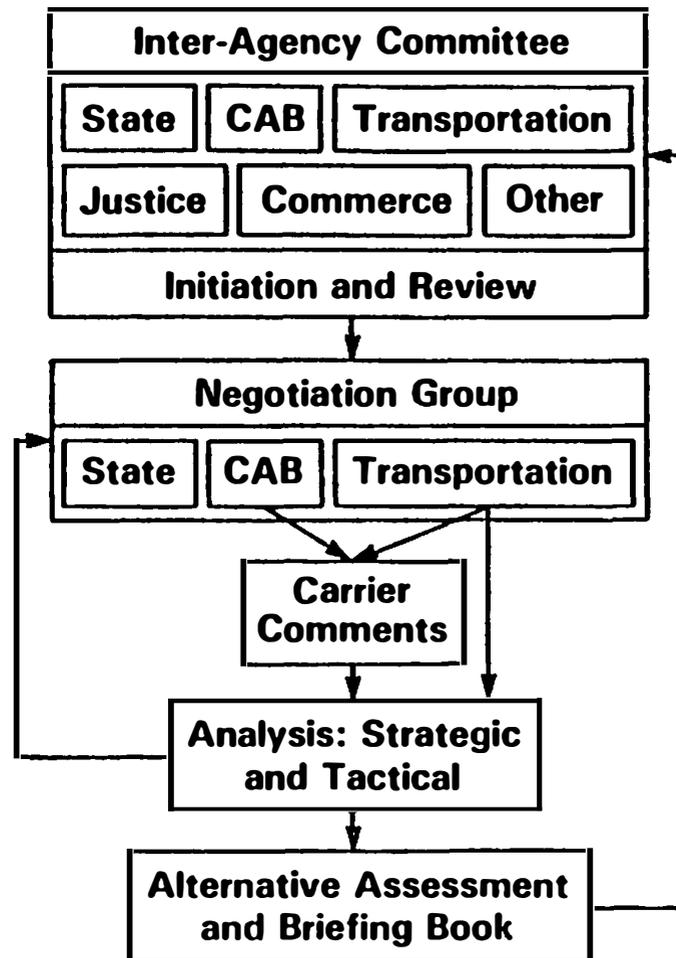
- o Encourage maximum traveler and shipper access to international markets by authorizing more cities for non-stop or direct service and by improving the integration of domestic and international airline services.

- o Allow flexibility to permit the development and facilitation of competitive air cargo services.

Development of U.S. Positions

Although the negotiation of bilateral agreements remains the primary function of the Department of State, U.S. positions are developed through an inter-agency process, with input from the Civil Aeronautics Board, the Department of Transportation, the Department of Justice, the Department of Commerce, and other Executive agencies (Figure I.1). However, since transportation policy is essentially the function of DOT, it has become necessary for this agency to be a focus for policy leadership and coordination. The DOT provides policy proposals to other agencies in specific aviation cases and to Congress where legislation appears to be necessary. Within this context, while all major issues relating to international bilateral agreements are discussed within the interagency organization, DOT takes the leadership in planning and preparing analysis of specific

FIGURE I.1
POSITION DEVELOPMENT & PROCESS



proposals to be examined. The DOT is continually engaged in the process of evaluating international bilateral agreement proposals to support negotiations.

In supporting bilateral negotiations, the DOT performs comprehensive analysis of multilateral air service opportunities; estimates effects of changes in U.S. and foreign carrier routes, service, and competition; and examines the transportation market effects of mergers and the expansion of domestic carrier networks into international markets. More specifically, it is the function of the DOT to provide an objective assessment of public and private benefits and costs; to select and choose mechanism for commercial opportunities; to provide a structure for the organization of evidentiary detail; and to provide an overall expertise to strengthen the negotiation process.

I.2 Analytical Framework for Analysis of Bilateral Proposals

For DOT to plan, prepare, and analyze alternative bilateral proposals in a more effective and timely manner, there is a need to develop an analytical framework to perform international air transportation operational and financial analysis. The analytical framework would provide the DOT with the capability

to perform timely sensitivity analyses of negotiable items such as changes in routes, aircraft type, frequency, fare proposals, and charter rules. The Transportation Systems Center, in Cambridge, Massachusetts, is currently developing a computer assisted analytical framework to handle complex scenarios in relatively short period of time.

The model under development recognizes three types of changes which might result from new bilateral agreement proposals. These changes include service characteristics (such as trip time, transfer and frequency), traveler characteristics (such as origin, destination, and routing), and network description (such as origin to hub, and hub to hub routings). Changes of service offerings of interest are, of course, those resulting from alternative bilateral agreements on international route service authorizations. The principal kinds of service scenarios to be evaluated are: the introduction of new service, new gateways, or innovative pricing. New service would include, for example, new service on an international segment; changed beyond gateway service rights; or changed capacity limitations. More specifically, the range of service scenarios could include the following changes: gateways, beyond points, intermediate points, airports served, number of carriers, different carriers, equipment (including gauge), capacity, and fares.

The model is required to compute, for any given scenario, operational and financial results for both the U.S. as well as the foreign-flag carriers. On the operational side the analysis includes scheduled and charter passenger traffic, load factors, and market shares. On the financial side, the analysis includes revenues, costs, and operating profit, for scheduled operations. In addition, the model provides useful summary information such as change in traffic at gateways and the number of beyond point and local passengers.

The evaluation of any particular scenario is accomplished by incremental analysis. Essentially, traffic is viewed as a complex function of service and fare and this sensitivity produces changes in market share and profitability. The model is continually being refined to capture the fundamental relationship between traffic, service, and fare. The ultimate goal is to develop a reliable model that can be used to analyze quality and price service options in a competitive market environment.

In its final form, the model will enhance the ability of the DOT to select and evaluate valuable negotiable items to present and discuss at the inter-agency meetings. Moreover, because of its computer-oriented design, the model can be

used to evaluate particular proposals as they arise during the negotiation cycle.

I.3 Previous Air Travel/Modeling Efforts

In this section, three noteworthy past air travel analysis methodologies are briefly reviewed. These include the Quality of Service Index (QSI), the Transatlantic Route Alternatives Analysis, and the International Quality of Service Index (IQSI). Each has been used in the past to perform analysis of air service changes as proposed in bilateral negotiations, route proceedings and other regulatory decision processes. The latter two methodologies are improvements upon the QSI method which was developed by the Civil Aeronautics Board and has been widely used by that Agency.

Quality of Service Index

The Quality of Service Index (QSI) was developed by the staff of the Civil Aeronautics Board in 1957 and was updated about 1970. Its purpose is to estimate the magnitude and distribution of air traffic changes as caused by changes in the quality of air service in an air travel market.

The QSI procedure first assigns weights to attributes (including schedule frequency, number of intermediate steps and type of equipment) of existing and proposed flights.

The weights for each flight are combined to form the Quality of Service indices. The total stimulation of traffic in the market is evaluated using the following formula:

$$Y = X / (.3741 + .5561X), \text{ where}$$

X is the ratio of the after to before QSI, and Y is the stimulation factor.* The distribution of traffic to each carrier or flight is assumed proportional to the percent of total QSI weight for that carrier or flight. Table I.1 contains the weights derived in the 1970 study.

Table I.1
CAB QSI Weights

<u>Factor</u>	<u>QSI Weight</u>	
Frequency	1.00	for one-way flight per each day of the week scheduled
Equipment: <u>10/</u> Jet	1.85*	for L-747*
	1.50*	for DC-10*, L-1011*
	1.30	for DC-8-61 (D8S)
	1.00	for B-707, B-720, B-727, B-737, CV-990/880, DC-8 (except-61), DC-9-30
	.78	for BAC-1-11, DC-9-10, SE-210
Turboprop	.75	for Electra
	.43	for VV-700/800, CV-580, YS-11
	.20	for N-262
	.13*	for DC-99*
Piston	.65	for Constellation, DC-7, DC-3
	.40	for CV-240/340/440, M-404
	.40	for DC-3
Stops	1.00	for nonstop
	.55	for one-stop
	.40	for two-stop
	.03	for three-or-more stops

*This formulation includes an overall average annual growth factor of 7.5%.

Although frequently used in the analysis of international air service changes, the QSI model has several distinct deficiencies with respect to analyses of this type.

Specifically,

(1) the estimating relationships were derived from domestic U.S. experience of the late 1960's before many of the recent changes to the air service marketplace had been introduced. In addition, the relationships were not well calibrated for long haul markets, markets with less than daily air service, or markets with connecting flight itineraries, all of which are common to international air travel.

(2) The estimating relationships do not directly treat several important causal factors such as travel time, fare level and trip purpose.

(3) The estimating procedure was keyed to finding the best fit for the stimulation algorithm. Consequently, the quality of service weights, when used for market share analysis, may not adequately represent traveler's observed preferences for one routing over another.

The problems with using the Quality of Service (QSI) methodology for international air demand analysis have been identified on many previous occasions. The methodologies described in the next two sections are two recent attempts to correct these deficiencies.

International Quality of Service Index

The International Quality of Service Index (IQSI) was developed by Simat Hellieson and Eichner, Inc. in 1977, and was used in the analysis of the Bermuda II Agreements with the United Kingdom.

The principal improvements incorporated into the IQSI methodology consist of: (1) addition of a "citizenship factor" which ostensibly takes into account foreign national's preferences for flying on flag carriers; (2) reestimation of QSI weights for aircraft type and number of stops using current international data; (3) adjustment of QSI weights for third country carriers.

The citizenship factor is the percent of home country passengers who will choose to fly on home flag carriers, independent of the Quality of Service ratings. The remaining fraction of passengers are divided among flights according to the QSI rating. Factors for August 1977 are presented in Table I.2. Note that negative citizenship factors indicate that there is a preference for avoiding the flag carriers of a country by citizens of that country.

The citizenship factors were developed from INS-I92 on-flight traffic counts and Official Airline Guide flight data using the original set of CAB QSI weights. Thus, the values derived for the citizenship factors are

Table I.2

CITIZENSHIP FACTORS CALCULATED FROM AUGUST DATA

Country/Region	U.S. Factors		Foreign Factors	
	Arriving	Departing	Arriving	Departing
	U.S.	U.S.	Foreign Country	Foreign Country
(1)	(2)	(3)	(4)	(5)
Guatemala	.203	.300	-.014	-.064
Panama	.115	.406	.083	.113
Central America	.083	.148	.060	-.072
Brazil	.118	.049	.258	.190
Colombia	-.036	.036	-.132	.124
Peru	.195	.310	.006	-.221
Venezuela	.313	.187	.242	.136
South America	.057	.083	.145	.062
Germany	.261	.185	.607	.242
United Kingdom	.126	.122	.179	.069
France	.139	-.019	.485	.430
Italy	.162	.105	.218	.121
Switzerland	.034	-.081	.760	.244
Netherlands	-.003	-.089	.780	.487
Spain	.124	-.020	.327	.122
Portugal	N.C.	N.C.	N.C.	N.C.
Denmark	-.035	-.131	.645	.197
Greece	.007	-.076	.661	.308
Belgium	.000	-.092	.757	.049
Ireland	N.C.	N.C.	N C.	N.C.
Europe	.087	.069	.335	.156
Senegal	.525	-.453	.388	-.063
South Africa	.019	-.162	.690	.301
Africa	.237	-.096	.237	-.056
Israel	-.232	-.257	.767	.930
Middle East	-.183	-.339	.768	.947
Japan	.108	.194	.108	.089
Far East	.041	.138	.167	.160
Australia	-.222	-.460	.151	.210
New Zealand	-.069	-.015	.339	.537
Oceania	-.519	-.545	.385	.359

N.C. = Not computed.

closely tied to the original QSI methodology and consequently suffer from some of the deficiencies noted above. The statistical limitations of this approach are evidenced by the wide variation of the citizenship factors derived for countries with similar air services and from season to season. However, the suggestion that passenger citizenship affects travel itinerary choice appears to be sound and deserves further investigation.

The IQSI methodology incorporates some modification of the original QSI weights for aircraft type and number of stages. The direction of changes from the CAB Quality of Service Index weights was to increase the relative weighting of wide body aircraft and non-stop flights. In addition, the model worked best if third country carrier's QSI ratings were reduced by 40%. The fact that changes in the QSI weights produces a better fit on predicting carrier-shares is not surprising given that the QSI model was estimated on rather old domestic data. The fact that the changes improved the predictive ability of the model only marginally indicates that more basic changes are needed if the model is to be substantially improved.

Transatlantic Route Alternatives Model

The Transatlantic Route Alternatives models were developed in 1975 by a consortium of consultants headed by Cambridge

Systematics, Inc. in order to analyze alternative solutions to the financial difficulties of U.S. carriers in the transatlantic market. The model was designed to be sensitive to the following types of air service changes: mergers, route swaps, and service cutbacks or additions by existing or new carriers. The model developed in this study is the most comprehensive international air analysis tool of those reviewed.

The Transatlantic Route Alternatives model incorporates many important improvements to the methods previously described. It uses origin and destination airline service data for 30 U.S. points and 15 European destinations. The model employs a modified QSI approach for estimating the market response to changed service. Separate sets of QSI weights were estimated for market share and stimulation (Table I.3). The Quality of Service index was expanded to account for connecting flights, lengthy transfer times and stops at congested gateways. However, variables such as travel time, fare, trip purpose, or passenger citizenship were not incorporated into the demand model, presumably because of the high cost of obtaining the basic data needed for that level of analysis.

The developers of the Transatlantic Route Alternative model recognized that the QSI, even with the improvements noted above, did not always predict route choice with high validity.

Factors not included, such as: time of day scheduling, fare differences, agreements and competition among various airlines sometimes play a very important role in shaping the distribution of air travel. In order to take these factors into account without directly estimating their individual impacts (requiring a costly reestimation of the demand model), the transatlantic route model used QSI in a modified way, called pivot point analysis. The idea behind this procedure is to let QSI determine the share of traffic for new flights but to let the distribution of existing O/D traffic retain its historical patterns. For example, an existing routing that had more than its QSI-based share of traffic in the base period will continue to have greater traffic relative to other existing routes after a service modification is made, while the new route's traffic will be equal to its share of QSI. For new routes there is no previous evidence to indicate that QSI is not the best predictor of traffic flow. The pivot point analysis procedure works best in cases where there are small changes in air service in a market. Where there is a major restructuring of air services, pivot point analysis and conventional QSI procedures produce nearly the same results.

The Transatlantic Route Analysis model also contains a financial submodel which calculates revenues and costs for U.S. carriers. Since the major purpose of the model system

TABLE I.3

Transatlantic Route Alternatives
QSI Rate Shares and Stimulation Weights

<u>Type of Flight</u>	<u>Rate Share Weight</u>	<u>Stimulation Weight</u>
Non stop	1.00	1.00
One-stop	.80	.280
Two-stop	.60	.170
Non-stop/non-stop online Transfer	.115	.090
Non-stop/one-stop online Transfer	.090	.040
Non-stop/non-stop interline Transfer	.071	.028
Non-stop/one-stop interline Transfer	.053	.020
Other	.027	.013
Penalty for Stop or Transfer at Congested Gateway	-.002	-.007
Penalty for Transfer Longer than 2 hours	-.024	-.001

was to investigate financial implications of international air service changes, the financial submodel incorporates a fairly detailed breakdown of costs attributable to air operations. The treatment is, however, somewhat uneven, as no information is presented on foreign air carriers.

One major deficiency of the Transatlantic Route Alternatives model for use as a general policy analysis tool stems from its lack of an automated interface with routing and level of service data. Flight schedules and level of service parameters were manually looked up in the printed Official Airline Guide. This is a time consuming and tedious operation. It causes the model to rely on a less complete network structure than desirable and limits the models transferability to other contexts.

All told, the Transatlantic Route Alternatives model is the closest to a complete air analysis tool. Many of its algorithms and approaches were expanded, modified or directly appropriated for the prototype International Air Analysis model, to be discussed in Chapter III.

II. INTERNATIONAL AIR TRAVEL DATA

II.1 Demand Data Base

A key element in any attempt to model changes in air travel due to changes in service offerings is a good description of travel patterns in the base period, i.e., a base period demand data base.

An adequate, while still manageable level of detail for the description of passenger trips is: origin to destination with complete itinerary.

Changes in service offerings affect the alternatives facing not only travellers over the affected segments, but also travellers whose actual itineraries don't utilize the affected segments but whose origins and destinations are such that they could shift their itineraries to the affected segments if they were made attractive enough.

CAB 10% Sample

The primary segments of interest are the international flights to and from the U.S., but the complete air itineraries of air travellers using these segments are of interest as well. The level of detail of itineraries chosen for this project is essentially that of the description in Data Bank 2A of the CAB. Data Bank 2A summarizes international air itineraries and the corresponding passenger traffic obtained by the CAB 10% ticket survey which covers 10% of all tickets lifted by U.S. air carriers.

In this report the CAB data collected in the 10% ticket survey will sometimes be referred to as the "(CAB) 10% Sample".

Reference will be made mostly to data in or derived from Data Bank 2A although other 10% sample data, primarily fare information is also available. (See Table IV for the file layout).

The primary limitation of the 10% sample from the point of view of the present project is the fact that its coverage is restricted to tickets lifted by U.S. carriers. It represents a 10% survey of all air travel in which a U.S. carrier is involved. However, in international air travel to and from the U.S. much of the travel involves no U.S. carrier and therefore is not covered by the CAB 10% sample. The primary purpose of the models being developed is to determine effects on U.S. carriers and foreign carriers of possible agreements to be negotiated with foreign countries usually involving service offerings of foreign carriers in the U.S. The determination of foreign carrier only passenger traffic is thus of great importance.

There is no source of data on foreign carrier only passenger traffic (no U.S. carrier involved) which is comparable to the CAB 10% sample for U.S. carrier involved traffic. As a consequence, the foreign carrier only traffic must be estimated using the 10% sample in conjunction with other data sources. This will be dealt with later in this section.

The international portion of the CAB 10% sample as represented in Data Bank 2A has about one million variable-length records. Each record specifies a flight itinerary and various passenger counts associated with the itinerary for the quarter and the year (more on this below). The passenger counts represent the number of tickets in the 10% sample whose itineraries had an

identical correspondence with the stated itinerary in certain specified ways.

A ticket will contribute to a passenger count for a record in the following ways:

1. The itinerary specified in the record is identical to that on the ticket.
2. The itinerary specified in the record will result if the ticket itinerary is broken according to specified CAB rules.
3. The itinerary specified by the record would otherwise correspond to the ticket if the itinerary were reversed in which case the passenger count in the record referring to the reverse direction is affected as each itinerary is represented by records in both the forward and reverse direction with each record containing (redundantly) passenger counts for both the forward and reverse direction.

The records in Data Bank 2A, as indicated, do not necessarily correspond directly to ticket itineraries. All records in Data Bank 2A correspond to at least parts of itineraries which have international segments. However, the itineraries in Data Bank 2A have been broken, where required into directional itineraries.

The procedure for breaking raw non-directional itineraries into directional itineraries are given in Vol. IX-4-1 of CAB's "Origin-Destination Survey ..."

The specification of an itinerary in Data Bank 2A, except for some details and exceptions that need not be considered here, consists of the same itinerary information which appears in an airline ticket including points of origin, destination, and transfer and also the carrier on each segment (leg) but excluding other information (times, flight numbers, dollar costs, class, etc). Thus an itinerary is schematically given thus:

airport 1, carrier 1, airport 2, carrier 2, , carrier N,
airport (N+1),

Where airport 1 represents the origin and airport N+1 represents the destination, and carrier 1, carrier 2, etc., are the carriers on distinct flights. Notably missing are any intermediate stops the plane may make (so long as the passenger does not change flights), and flight numbers on the segments.

Since the very frequently used itineraries are each represented only once, with the level of traffic on each represented by the passenger counts, while many very infrequently used itineraries are also represented, but with a passenger count of only one or two, the very large number of records in Data Bank 2A might be said to be very uneven in their useful information content.

One million records (150 to 300 characters each) constitute a file too long for repeated processing. The process by which the number of records was reduced is now described in more detail. The reduction in size is brought about in several steps:

1. Elimination of records not referring to itineraries from U.S. point to European point.
2. Merging of records with identical itineraries (airport 1, carrier 1, airport 2, carrier 2, . . .) separated on Data Bank 2A for technical reasons.
3. Elimination of records not showing a total year's passenger count of at least 3.
4. Elimination of records not showing one of a selected list of U.S. cities (plus Toronto and Montreal) and European cities as origin, destination and intermediate points.

The essential purpose and effect of these four major steps are as follows:

1. Limit the travel represented to U.S.-Europe, an obvious requirement for studying U.S. - European country negotiations. Traffic through U.S. (e.g., to South America) is eliminated, since the complication added by leaving that traffic in would be too great. In addition, redundant records showing reverse itineraries are eliminated.

2. The merging of records with identical itineraries is an obvious technical requirement.

3. The elimination of records with yearly passenger counts of only one or two passengers, serves several very important purposes. The importance can be seen by the fact that this reduction eliminates 90% of the records, but only 35 percent of the traffic. For heavily travelled origin destination pairs the effect is to remove idiosyncratic or "irrational" routes, i.e., routes which cannot enter a model of reasonable alternative routes for the OD pair. For lightly travelled OD pairs, a larger bias is introduced as the price for this great simplification. The effects of these deletions must be compensated for by adjustment factors and/or adding all the traffic back in at a later stage once the frequently used itineraries have been used to form the basic structure of the international air travel data base. The deleted traffic would be assigned to records in the data which match the raw records in important characteristics. This redistribution of deleted records has not been undertaken at

this stage of the development, but instead the correction for the deleted traffic is made by adjustment factors. The actual process currently being used will be described in Chapter III.

4. The elimination of records not representing travel between major cities was a step primarily aimed at forming the skeleton of an international air travel network as all cities on international flights between Europe and the U.S. are included. The amount of traffic that was lost by this restriction was again small compared to the simplification in the data base which was thereby achieved; however, until the traffic originating or terminating in small cities (especially in the U.S.) is reintroduced biases of a nature and magnitude difficult to estimate will be present.

The I92 Data

The second primary source of "demand data", i.e., data on what international air travel actually took place in a certain period is the I92 data collected by the Immigration and Naturalization Service on Form I92 and kept as a data base at TSC.

The I92 data base is in some ways more comprehensive and in other ways less comprehensive than the CAB 10% sample.

Its strongest point is that it has 100% coverage of all international air passenger movements into and out of the U.S. including those on foreign carriers. The traffic is broken down by carrier, flight number, U.S. port of entry or exit and foreign on-flight origin or destination and by U.S. citizen/alien. For example, a flight on a foreign carrier which originates in

Chicago, stops in Boston, and goes to Paris and Zurich would be represented with traffic counts indicating how many citizens and how many aliens boarded in the U.S. and how many passengers in each category debarked in Paris and in Zurich. The breakdown of the traffic by U.S. on-flight city is uncertain because INS reporting requirements are not strict in that regard.

The chief limitation of the I92 from the point of view of international air travel modelling is that it lacks information on the origin and destination of the passengers or where they entered the air travel network and where they left the network as there are no connected itineraries, but only passenger flows on single international flights. To the extent that accounting for connections in international air travel is important for modelling the impact of changes in service offerings, the I92 data is inadequate while the CAB 10% sample data is excellent in this regard.

It is seen that the structure of the connections of the international air network are best determined by the CAB 10% sample but that certain of the of the link flows (most especially on foreign carriers) are best determined by the I92 data base. The basic difficulties with using the I92 data in conjunction with CAB 10% data to refine the demand data base are, outside of technical problems bringing the data bases together, connected with two problems:

1. The data and coverage are most likely not exactly compatible, i.e., do not agree where their information contents overlap.
2. The missing information in the CAB 10% sample is not determined uniquely by the I92 data.

Primary responsibility for maintaining I92 as a data base resides at TSC. A monthly summary file for each month is available as a 1022 data base file which makes it easy to select flights with various characteristics (e.g., between U.S. and Europe). The information contained in each monthly summary record (about 1500 per month) include:

1. Airline
2. Flight number
3. U.S. City
4. Foreign City
5. Number of citizens carried
6. Number of aliens carried
7. Number of performances represented in this record

The key point to keep in mind for the purposes of this project is that, because of reporting requirements of the INS, the number of passengers in any category which each record associates with any foreign city is accurate, but the number of passengers associated (embarking, debarking) with U.S. cities are presently reliable only when aggregated over the U.S. For example, if there were a flight PA 999 (flight number) from Philadelphia to Boston to London to Paris and if for that flight number there were four records (for that month) associated with:

1. Philadelphia - London/PA999
2. Boston - London/PA999
3. Philadelphia - Paris/PA999
4. Boston - Paris/PA999

Then the passenger count as broken down by Boston and Philadelphia may not be reliable, but if Boston and Philadelphia are added together the sums are reliable. Thus the total number of U.S. citizens from Boston or Philadelphia to Paris on PA999 could be obtained by adding the number of citizens from the Philadelphia/Paris/PA999 record to that for the Boston/Paris/PA999 record.

II.2 Supply Data Base

The OAG DATA

The third major source of data, and for the project an essential one, is the Official Airline Guide. This data, from the same source as the printed version used for passenger reservations but in computer readable form, constitutes the "Supply data base". Information is given on all U.S. domestic and international flights on scheduled airlines, the frequencies, departure times, arrival times, equipment types as well as the ports-of-call.

These data are essential in order to determine the competitive alternatives to hypothetical new service offerings (or deletions) the impacts of which the model seeks to determine. These data are also essential for determining the proper connections and are needed to complete the characterization of the level of service provided by new service offerings. THE OAG data thus enables the construction of a set

of level of service characteristics of any hypothetical changes in international air services and of level of service characteristics of competing existing alternatives.

In Section III.1 on the supply model, the process is given, for determining QSI (Quality of Service Index) values from the OAG data combined with certain information derived from the demand file. The OAG is used not only to determine frequencies and equipment types but even what connections are possible.

The OAG data base contains all the data elements in printed version of the OAG. Both international and domestic flights are included. Thus best connections from any U.S. city to any European city can be determined on the basis of timing, equipment type, airline, stops, etc. All these factors enter the process of determining best connections and quality of service (QSI) values.

The OAG data is maintained at TSC in an automated 1022 data base. Such a data base can be used to easily create derivative files of various sort structure. The basic 1022 file is a flight stage file; that is each record represents a single stage or leg of a flight. The file may be easily sorted by flight number and cities to determine which cities are connected by which through flights. Determining efficient connections of flights requires further processing but the information required is in the records, namely in each record the following is included:

1. Departure city (and airport)
2. Arrival city (and airport)
3. Departure time
4. Arrival time
5. Flight number and carrier
6. Frequency (days operating each week)
7. Effective dates

Other information is also present most notably

8. Equipment type
9. Class of service
10. Latitudes and longitudes

Table II.1 shows the field names in the records, there are 17,000 records.

Only those records involving flights connecting cities from the the selected cities list (Table III.1) and for which at least one of the cities is in the U.S. were selected for use in the initial model reported on here.

The details of processing the OAG data will be discussed in Section IV.3.

II.3 "Foreign Carrier Only" Traffic

The same "demand model" which apportions traffic according to the competing level of service, i.e., "supply" characteristics can be applied to estimate missing elements of the demand data from other elements of the demand data together with elements of the supply data. Thus the OAG information enables one to compare levels of service for routings which involves U.S. carriers to those for routings which do not involve U.S. Carriers and thus to estimate the unknown traffic on the latter routings from traffic on the former routings which is known from the CAB 10% sample.

OAG Record Layout

OAG Field Names and Field Numbers

Here is a listing of OAG field names, their associated field numbers, and the format of each word.

Field Nr -----	Field Name -----	Format -----
1	Leave world Area Code	I
2	Leave Airport	A3,2X
5	Arrive World Area Code	I
6	Arrive Airport	A3,2X
7	Arrive Time (Local)	A4,1X
8	Plaq Code	I
9	<u>Arrive Time (GMT)</u>	A4,1X
11	Equipment Code	A3,2X
12	ILLEGAL FIELD NUMBER	
13	Carrier	A2,3X
14	Flight Number	A5
15	ILLEGAL FIELD NUMBER	
16	Class of Service	A5
17	Frequency - word 1	A5
18	Frequency - word 2	A2,3X
19	Suppress Code	A1,4X
20	ATIS Code	A1,4X
21	Elapsed Time	A4,1X
22	Effective Date	A4,1X
23	Discontinued Date	A4,1X
24	Leave Latitude	I
25	Leave Longitude	I
26	Arrive Latitude	I
27	Arrive Longitude	I

As a result foreign carrier only traffic can be estimated from the CAB 10% sample data together with the OAG data. Such estimates provide also the needed routing structure. These estimates lead to link loadings on international flights (sometimes referred to as "water legs" of international flight itineraries) of foreign carriers. These passengers loadings on foreign carrier flights to and from the U.S. can be compared to similar figures reported in the I92 data. The obvious correction is to multiply the estimated traffic on various routings by factors which will make the total Transatlantic travel on foreign carriers, at some level of aggregation agree with the I92 data. It would seem best to use a separate factor for each carrier and each "market", i.e., for all flights that are on a given foreign carrier and depart a given last U.S. city enroute to a given foreign city. The traffic on that leg according to I92 would be aggregated (over flights and over the CAB reporting period) and used to determine a factor by which to multiply associated flights such that the total traffic over the flight leg for the carrier according to revised estimates would match the I92 totals.

In actuality, a single factor was developed over all foreign carriers and all markets, i.e., a single foreign carrier factor, as a simplification for the current implementation in line with other simplifications in the current model and demand data base.

III. INTERNATIONAL AIR ANALYSIS MODEL - OVERVIEW

In this chapter, a brief overview of the major components of the International Air Analysis model is presented. Subsections deal with the Supply Generation models, the Demand Model and the Financial Impact and Report Generation Models. The overview focuses on the overall flow of the computer system, major data requirements and algorithm interpretations. Later sections explore each specific routine in more depth, and the appendix contains the actual code.

III.1 Supply Model

The basic function of the International Air Model's supply component is to define North Atlantic air service routings and to develop the level of service information necessary to support the demand model analysis. The steps included in this procedure include:

- a) definition of the International air service routings and appropriate connecting itineraries between major traffic generators on either side of the Atlantic;
- b) calculation of origin/destination level of service parameters; and
- c) calculation of the Quality of Service indices for each service itinerary.

Definition of the Air Service Network

The International Air Analysis model employs an air service network which includes the cities listed in Table III.1. These cities are the major generators of air traffic in the North Atlantic market. They consist of all of the major air service gateways and downstream points that existed in the third quarter of 1977, and also include most potential gateway cities. In cases where multiple airports are part of a metropolitan area, air service to each airport is separately recorded.

The international air service network is defined in terms of flight combinations which connect many of these points across the Atlantic. In the Air Service Network, two points are connected if they satisfy either of the following criteria:

- a) They are steps along the route of an international flight; or
- b) sufficient¹ base year traffic uses a connecting flight itinerary between the points.

In the context of the International Air Service model,
"sufficient base year traffic" means that the pair of cities are listed as an origin and destination in at least one demand file record.

TABLE III.1

Cities in the International Air Network

<u>U.S. Cities</u>	<u>European Cities</u>
Atlanta	Amsterdam
Baltimore	Athens
Boston	Berlin
Chicago	Brussels
Cleveland	Cario
Dallas/Fort Worth	Copenhagen
Denver	Cologne
Houston	Dublin
New Orleans	Frankfort
Los Angeles	Geneva
Miami	Glasgow
Kansas City	Hamburg
Minneapolis/St. Paul	Istanbul
New York	Lisbon
Philadelphia	London
Phoenix	Luxembourg
Pittsburgh	Madrid
St. Louis	Manchester
San Francisco	Milan
San Juan	Munich
Seattle	Nice
Tampa	Oslo
Washington	Paris
Montreal	Rome
Toronto	Shannon
	Stockholm
	Tehran
	Tel Aviv
	Vienna
	Warsaw
	Zurich

The cities may be, and are in general, connected by multiple routings, i.e., there are usually many paths among which travelers may choose in making international air travel routing decisions. It is important to note that the model distinguishes between otherwise identical routings where only air service carriers differ.

The air service network between any two points generally consists of direct flights, on-line connections and interline connections. Because there are so many possible combinations of connecting flights to each international flight it is not feasible nor advisable to separately specify every one. Instead the actual distribution of connecting flights is approximated by the single most logically traveled connecting flight. The following algorithm is employed:

- A.) For every pair of cities which have connecting air service;
- B.) For every international flight which is part of a connecting flight itinerary;
- C.) Select the single direct service connecting (feeder/distribution) flight which best satisfies the following criteria:

- 1) The connecting flight is scheduled at least as frequently and on the same days as the international flight.
- 2) Total travel time is the minimum for all possible connections, except that on-line connections are favored over interline connections for travel times which are as much as 2 hours longer.
- 3) No connections can be made in which the separation between connecting and international flights is less than the minimum transfer time for that airport and type of connection.

Although some proportion of the total traffic undoubtedly uses a feeder/distributor connection other than the one identified by the above procedure, this method has proved to be a sufficiently precise approximation (especially given that the current Quality of Service demand model is only roughly sensitive to distinctions between types of connections).

If an improved demand model were to be employed, e.g., one which was sensitive to travel time differences, then a more exacting procedure for selecting connecting flights would be developed. Possible improvements might include selecting the "best" set of connecting flights or picking the "best" connection for each day that the international flight was scheduled.

Calculation of Origin/Destination LOS Parameters

Once the identification of all flights which compose connecting as well as direct flight itineraries has been completed, the next stage of the analysis is to determine the level of service for origin to destination routings. Level of service information which is currently calculated by the International Air Analysis model includes the following variables:

- 1) Total O/D travel time
- 2) Transfer time at connecting airports
- 3) Number of on-lines and interline connections
- 4) Number of intermediate stops
- 5) Flight frequency
- 6) Aircraft type used on each trip leg
- 7) Airports visited
- 8) Carriers on each trip leg

The total transit time is calculated from the departure of the first flight at the trip origin to the arrival of the last flight at the destination. Transfer time at connecting airports does not include ground time at intermediate stops, however, this quantity may be calculated from the previous two variables. Sometimes aircraft are switched at intermediate stops along a flight without changing the flight number; this is counted as an on-line connection. The flight frequency is the number of

scheduled flights per week taking the same itinerary. If a flight itinerary is modified on some days of operation, then subflight categories are identified and flight frequency is recorded for each. Although the demand model does not currently use days of operation or departure and arrival times, if needed for future applications, these data can be calculated without significant modification to the computer code. The last data vector - the airports visited along a flight itinerary - is used to specify whether a flight itinerary is subject to delay due to congestion at heavily traveled airports.¹

Although the International Air Analysis demand model does not now use fare information to either estimate traffic stimulation or routing share, the sources of the basic data for these analyses have been identified. First class and economy fares are printed and can be readily determined for most itineraries. Discount fares are available in only a limited number of markets, so that full fare connecting flights must sometimes be taken in order to make a connection to a low fare flight. The most important information with regard to routing choice is to identify in which itineraries fares are higher than the standard rate; an itinerary must be circuitous by a significant amount before a higher fare is charged. For stimulation average fares for a market are needed.

¹ Congested cities are New York, Chicago, Los Angeles, Atlanta, London and Paris.

Quality of Service Index Calculations

The origin/destination level of service information is used to calculate the Quality of Service Index for each routing in each transatlantic market. The QSI is calculated by employing the weights presented in Table III.2. The first column contains the information for market share analysis and the second column is used to calculate QSI values for determining stimulation. The use of these indices is explained in the next section: Demand Analysis.

The weights for each of the indices were obtained without modification from the Transatlantic Route Alternatives Analysis Model. The reader is referred to the documentation of that model for a thorough explanation of the derivation of these weights. Briefly, the way the route QSI value is calculated is to first determine in to which category the origin/destination flight itinerary best fits. The seven categories consist of different combinations of connection types and

number of stops. From this value is subtracted a constant amount if the itinerary passes through a congested city or has a transfer time greater than 2 hours. The resulting factor is multiplied by the weekly flight frequency and by an aircraft type adjustment. The aircraft factor refers only to the equipment used over the water leg flight segment. Aircraft weights are:

<u>Aircraft Type</u>	<u>Weight</u>
747	1.69
DC10	1.34
707	1.00
Concord	1.00 ¹

New Services

In the case of new or modified service the same basic procedure is repeated with one major alteration. Because no traffic history exists for proposed new flights, the points that connect to the new flight cannot be identified from the data, as before. Instead, a new international flight is said to connect to any gateway city if:

¹This number was estimated as this aircraft type was not included in the original study

A) Any existing international flight traveling on the same water leg as the new flight has a connection in the base network at that city; and/or

B) The analyst specifies that connection should be made for that gateway city.

It is important to note that new service may indicate deletions and modifications to existing flights as well as additions of new flights. In all cases the origin/destination level of service and Quality of Service Indices are calculated in the same fashion as for existing service.

III.2 Demand Model

As explained in the previous section, the data in the OAG data base is combined with information on actually used connection points from the demand data base to produce the basic supply file, QSII. QSII contains: for each international flight, for each OD pair served by that international flight, (either directly or through connections), two quantities, the market share QSI and the stimulation QSI. These characterize the level of service between the given origin and destination using the given international flight. Thus if there is a certain international flight, say AFXXX between New York and Paris which is used by passengers going from Detroit to Geneva, there will be a record in QSII specifying two numbers as the QSIM and QSI (QSIM for market share and QSI for stimulation) for the service between Detroit and Geneva using AFXXX for the intercontinental segment. These QSI level of service numbers are based on "best connections", that is are calculated on the basis of the best (according to criteria stated in Section III.1) connecting flight from Detroit to New York to meet AFXXX, etc. In Section III.1 the factors which currently enter these QSI numbers were specified; it should be recalled that they depend on the flights used and airports used and such factors as flight frequency, equipment type; number of changes of flight and carrier, etc. The concern in this section is the use of these QSI numbers to predict changes in travel as

a result of changes in services as reflected in the QSI numbers, but the methodology is independent of how the QSI numbers are obtained.

The fundamental assumption of the demand model is that estimates of traffic stimulation and diversion are to be calculated using ratios of QSI values. For example, if the portion of traffic between two cities which uses one itinerary vs. another is unknown it may be estimated to split according to the ratio of QSIM's.

Whenever the demand data base already contains an estimate of the relative attractiveness of two or more itineraries this estimate is not to be altered by the model; rather the model preserves as far as possible the distribution of traffic among alternatives represented in the base year situation, but estimates the share of traffic that a new flight, for example, would attract in each OD market based on its share of the QSI in the market.

The detailed program description of the demand model module is given in Section IV.2 but a basic description is given here of the procedures and algorithms. The changes in traffic due to a new scenario are to be determined. For example, a scenario may be described by one or more international flights being added or deleted or altered in characteristics. For

each flight so changed (or added), supply records are generated for all OD pairs affected (directly or indirectly, through connecting flights) similar to those described just above in the QSI1 file. Being generated for each OD pair which is expected to use the affected flight, these (QSI2) are numerous, but not so numerous as those in QSI1 which refers to all actual flights in the base period rather than to the few affected flights.

The demand model module calculates the effects of the changes in service, as specified in the scenarios, on each OD pair in turn as follows:

1. select an OD pair
2. see if any QSI2 records (giving the altered QSI values) refer to the OD pair. If any do then,
3. for each QSI2 record referring to an international flight find any corresponding QSI1 record referring to the same international flight, (same flight number and same carrier)
4. for those records in QSI2 which match records in QSI1 (by flight number, carrier, and water leg) form $\Delta QSIM$ and $\Delta QSIS$. $\Delta QSIM$ is the difference between the corresponding values in the QSI1 and QSI2 records, i.e., $\Delta QSIM = QSIM \text{ as specified in QSI2} - QSIM \text{ as specified in QSI1}$ in the record corresponding to the same flight.

5. The QSI records (supply data base) are by flight but the records in the demand data base, being derived from the CAB 10% Sample, are more aggregate in the sense that flight numbers are not distinguished but only carriers on segments are (See Section II.1). In another aspect there is the possibility of more detail in the demand data base in that, unlike the supply data base (QSI file), several itineraries corresponding to a single OD pair - water leg - water leg carrier combination are possible. Consequently at this stage the QSI values from the supply file and the traffic counts from the demand file are aggregated over each water leg - water leg carrier combination for the subject OD pair (QSI values are also so aggregated).
6. Now the element of interest are the water leg - water leg carrier combinations - e.g., NYC/PAR/AF which are used by traffic between the OD pair being worked on. Let these elements be called water legs for short even though a specification of carrier is included, so that two distinct water legs can be between the same cities if the carriers are different. Index the water legs (so generalized) for the OD pair by i . Let the QSIM value from QSI1 for the i th water leg be designated by $QSIM_i$.

This is the sum of the QSIM value from all records from file QSII which correspond to the given OD pair and to the water leg i . Similarly there will be a $\Delta QSIM_i$ which is also a sum of $\Delta QSIM$ values over the water leg i . Also $QSIM_i$ and $\Delta QSIM_i$ are similarly calculated. Let the total traffic in the demand file on water leg i be denoted by T_i .

7. Now the traffic diversion and stimulation estimates can be calculated. First the primary algorithm and then a variation on it which improves the accuracy will be described.

Let the total traffic between the OD pair as represented in the demand file be denoted by T .

$$\bar{T} = \sum_{i=1}^N T_i$$

assuming these are N water legs connecting the OD pair. First some equations for traffic diversion and stimulation will be given and then a discussion will follow. First consider diversion:

$$\text{Let } \bar{Q} = \sum_{i=1}^N (QSIM_i + \Delta QSIM_i)$$

Then: if $\Delta QSIM_i \geq 0$

$$\Delta T_i = \Delta \frac{QSIM_i}{\bar{Q}} \cdot \bar{T} \quad (\text{eq. 1})$$

while if $\Delta QSIM_i < 0$

$$\Delta T_i = \frac{\Delta QSIM_i}{QSIM_i} \cdot T_i \quad (\text{eq. 2})$$

In either case (as in combination cases):

$$T_i' = T_i + \Delta T_i \quad (\text{eq. 3})$$

$$T_i'' = T_i' \frac{\bar{T}}{\sum T_i'} \quad (\text{eq. 4})$$

Now consider stimulation:

$$\text{Let } \rho = 1_i + 1.71 \ln \left(\frac{\sum (QSIM_i + \Delta QSIM_i)}{\sum (QSIM_i)} \right) \quad (\text{eq. 5})$$

Then:

$$T_i^{\text{new}} = T_i'' \cdot \rho$$

The stimulation aspect is simple to describe. T_i'' sums to the same total traffic as T_i ; therefore a simple stimulation factor may be applied to give the final traffic, all water legs for the OD being assumed to have the same stimulation factor. The stimulation factor ρ is a function of

$$\frac{\sum_{i=1}^N \Delta QSIM_i}{\sum_{i=1}^N QSIM_i}$$

the functional form in equation 5 is taken from Ref.1:

The market share or diversion aspect is slightly more complex in execution but very similar in concept. A distinction must be made between routes for which the QSIM increases and those for which it decreases. In order to avoid singularities the rule is: when the QSI on the route increases the traffic on the route increases by a proportion of the total OD traffic which is just the proportion of the increase in QSIM on the route ($\Delta QSIM_i$) to the total final QSIM on the OD pair ($QSIM_i + \Delta QSIM_i$). The requirement leads to equation 1 (when combined with equations 3 and 4). However, when the QSIM_i of a route decreases (such as when a flight is deleted) the decrease should be a fraction of the base traffic on the route, T_i . The fraction by which it decreases is the proportion by which the QSIM on the route is decreased i.e., $\Delta QSIM_i / QSIM_i$. After this decrease all traffic must be changed by one multiplier to bring the total back to \bar{T} prior to applying the stimulation factor; hence equation 2 (combined with equations 3 and 4).

Some reflection shows that equation 1 is not suitable for the decreasing QSI situation (since then for example the estimated new traffic could fall below 0) nor is equation 2 best for the increasing QSI situations (since for example

Ref. 1. Transatlantic Route Alternative Report, Cambridge Systematics, 1975.

a new service may open a route for which no service existed before so that there was no base traffic in the route). Consequently, the two cases are treated differently, but as defined in equations 1 through 4 the two cases may be consistently combined to estimate market shares for routes when some have their QSIM increased and others have theirs decreased.

The traffic having been stimulated and reassigned to the water legs according to the above method, the water leg traffic must be assigned back to itineraries which are in the form of demand file records.

The demand file records in accordance with the CAB10% sample data from which they are derived express itineraries at a level of detail described in Section 7, i.e.,

city₁/carrier₁/city₂/carrier₂/
city₃/carrier₃/ " "

The new traffic (the resultant not the change) on each water leg is assigned to the corresponding demand file records (those whose OD and water leg match) in proportion to their old traffic.

Traffic on water legs not previously represented in the demand file has its traffic assigned to newly generated demand file records.

The improvement alluded to earlier in this section is quite simple to incorporate. It addresses the problems that arise from the fact that even in the base case the traffic amounts on various routes may be proportional to the total computed QSI's on these routes. For example, sizeable QSI values may be calculated for routes which are never actually taken or low QSI values may on occasion crop up for heavily travelled routes. The latter is an anomalous situation which must be corrected in some cases. These situations should be rare but a simple expedient helps correct the problem where it exists and probably improves the results even where there is no gross discrepancy.

The idea is that traffic share is to be proportional to QSI share. So in computing the total QSI for the OD pair one considers a QSI to traffic ratio computed with a weighting factor of QSI times traffic and then multiplies this factor times total traffic. The weighting factor, QSI times traffic, tends to weight more heavily the cases where QSI and traffic are proportional. Thus in place of

$$\bar{Q} = \sum_{i=1}^N QSI_i$$

we take:

$$\bar{Q}' = \frac{\sum_{i=1}^N (QSI_i)^2 T_i}{\sum_{i=1}^N QSI_i T_i} \cdot \sum_{i=1}^N T_i$$

Consider the following case:

Hypothetical case 1

i	QSI_i	T_i
1	.01	1000
2	1.5	1500
3	3.0	2700

$$\bar{Q} = 4.51$$

$$\bar{Q}' = 5.70$$

Hypothetical case 2

i	QSI_i	T_i
1	10.0	10
2	1.5	1500
3	3.0	2700

$$\bar{Q} = 14.5$$

$$\bar{Q}' = 4.99$$

In the first case the formula in effect decides that route number 1 should have had a QSI of about 1 in line with its traffic. In the second case it effectively decides that the

QSI of 10 for the first route is also out of line with its traffic, but in this case it estimates that QSI of the first route must be decreased.

The recalculated value of \bar{Q}' for the estimated total competing QSI on the route is to be used with $QSIM_i$ and the resulting \bar{Q}' substituted for \bar{Q} in equation 1. The same expression is to be used, but now with $QSIM_i$ to determine $\sum_i QSIM_i$ for equation 5. The quantity $\sum_i \Delta QSIM_i$ in equation 5 is not changed when using this correction.

III.3 Financial Impact Assessment

The financial model for allocating revenues and expenses of passenger aviation has three main purposes:

1. to allocate revenues among specific carriers and flights
2. to allocate costs among various cost categories for specific flights, or specific carriers, or all carriers
3. to compute load factors and revenue/cost ratios.

The program first reads in flight and passenger origin-destination data obtained by allocating carrier origin-destination estimates among appropriate flights by use of the QSI index. From this, it obtains, for each flight, the flight route and link distance, block times, and passenger loading for each link. It then combines this information together with cost and revenue parameters obtained by aggregating Form 41 data¹ by carriers to obtain the final output; an estimate of load factors, revenues, cost breakdowns among various categories, and revenue/cost ratios, for individual flights and carriers.

The passenger data is obtained by a model of passenger demand (peak quarter) and flight activity for a given carrier and origin-destination pair. As this model covers international flights, not domestic, the resulting link loadings will also reflect international passengers only, which

¹Form 41 data and allocation criteria are

must be borne in mind when interpreting the results for domestic legs of flights. Because of this the carrier summaries are arranged to show only the over-the-water leg for each flight.

The revenue and cost categories shown in the financial tables (and, as shown in parentheses following each category below, the link loading values on which they depend) are:

load factors

passenger revenue (revenue passenger-miles)

total revenue (passenger revenue)

aircraft direct operating cost (block time)

cabin crew cost (block time)

aircraft and traffic service cost (constant)

reservations and sales cost (passengers)

passenger commissions (passengers)

cargo commissions (passengers)

advertising and publicity expense (passenger revenue)

incidental passenger expenses (revenue passenger-miles)

general and administrative expenses (other expenses)

total costs

total revenue/total costs

Financial data are presently not available for foreign carriers. Therefore, for those carriers, route structures, link passenger loadings, and load factors are computed, but no financial descriptions.

IV. INTERNATIONAL AIR ANALYSIS MODEL - COMPUTER PROGRAM DESCRIPTIONS

IV.1 Creation of the Demand Data Base

Overview

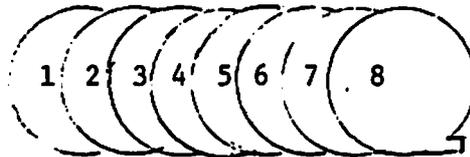
Step 1: From eight CAB Data Bank 2A tapes (3rd quarter 1977, 3Q77) containing 944,000 records, select all records with the directional origin in the "Greater U.S." (or US, defined as North and South America) and directional destination in "Greater Europe" (or EUR, defined as Europe including Western Russia, Africa, the Mideast, Afghanistan, India, Sri Lanka). See Appendix A for associated World Area Codes. Translates from ECBDIC/packed decimal to ASCII. Outputs 187,000 records to PT43: TAPE1.DAT, TAPE2.DAT, ..., TAPE8.DAT. Also outputs for further analysis various traffic counts by directional origin city on corresponding DOC1.DAT, ..., DOC8.DAT. Uses TSCLIB utilities MAGTAP, EA.MAC, PAKDEC.MAC.

Step 2: Reads PT43:TAPEn.DAT files and merges data over ticket origins/destinations. Converts eight 3Q77 traffic counts to: three inbound (towards U.S.) 3Q77, three outbound 3Q77 and one total annual, CY77, traffic counts. (Actually, calendar year 1977 is a misnomer as it refers to the 4th quarter of 1976 and 1st three quarters of 1977). Outputs 18,000 records with CY77 traffic greater than to PT52: AFILE.DAT and 140,000 records with CY77 traffic of two or less to PT43:BFILE.DAT. Output is reformatted to reduce record length. Also outputs various traffic counts to PT52:CFILE. Note that traffic counts represent 10% of actual travel.

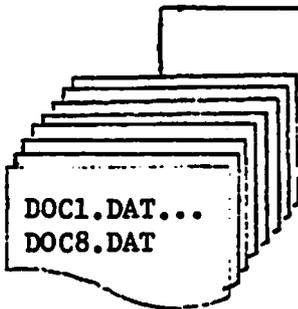
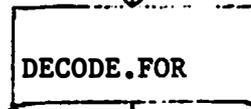
FIGURE IV.1

DEMAND DATA BASE PROCESSING

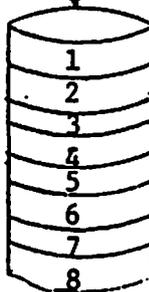
STEP 1



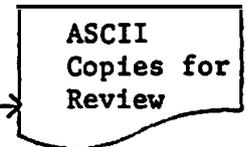
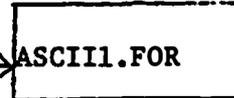
Data Bank 2A
944K EBCDIC/
Packed Decimal recs.



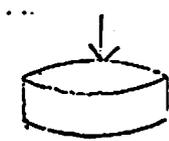
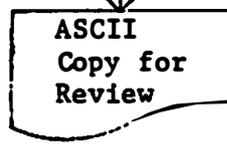
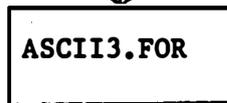
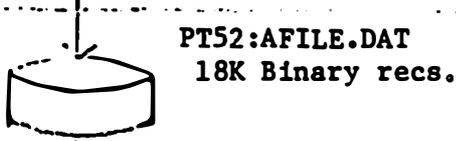
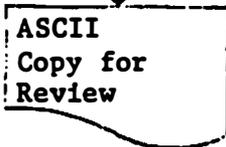
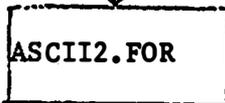
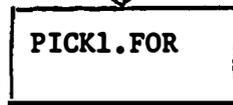
ASCII Files



PT43:TAPE1.DAT...TAPE8.DAT
187K Binary recs.

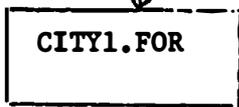


STEP 2

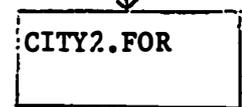


PT43:BFILE.DAT
140K Binary recs.

STEP 3



PT52:HFILE.DAT
ASCII File



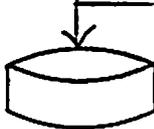
PT52:HFILE.DAT
ASCII File

FIGURE IV.1 (CONT'D)

STEP 4

1

GATE.FOR



PT52:EFILE.DAT
8K Binary Image recs.

STEP 5

PICK2A.FOR



DSKA:COUNT.DAT
Binary File

PICK2B.FOR

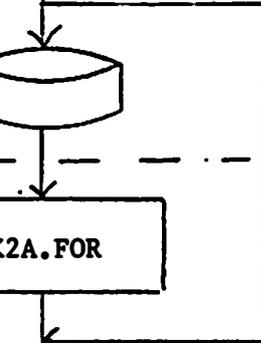


PT52:FFILE.DAT
6K Binary Image recs.



PT52:GFILE.DAT
2K Binary Image recs.

2



Step 3: Examines AFILE and outputs traffic counts by directional origin/destination (O/D) city pairs to PT52:HFILE.DAT (U.S. origins) and PT52:HFILE2.DAT (Eur. origins). Data are used for further analysis.

Step 4: Reads AFILE and skips all records with:

1. over five segments
2. directional O/D cities not on a list of 58 US and Eur cities
3. incomplete transatlantic (water leg) data
4. just foreign carriers

Outputs 8,000 records to PT52:EFILE.DAT reformats output..

Also outputs sample records to DSKA:EMIN12.DAT.for further analysis.

Step 5: Reads EFILE and calculates total CY77 traffic for each water leg (defined by gateway city numeric, airport designators, and segment carrier). Multiplies all 3Q77 traffic counts by 10. Outputs 6,000 records with water legs having total CY77 traffic greater than five to PT52:FFILE.DAT and the remaining 2,000 records to PT52:GFILE.DAT.

Step 6: Reads PT52: ODRTE1.DAT, ODRTE2.DAT, (containing August 1977 Official Airline guide flight data and discussed in Section IV.3, Supply Models) and FFILE, and creates new FFILE records representing itineraries with just foreign carriers. Outputs, using the FFILE format, 1,300 records with just U.S.- EUR traffic to PT52:INTRM1.DAT and 1,300

records with just EUR-U.S. traffic to INTRM2.DAT.

Adds INTRM1 and INTRM2 to FFILE.

Step 7: Reads FFILE and skips records not having water legs (defined only by city numerics and segment carriers) listed in PT52:ZPFILE.DAT (production discussed at length in KHL-TSC-78-1620, "Air Analysis Project: Pre-Processor and Report Manual". Outputs 18,000 records to PT52: FFILE.DAT.

Detailed Description of Steps:

Step 1: Selects and Translates CAB Data Bank 2A Records

A. Input:

Eigh 800 BPI tapes toalling 944,000 records in EBCDIC and packed decimal code. Variable record length: 141-509 eight-bit bytes. Block length is 145-5000 eight-bit bytes. Standard IBM lables. File contains detailed itinerary descriptions including cities, airports, carriers, distance, and coupon data plus US-EUR (outbound) and EUR-US. 10% traffic counts for the third quarter of 1977 and the three preceding quarters. Unit of record is the individual itinerary half created by breaking round-trip itineraries found in CAB Data Bank 1. File is sorted by directional O/D city numeric. Record format is per Table IV.1. Original tapes and copies are stored:

TABLE IV.1
CAB File 2A Formats

Field Name	Justfield	Start Position	Field Length	Data Type	Data Representation	Data Description
1 Record Length	R	1	2	N	B	Total # bytes in record
2 Filler	-	3	2	N	B	Zeros
3 Year of Report	R	5	2	N	E	Eg. 77 for 1977
4 Qtr. of Report	-	7	1	N	E	Contains 1, 2, 3, or 4
5 Ticket Origin City Alpha	-	8	3	A	E	3 Letter City Code
6 " " " Numeric	R	11	3	N	P	A numeric code corresponding to the alphabetic city spelling differentials among airports of multi-airport cities
7 " " " Airport	-	14	1	N	P	
8 " " " World Area Code	-	15	2	N	P	3 digit code (see Figure)
9 " Destin. City Alpha	-	17	3	A	E	See Field 5 description
10 " " City Numeric	R	20	3	N	P	" 6 "
11 " " " Airport	-	23	1	N	P	" 7 "
12 " " World Area Code	-	24	2	N	P	" 8 "
13 Outbound Passengers Current Quarter	R	26	4	N	P	Number of passengers on routings with a foreign point, departing the <u>directional</u> origin with the itinerary in this record
14 " " 1st prev. qtr	R	30	4	N	P	
15 " " 2nd " "	R	34	4	N	P	
16 " " 3rd " "	R	38	4	N	P	
17 Inbound passenger current quarter	R	42	4	N	P	See fields 13-16 description
18 " " 1st prev. qtr.	R	46	4	N	P	"
19 " " 2nd " "	R	50	4	N	P	"
20 " " 3rd " "	R	54	4	N	P	"
21 Directional origin city name	L	58	30	A	E	City name spelled out
22 Direction origin city destination	L	88	20	A	E	"
23 Online Distance	R	108	3	N	P	Direct dist. between directional origin/dest. cities in miles
24 Survey Designator	-	111	1	A	E	D=domestic, I=international
25 Online carrier	-	112	2	A	E	if some carrier for all segments, then = 2 letter carrier code, else = 99 number of points on routing after directional origin
26 # of Coupon Segments	R	114	2	N	P	
27 Directional origin city alpha	-	116	3	A	E	See field 5 description
28 Filler	-	119	1	b	E	
29 Direct. origin city numeric	R	120	3	N	P	See Field 6 description
30 Direct. origin airport	-	123	1	N	P	" " 7 "
31 " " World Area	-	124	2	N	P	" " 8 "
32 Downline Carrier	-	126	2	A	E	2 letter carrier code
33 Downline Coupon Type	-	128	1	A	E	" if same as previous segment
34 " Distance	R	129	3	N	P	See note 2. Direct mileage between this and previous city
35 " City Alpha						See Field 5
36 " Online Break point						See note 3
37 Downline City Numeric						See Field 6
38 " " Airport						See Field 7
39 " World Area						See Field 8

Notes 1, 2, 3 are found in the Patahask 2a Master File Description, Appendix A.

Archive Tape #	Copy Tape #	Directional Origin City	
		From	To
AM 1783	A1783C	AAL	CAI
AM 1787	A1787C	CAI	ELP
AM 1781	A1781C	ELP	LOS
AM 1788	A1788C	LOS	MEX
AM 1782	A1782C	MEX	JFK
AM 1784	A1784C	JFK	ANV
AM 1785	A1785C	SKB	TPA
AM 1786	A1786C	TPA	ZRH

Notes: 1 no record gap

2 For city name associated with alpha codes see
Official Airline Guide

B. Output:

1. Eight files: PT43: TAPE1.DAT, TAPE2.DAT, ..., TAPE8.DAT
totalling 187,000 binary records in ASCII compatible code.
Records are variable length, 42-234, 36-bit binary words
representing 31-223 fields ordered the same as the input tapes.
Note that fields 1-4 of the input records are not output. Set
of files contains only those records selected per the below
process. PT43 is an RP06 disk pack with 290,000 useable blocks
(of 128 36-bit words each) of storage.

2. Eight files: PT52:DOC1.DAT, DOC2.DAT, ..., DOC8.DAT
in ASCII. Reports giving:

a. 3Q77 inbound and outbound traffic counts CY77 inbound
and outbound traffic counts by directional origin
city.

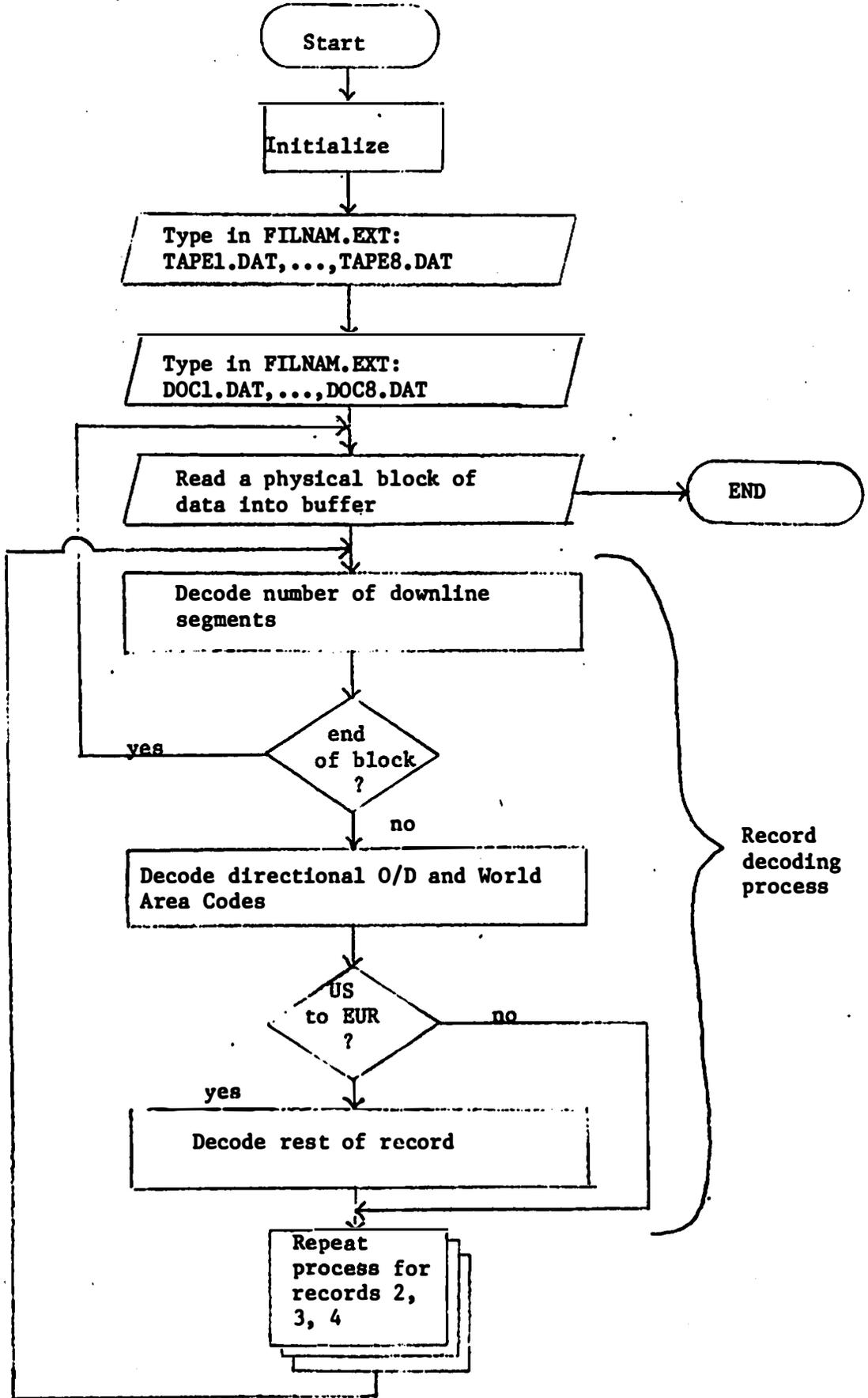
- b. record counts on different levels of CY77 traffic
- c. various other block and record counts.

For further information see Figure IV.2.

C. Process:

Program DECODE.FOR uses the TSCLIB utility, MAGTAP, to read physical blocks of the specified DB2A tape into a large array at four 8-bit bytes per word, zero filled right. Using the TSCLIB utility, PAKDEC.MAC, the bits indicating the number of downline segments in the first record are decoded from packed decimal and the record length calculated. Next, the directional O/D world area codes (WAC) are decoded. If the record does not represent an itinerary from the "greater U.S." to "greater Europe", then the record is skipped. Otherwise, the record is decoded using PAKDEC and the TSCLIB utility, EA.MAC (for EBCDIC values). For details on TSCLIB utilities see the system file, TSCLIB.MEM. Various counters for the report file are changed. Technical note: the fixed portion of DB2A records is 31 4-byte words long plus one extra byte. Each of the variable segments has four 4-byte words. Therefore, byte positions vary for identical fields within four-record sets. E.g., within the program input buffer, the byte representing the number of downline segments is the 2nd set of eight bits in

EBCDIC/PACKED DECIMAL DECODING PROGRAM



its word for record one, the 3rd set in record two, the 4th in record three, and the first in record four. Therefore, the program handles four records per loop. When the entire program buffer has been examined, a new physical block of tape is read, until the file is exhausted.

The process is performed using: EXECUTE DECODE.FOR,SYS: TSCLIB.REL/LIB and typing in the two output file names when prompted. When the end routine is performed, certain totals in the report file will also be typed out. Since the output is in binary code, it must be processed by program ASCII1.FOR into ASCII code for visual checking.

DECODE.FOR can be modified for different definitions of "greater U.S." and "greater Europe", or other regions, by changing the world area code constants in each of the four major sectors of code. See starred statements in listing.

Step 2: Merges records over ticket O/D cities, deletes full spellings of directional origins/destinations, summarizes traffic counts, reformats output.

A. Input:

Eight files: PT43:TAPe1.DAT,...,'TAPe8.DAT of 187,000 binary coded records in the format detailed in Figure 2, excepting fields 1-4.

B. Output

1. PT52:AFILE.DAT, 18,000 binary coded records with total CY77 traffic ≥ 3 , in the format shown in Figure IV.3.

2. PT43:BFILE.DAT, 140,000 binary coded records with total CY77 traffic < 3 , in the same format.

3. PT52:CFILE.DAT, binary coded output listing summarized traffic counts for records assigned to AFILE and BFILE, by directional O/D city pairs.

C. Process:

Program PICK1.FOR reads the eight TAPEn.DAT fields in the order specified in its data statement. This insures that records are sorted by directional O/D ticket O/D. For each directional O/D city pair (defined by city numeric and airport designator) data are merged over ticket O/D's and traffic counts are made for:

3Q77	inbound	(U.S. to EUR)	US/US tickets	
"	"		EUR/EUR	"
"	"		other	"
"	outbound	(EUR to U.S.)	US/US	"
"	"		EUR/EUR	"
"	"		other	"

CY77 total in/out bound

Records with total CY77 traffic ≥ 3 are output to AFILE, the rest to BFILE. Upon a change in directional O/D pair, total counts in those seven categories, disaggregated by

FIGURE VI.3

A&B File Formats
Contents

Field

1	Directional Origin City Alpha Numeric
2	" " " Numeric
3	" " " World Area Code
4	Survey Designator
5	Online Distance
6.	Online Carrier
7	Number of Segments (NSEG)
8	3Q77 Inbound Traffic U.S./U.S. Tickets
9	" " " FOR/FOR "
10	" " " Other "
11	3Q77 Outbound Traffic U.S./U.S. Tickets
12	" " " FOR/FOR "
13	" " " Other "
14	CY77 Total Traffic

The following fields are output 1 to 24 times depending upon the value of NSEG

15	Downline Carrier
16	" Coupon Type
17	" Distance
18	" Distance
19	" City Alpha Numeric
20	" Breakpoint
21	" City Numeric
22	" Airport Designator
23	" City World Area Code

Note: The last downline segment gives data for the directional designation city

A/BFILES are output to CFILE. A/BFILE records are reformatted per Figure IV.2. This process is performed using: EXECUTE. PICK1.FOR.

CFILE is converted from binary to ASCII for visual checking, using ASCII2.FOR. Part or all of A/BFILE's can be similarly converted using ASCII3.FOR.

PICK1 can be modified to sort on a CY77 total traffic other than three by changing the constant in the starred statement. Also, the order in which the TAPE.DAT files are processed can be changed by changing a data statement.

Step 3. Using AFILE, creates files of directional origin cities (defined by city numeric and airport designator) by water leg (defined by gateway city numerics, airport designators, and segment carrier). file includes seven traffic count totals by water leg, creates a similar file of directional destinations.

A. Input

1. For directional origin cities, AFILE sorted by water leg (U.S. gateway city, airport, EUR gateway city, airport, carrier).
2. For directional destination cities, AFILE sorted by water leg (EUR gateway city, airport U.S. gateway city, airport, carrier).

B. Output:

1. For US origin cities, PT52:HFILE.DAT in ASCII.
2. For EUR destination cities, PT52:HFILE2.DAT in ASCII.

C. Process:

Program CITY1.FOR reads AFILE records for a water leg, totals seven traffic counts, outputs five water leg definers, seven traffic count totals, and list of associated origin cities to HFILE. Program CITY2.FOR performs similarly for destination cities. Processes are performed using:

```
EXECUTE CITY1.FOR
```

```
EXECUTE CITY2.FOR
```

D. Modifications

The programs could be modified to define water legs and O/D cities solely on gateway city numerics without redesigning. Just eliminate all references to the airport designators.

Step 4: Eliminates AFILE records with: incomplete water leg data, just foreign carriers, over five downline segments, or O/D pairs not on a given list of fifty-eight cities. Reformats output, dropping city alphanumeric designators and adding a field for segment number of water leg.

A. Input:

PT52:AFILE.DAT sorted by O/D.city numeric

B. Output:

1. PT52:EFILE.DAT, 8,000 binary coded records in format described in Figure 6.
2. DSK:EMINI.DAT, a small sample of EFILE output in binary code.

C. Process

Program GATE.FOR reads AFILE records and checks if O/D cities are found in the data statement list of 58 city numeric codes (Fig. IV.4). If not, it counts the event and repeats the process. Otherwise it counts the number of downline segments. If that number is > 5 , then it counts the event and skips to the next record. Otherwise, it checks a transatlantic segment. If there is none, it counts the event and skips to the next record. Otherwise, it checks coupon type for each segment for non-US airline. If there is no US airline, it counts the event and skips to a new record. Otherwise, it outputs the record in Binary Image code per format in Fig. 6 and repeats until input file exhausted.

Technical note: Binary Image code is necessitated by later processing using programs written in PASCAL. Process is performed using: EXECUTE GATE.FOR. For further information, see Appendix G.

An ASCII copy of part or all of the file for visual checking can be obtained using ASCII4.FOR

TABLE IV.4

"Alphanumeric and Numeric Codes for the
58 Key Origin or Destination Cities"

ATL	5850	AMS	3140
BAL	7220	ATH	5770
BOS	12200	TXL	10220
ORD	18500	BRU	13430
CLE	19770	CAI	14870
DFW	23210	CGN	20360
DEN	24090	CPH	21170
DTW	24260	DUB	25310
IAH	37320	FRA	30120
MCI	42650	GVA	31450
LAX	51410	GLA	32020
MIA	57560	HAM	35020
MSP	57970	IST	39560
MSY	63580	LIS	50590
JFK	63760	LHR	51120
PHL	69880	LUX	52090
PHX	69980	MAD	52530
PIT	70470	MAN	53940
PDX	71790	MXP	57690
STL	78460	MUC	61340
SFO	79830	NCE	63900
SJU	80220	OSL	66730
SEA	82630	CDG	68310
TPA	87870	FCC	76900
DCA	96460	SNN	83220
YMX	59460	ARN	85960
VYZ	90900	THR	89000
		TLV	89060
		VIE	94840
		HAW	96370
		ZRH	99960

D. Modifications:

GATE.FOR can be modified to select on a different set of cities by changing the data statement list.

Step 5 identifies O/D water leg sets with total CY77 traffic ≥ 6 . Sorts EFILE records with those water leg sets into FFILE.DAT and the remaining EFILE records into GFILE.DAT. Multiplies all 3Q77 traffic counts (not CY77) by 10.

A. Input:

PT52:EFILE.DAT described above sorted by:

Directional origin city numeric, airport designator
Directional destination city numeric, airport designator
Water leg US gateway city numeric, airport designator
Water leg EUR gateway city numeric, airport designator
Water leg carrier

B. Output:

1. PT52:FFILE.DAT, 6,000 Binary Image records in the format described in Fig. IV.5. Records have O/D water leg sets whose summed CY77 traffic is ≥ 6 .

2. PT52:GFILE.DAT, 6,000 Binary Image records in the format described in Fig. IV.5. Records have O/D water leg sets whose summed CY77 traffic is ≤ 6 .

FIGURE IV.5
EFILE, FILE AND FILE FORMATS

<u>Field</u>	<u>Contents</u>
1	Number of Segments
2	Segment Number of Water Leg
3	Directional Destination Numeric
4	" " Airport Designator
5	" " World Area Code
6	Water Leg U.S. City Numeric
7	" " " Airport Designator
8	" " " World Area Code
9	" " Carrier
10	" " Distance
11	" " Europe City Numeric
12	" " " Airport Designator
13	" " " World Area Code
14	Directional Origin City Numeric
15	" " " Airport Designator
16	" " " World Area Code
17	First Segment Carrier
18	" " Distance
19-23	Second Segment Data
24-28	Third " "
29-33	Fourth " "
34-38	Fifth " "
39	3Q77 Inbound U.S./U.S. Ticket Traffic
40	" " FOR/FOR " "
41	" " Other " "
42	" Outbound U.S./U.S. Ticket Traffic
43	" " FOR/FOR " "
44	" " Other " "
45	CY77 Total Traffic

C. Process:

Program PICK2A.FOR reads EFILE records and sums CY77 traffic over each O/D water leg set. For each water leg set, outputs a record to COUNT.DAT with the number of EFILE records for the set, a flag indicating sort to FFILE or GFILE, and the determining CY77 total (for visual checking). The process is performed using: EXECUTE PICK2A.FOR. Program PICK2B.FOR reads COUNT and EFILE, multiplies the six 3Q77 counts by 10, and outputs the EFILE records to FFILE or GFILE depending upon the sort flag in the COUNT record. The process is performed using: EXECUTE PICK2A.FOR

EFILE and GFILE can be translated from binary image to ASCII using ASCII4.FOR.

D. Modifications:

PICK2A.FOR can be modified to sort on a CY77 traffic count other than 6 by changing the value of N in the PARAMETER statement. Water leg sets may be redefined on just city numerics and carrier by eliminating all references to airport designators.

Step 6. Creates FFILE records of itineraries having just foreign carriers

A. Input:

1. PT52: ODRTEL.DAT, ASCII file created under HH Aerospace contract; contains Quality of Service Indices (QSI) for EUR-US flights by directional O/D, water leg, and flight number.

2. PT52:ODRTE2.DAT, as above but for US-EUR flights.

3. PT52:FFILE.DAT produced in Step 5 and sorted by directional O/D city numerics, water leg city numerics, and water leg carrier.

B. Output

1. PT52:INTRM1.DAT: 1,300 Binary Image records in the format of Fig. 4, containing newly created itineraries with just foreign carriers. Each record has from one to three segments, including the water leg, and 3Q77 EUR-US traffic only. CY77 traffic is zero.

2. PT52:INTRM2.DAT, 1,300 Binary Image records as above except with 3Q77 US-EUR traffic only.

3. TRACR1.DAT and TRACR2.DAT: ASCII files used solely for debugging process.

C. Process:

Program QSI1.FOR reads the first ODRTEL record with a foreign carrier and stores the QSI under $QSIM_f$. It then reads all US carrier ODRTEL records for that O/D pair, summing QSIM, yielding $QSIM$. Then all FFILE records for that O/D pair are read and their 3Q77 EUR-US traffic summed, yielding V . Foreign carrier traffic for that O/D pair, using the itinerary

of the first ODRTEL record, is calculated using:

$$V_F = \frac{QSIM_F}{QSIM} * V$$

A new FFILE-formatted record is then created, using data from ODRTEL and the FFILE records read, and output to INTRM1.DAT.

Program QSI2.FOR uses a corresponding process to create INTRM2.DAT records of US-EUR foreign carrier traffic. The processes are performed using:

```
EXECUTE      QSI1.FOR
```

```
EXECUTE      QSI2.FOR
```

For further information, see Appendix J.

The system PIP utility is then used to add INTRM1 and INTRM2 to FFILE with the command:

```
COPY PT52:FILE.DAT = FFILE.DAT, INTRM1.DAT, INTRM2.DAT
```

The combined file can be translated from Binary Image to ASCII for visual checking using ASCII4.FOR.

Step 7. Removes FFILE records having water legs listed in ZPFILE.DAT.

A. Input:

1. PT52:FFILE.DAT: 8,600 Binary Image records as described above, sorted by water leg.
2. DSK:ZPFILE.DAT: Binary Image file of water legs for which no flights exist, sorted by water leg. Produced by program MATCH.PAS and discussed in "Air Analysis Project: Pre-Processor and Report Manual", KHL-TSC-78-1620, Aug. 1979.

B. Output:

PT52: FFILE.DAT: 8,000 Binary Image records

C. Process:

Program REMOVE.PAS examines the two water leg gateway city numerics and carrier code for each FFILE record and compares them against the list in ZPFILE. If a match is not made, then the record is output, else it is skipped. The process is performed using:

R REMOVE

For further details consult the referenced document.

IV.2 The Demand Model

The demand model consists of three elements:

1. FFILE quantifies traffic or "demand". Its key variables are:
 - A. origin and destination cities.
 - B. Water leg, or gateway, cities and carriers.
 - C. 3Q77 traffic counts EUR to US and US to EUR.
 - D. other intermediate cities and carriers.

2. QSI files quantify access or "supply" along origin-water leg-destination routes. QSI1E and QSI1W give historical or "base case" demand for east and westbound traffic respectively. Their key variables are:
 - A. origin and destination cities
 - B. water leg cities, carrier, and flight number
 - C. QSIM, or QSI with respect to reallocation of traffic among different routes between an O/D pair
 - D. QSI1S or QSI with respect to new or "stimulated" traffic between the O/D pair.

3. A four step process predicting new demand as a function of changes in flight frequency, route, or equipment. The steps are:

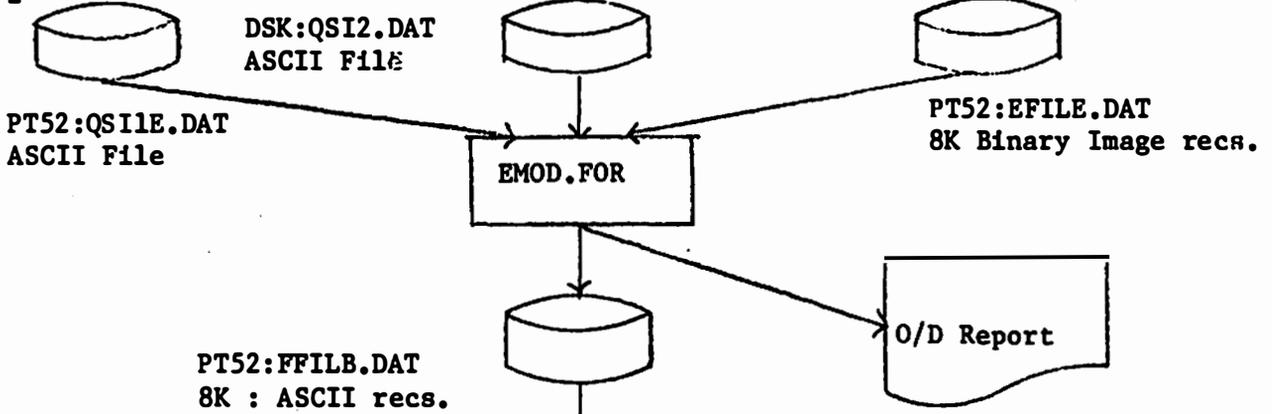
Figure IV.6

QSI BASED DEMAND MODEL

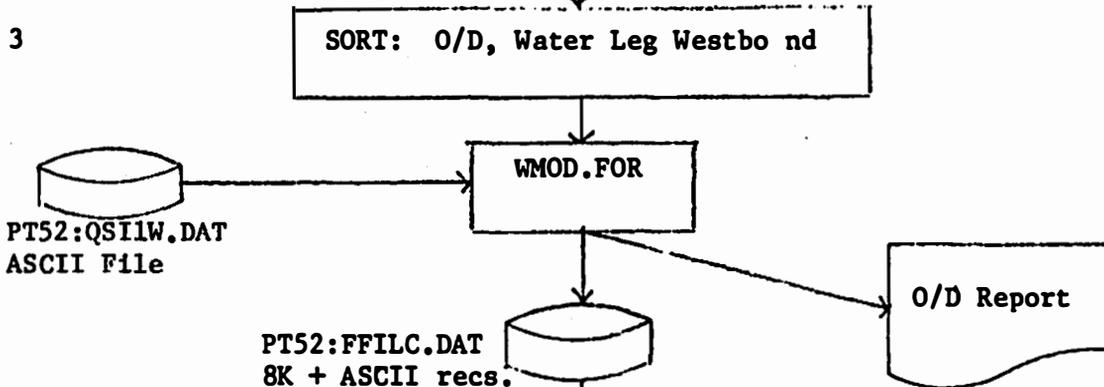
From flight itinerary, frequency and equipment changes, create changes in QSI file

STEP 1

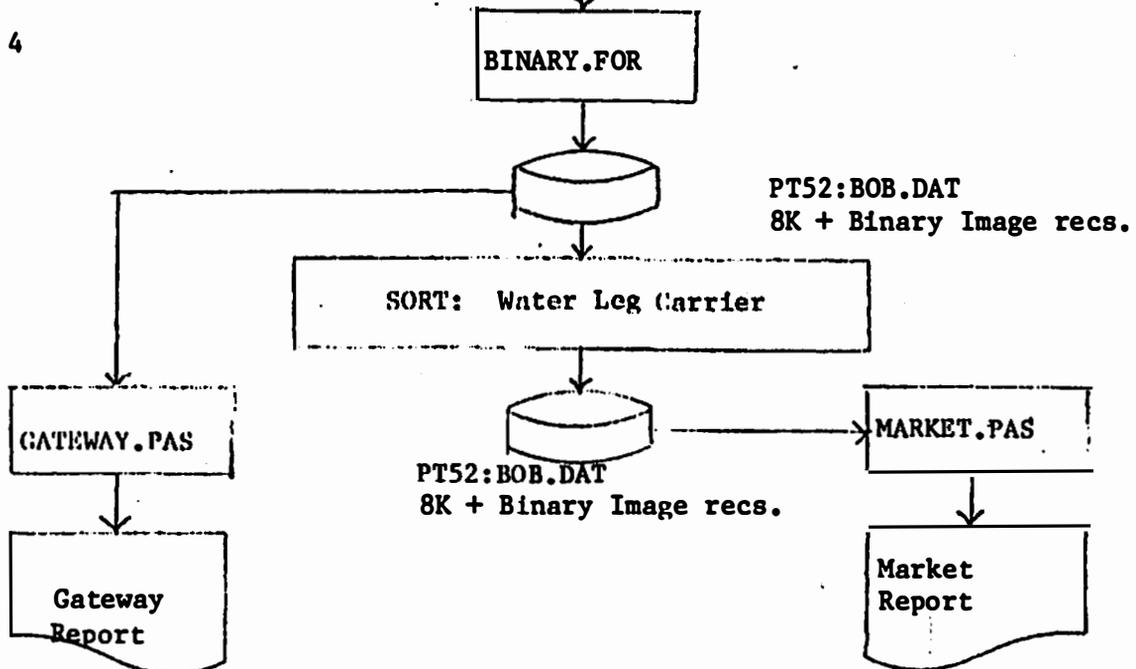
STEP 2



STEP 3



STEP 4



A. Given alternate flight schedules, QSI2 "alternate scenario" supply files are created in the same manner as were the QSI1 files; with the exceptions that both eastbound and westbound flights are represented in each scenario file and that only changed QSI records are represented.

B. Given FFILE's base case US to EUR demand, QSI1E's base case supply, and a QSI2 alternate supply scenario supply file, program EMOD.FOR calculates new US to EUR traffic counts for each O/D pair with changed QSI's using the algorithm:

$$1. \quad S = 1.0 + (.17 * \ln \left(\frac{\sum QSIS_2_i}{\sum QSIS_1} \right))$$

$$2. \quad V = \sum T_i$$

$$3. \quad \text{If } QSIM2_i > QSIM1_i, \\ \text{then } \Delta T_i = \frac{QSIM2_i - QSIM1_i}{\sum QSIM2_i} * V$$

$$\text{If } QSIM2_i = QSIM1_i, \text{ then } \Delta T_i = 0.0$$

$$\text{If } QSIM2_i < QSIM1_i,$$

$$\text{then } \Delta T_i = \frac{QSIM2_i - QSIM1_i}{QSIM1_i} * T_i$$

$$4. \quad T_i' = (T_i + \Delta T_i), \quad T_i' \geq 0.0$$

$$5. \quad T_i'' = T_i' * \frac{\sum_i T_i'}{\sum_i T_i'} * S \quad \text{where:}$$

- a. $QSIS1_i, QSIS2_i$ are total stimulation QSI's
(defined above) for water leg i of the O/D pair
- b. If $T_i > 0$, then $QSIS1_i \geq 0.2$, else $QSIS1_i \geq 0$
- c. $QSIS2_i \geq 0$
- d. $QSIM1_i, QSIM2_i$ are total nonstimulation QSI's
(defined above) for water leg i of the O/D pair.
- e. If $T_i > 0$, then $QSIM1_i \geq 0.2$, else $QSIM1_i \geq .0001$
- f. $QSIM2_i \geq 0$
- g. T_i is total 3Q77 US to EUR traffic on water leg i
of the O/D pair; $T_i \geq 0$
- h. S is the computed stimulation factor; $S \geq 0.0$
- i. V is total 3Q77 US to EUR traffic for the O/D pair; $V > 0$
- j. $\Delta T_i'$ is the change in T_i due to reallocation of exist-
ing traffic
- k. T_i^h is total quarterly US to EUR traffic on water leg
 i after reallocation but before stimulation
- l. T is total quarterly US to EUR traffic on water leg
 i after reallocation and stimulation. The program
then outputs FFILE records with traffic counts un-
changed and changed and new records for new itineraries
to FFILB.DAT.

C. Given FFILB's base case, EUR to US demand, (sorted by O/D, water leg westbound), QSILW's base case supply, and the above QSI2 alternate supply scenario program, -WMOD.FOR uses the above algorithm to calculate new EUR to US traffic counts for each O/D pair with changed QSI's. It then outputs FFILB records with traffic counts unchanged and changed and new records for new itineraries to FFILE.DAT. To facilitate visual checking, FFILE. is output in ASCII and resorted by O/D and water leg eastbound.

D. FFILE is converted to a Binary Image file, BOB.DAT and read by program GATEWA.PAS to obtain a report of traffic through selected gateway cities. BOB.DAT is sorted by carrier and read by program MARKET.PAS to obtain a report of traffic originating at and connecting with selected cities.

Detailed Description of Steps:

Step 1. Creates QSI2 files of changes in supply due to flight changes.

For details see Section IV.3. In general supply changes as a function of: flight frequency, routings, and equipment.

Step 2. Calculates predicted eastbound traffic or demand as a function of the Base Case supply and demand and an alternate scenario supply.

A. Input

1. PT52:FFILE.DAT: 8K Binary Image records, sorted by directional O/D cities, water leg gateway, cities, and water leg carrier, eastbound. The file represents Base Case demand. See Section I above for further details.

2. PT52"QSI1E.DAT: ASCII file, sorted as FFILE. The file represents Base Case supply format is in Fig. 2. See H:H. Aerospace for further details.

3. DSK:QSI2.DAT: ASCII file, in the format shown in Fig. 2. Eastbound records have a route direction flag value of 1 and are sorted as the two above files.

B. Output:

1. PT52:FFILB.DAT: > 8K ASCII records in the same format and sort order as FFILE. This output is in ASCII for visual checking. The file represents an alternate supply scenario. TECHNICAL NOTE: QSI's are disaggregated by carrier and flight number but their associated itineraries are not disaggregated by intermediate stops which are not gateway or O/D cities. Traffic counts are associated with itineraries which are disaggregated by intermediate stops as well as O/D and gateway cities and carriers. However, itineraries are not disaggregated by flight number. To achieve a "common denominator", QSI records and itineraries are grouped by water leg. Therefore, the programs implementing the model insure that for each O/D pair considered:

1. Each water leg has at least one FFILE, one QSI1 and one QSI2 record.

2. Each QSI1 record is matched by a corresponding QSI2 record and vice versa. In addition, the model is mathematically limited to cases with an O/D pair has a Base Case demand greater than zero.

3. Summary tables are typed out for each O/D pair.

C. Process

Program EMOD.FOR calculates predicted eastbound traffic, iteratively by directional O/D pair, in three steps:

1. Gathering the records:

a. it reads QSI2 until an eastbound record is found. This identifies the O/D pair.

b. It reads through FFILE, outputting to FFILB those records it skips, until all FFILE records for that O/D pair are stored in an array. Total 3Q77 traffic is summed over each water leg. If there are no such records found or their total 3Q77 eastbound traffic is zero, then the even is noted and the program seeks the next O/D pair with supply changes.

c. Else, it reads QSI1, storing in an array all supply change records including the one first defining the O/D pair.

2. Filling in the arrays and totalling:

- a. the program then insures that all water legs identified by the set of gathered FFILE, QSI1, and QSI2 records have at least one FFILE and one QSI1 record. Where either is lacking The data is created from available FFILE, QSI1 and QSI2 data. If total 3Q77 traffic on the water leg is greater than zero, then newly created or "dummy" QSI1 and QSI2 values are set to .02, the lower threshold for inclusion in the QSI files. If the traffic is zero, then the QSI's are set to zero. This process will result in dummy FFILE records where there is base case or alternate scenario supply but no base case demand indicated in FFILE. These dummy FFILE records are valid demand records with zero CY77 traffic much as were the foreign carrier records added to the Base Case.
- b. In a similar manner, the program then insures that all stored QSI1 records have a matching QSI2 record and vice versa.

c. When the FFILE, QSI1, and QSI2 tables are thus "squared", the program sums QSI1M, QSI1S, and QSI2S values over each water leg. If the total QSI1M for any water leg is zero, it is reset to the insignificant value, .0001 to prevent later division by zero.

3. Calculating the new traffic using the formulae:

a. The program then computes the factor by which total O/D traffic is raised or reduced due to the supply changes.

b. It then computes the reallocation of existing traffic among the water legs and multiplies the new traffic by the overall O/D stimulation factor.

c. Finally, the total eastbound 3Q77 traffic is parsed out among the three ticket type fields, either in proportion to their share of Base Case water leg total was zero. All computations are done Case total was zero. All computations are done with real numbers until this last step, where rounding to integer values is upwards. The program then outputs all records in the FFILE array, types out a summary table for the O/D pair, and returns to the first step.

D. Modifications:

As all of the computations calculating new traffic are placed in one block of code, roughly from label 585 to 627, most foreseeable changes to the model's algorithm can be implemented here with no effect on the rest of the program.

Step 3. Calculates predicted westbound demand as a function of the Base Case supply and demand and an alternate scenario supply.

A. Input:

1. PT52:FFILB.DAT, 8K ASCII records output from EMOD. This is the Base Case demand file as only eastbound traffic counts were affected by EMOD.

2. PT52: QS1W.DAT: ASCII file in the format shown in Figure 2, sorted by O/D, water leg westbound. This is the base case westbound supply file.

3. DSK:QSI2.DAT: The same file as used by EMOD. However, only records with a route direction flag value of 2 are considered; and they are sorted by O/D water leg westbound. This is the alternate scenario westbound supply file.

B. Output:

1. PT52:FFILE.DAT: 8K ASCII records in the same format as FFILE and FFILB, sorted by O/D, water leg eastbound. This file represents demand predicted under the alternate supply scenario.

2. O/D summary tables like those from EMOD are typed out.

C. Process:

1. FFILB is sorted by O/D, water leg westbound

2. Program WMOD.FOR calculates predicted westbound demand and outputs FFILE.DAT in the same manner used by EMOD.

For further details, see Appendix L.

3. FFILE is then resorted by O/D, water leg eastbound.

D. Modifications:

Changes in the model's algorithm can be implemented in WMOD in the same manner as in EMOD as the program are virtual twins. However, beware that some label numbers differ slightly.

Step 4. Produce summary reports

A. Input:

PT52: FFILE.DAT as produced above.

B. Output:

1. Gateway report giving new demand for selected gateway cities.
2. Market report giving new demand for selected O/D and intermediate cities.

C. Process:

1. Program BINARY.FOR converts FFILE from ASCII to the Binary Image file, BOB.DAT, for later processing. For listing, see Appendix M.
2. Program GATEWAY.PAS reads BOB.DAT and produces a gateway report having the title keyed. For details of this program, see KHL-TSC-78-1620, Aug. 1979.
3. BOB.DAT is sorted by carrier.
4. Program MARKET.PAS reads BOB.DAT and produces a market report having the title keyed in. For details of this program, see KHL-TSC-78-1620, Aug. 1979.

System Modifications

The present ASCII format of FFILE is for visual checking and may be changed to Binary Image by just changing the file opening command and the write commands in WMOD.FOR. This would eliminate the necessity for BINARY.FOR.

Similarly, FFILB would be output and read in Binary Image format, saving some run time.

Finally, the O/D water leg sort of FFILE may be dispensed with.

IV.3 THE SUPPLY MODELS

Overview

The ATPM flight LOS and QSI programs take the OAG Flight Stage data base and the Gateway/Port Connection Table (HFILES) and produce Gateway/Gateway LOS and QSI files (BSCnOD.DAT and WATER.LEG).

You can choose the month and year for the OAG Flight Stage data base. A group of U.S. gateway cities may be chosen, as well as a group of European gateway cities. The programs automatically find all flights connecting the U.S. and European gateways. All such gateways are designated as "ports". Each transatlantic port pair from a flight is called a "water leg". A water leg may have intermediate stops. The programs generate records summarizing LOS and QSI values for water legs of interest.

The programs also generate direct connection records connecting, on each side of the Atlantic, gateways with ports. The Gateway/Port Connection Table tells which gateway city will connect up with a port city for a given water leg, as well as the water legs of interest.

Minimum connection times at each port city may be specified in the following categories: online and offline, connection to transatlantic and transatlantic to connection, and interairport and intra-airport. The programs then find the best connections to water legs from the point of view of minimizing total travel time, subject to giving online connections a two-hour advantage. Origin -to-destination records containing LOS and QSI information are then generated for use by subsequent programs in the ATPM system.

Alternate scenario files can be generated, which add new flights and/or designate old flights for deletion. Section II constitutes a user's manual for running the programs. Section III gives program flow charts and program descriptions in order of program flow.

Appendix A gives input and output file formats. Appendix B gives program listings. Appendix C gives a program and file name glossary.

II Running the Programs

How to run a base case:

- 1) Select the appropriate month and year for the base case. If August 1977 is chosen skip to 3)
- 2) Get the corresponding OAG tape data base and run [3036,250] OAGCOP.FOR with the tape mounted as logical unit 16. This produces file PT43:
[3036,250] OAGCOP.DAT
- 3) Insure that [3036,250] USLL.DAT contains a record (see format description in Appendix A) for each airport of interest at a "U.S." (US) gateway city of interest. The cities do not actually have to be in the United States. Insure that [3036,250] EULL.DAT contains a record (see format description in Appendix A) for each airport of interest at a "European" (EU) gateway city of interest. The cities do not actually have to be in Europe. Only the first 100 airports in each file will be processed. There are presently less than 65 airports in each file now. Insure also that

[3036,250] EULL.DAT contains a record (see format description in Appendix A) for each airport of interest at a "European" (EU) gateway city of interest. The cities do not actually have to be in Europe. Only the first 100 airports in each file will be processed. There are presently less than 65 airports in each file now. Insure also that [3036,265] PRTNM.DAT contains an entry for each city of interest. Up to 31 US and 31 EU cities will be processed. Presently 27 US and 31EU cities are entered in PRTNM.

- 4) Submit the batch file [3036,250] FLT.CTL for processing. (private disk packs PT 43: and PT52: should both be mounted when the control file is executed). This will execute $\left. \begin{array}{l} \text{US} \\ \text{UE} \\ \text{EU} \end{array} \right\}$ FLT, PRDIS and the baseline international flight file, UEDSC.DAT, and the full direct connection flight files $\text{DEP} \left\{ \begin{array}{l} \text{US} \\ \text{UE} \\ \text{EU} \end{array} \right.$ and $\text{ARR} \left\{ \begin{array}{l} \text{US} \\ \text{UE} \\ \text{EU} \end{array} \right.$
- 5) Obtain the desired files of cities connected to a particular water leg, HFILE.DAT and HFILE2.DAT. Hand modifications could be made, if necessary, to produce the desired pattern of interconnections.
- 6) Submit the batch file [3036,250] HFILES.CTL for processing (PT52: should be mounted when the control file is executed.) This will reduce the connection files to those needed for the desired gateway/port pattern of interconnections. It also separates the inbound and outbound water leg flights, saving only those actually mentioned in one of the HFILE's.

The n in each file is a sequence code denoting scenario number. Manually edit the files so that the number of days of operation is set to zero.

- a) In UEnDIS.DAT, set NFR, the number of days of operation per week, to zero.
 - b) In USnEU.DAT or EUnUS.DAT set DI(5), DI(6), days of departure (local time), to seven zeros and AI(5), AI(6), days of arrival (local time) to seven zeros.
- 3) For each international flight to be added, create in UEnDIS.DAT a type 1 record followed by NSEQ type 2 records. This is most conveniently done by modifying a similar flight. Days of operation should not be zero.
 - 4) Create the corresponding records in USnEU.DAT or EUnUS.DAT. There should be a record for each transatlantic pair of cities from the flight itinerary. Days of operation should not be all zero.
 - 5) Submit the batch file BSCnOD.CTL for processing (PT52: should be mounted when the control file is executed). This produces the scenario QSI file BSCnOD.DAT and international flight image file WATERn.LEG.

III Program Flow Charts and Program Descriptions

Figure 1 gives the Flow Chart of program interrelationships. Each program will now be described in approximate order of appearance.

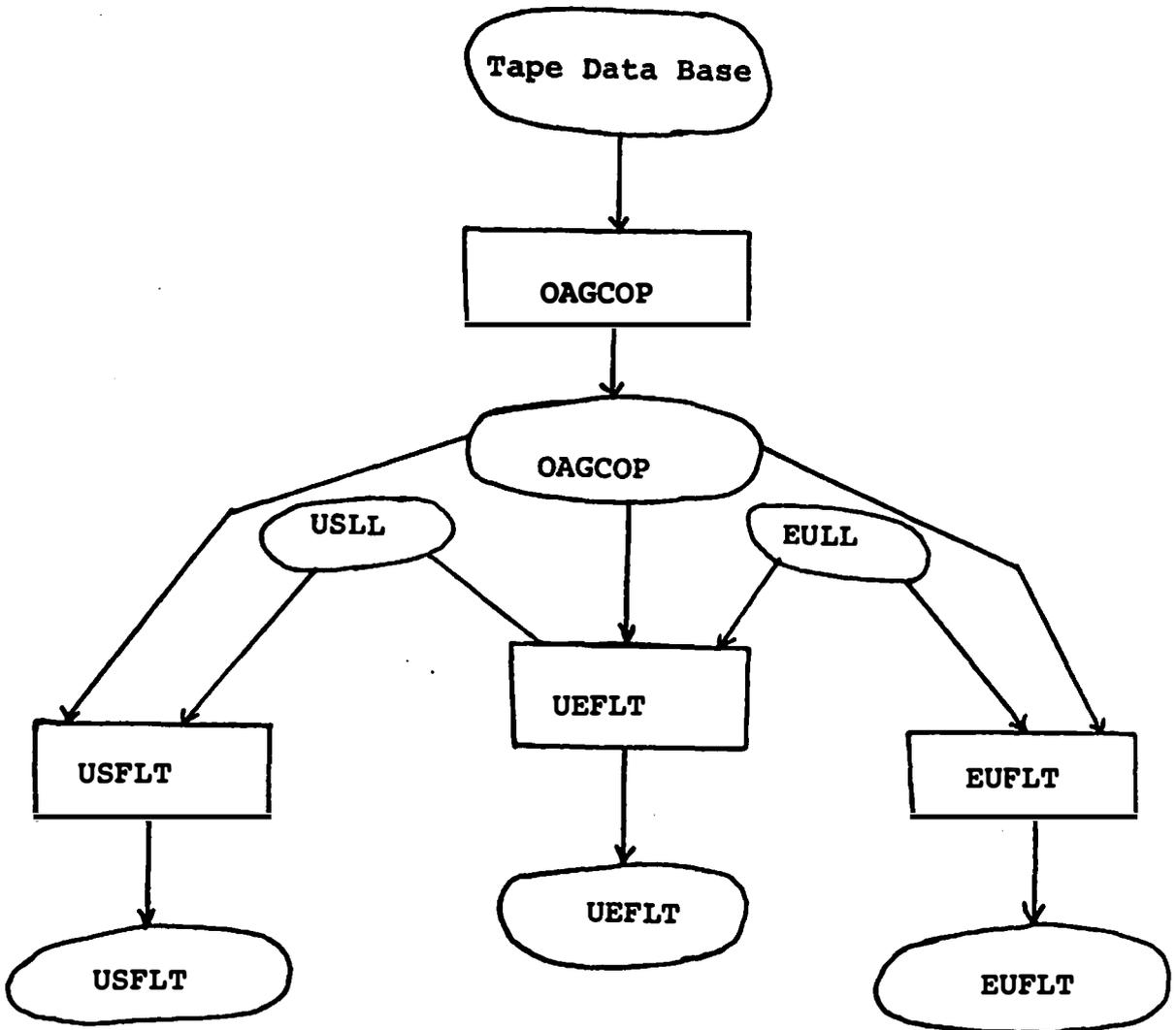


Figure 1a Flow Chart

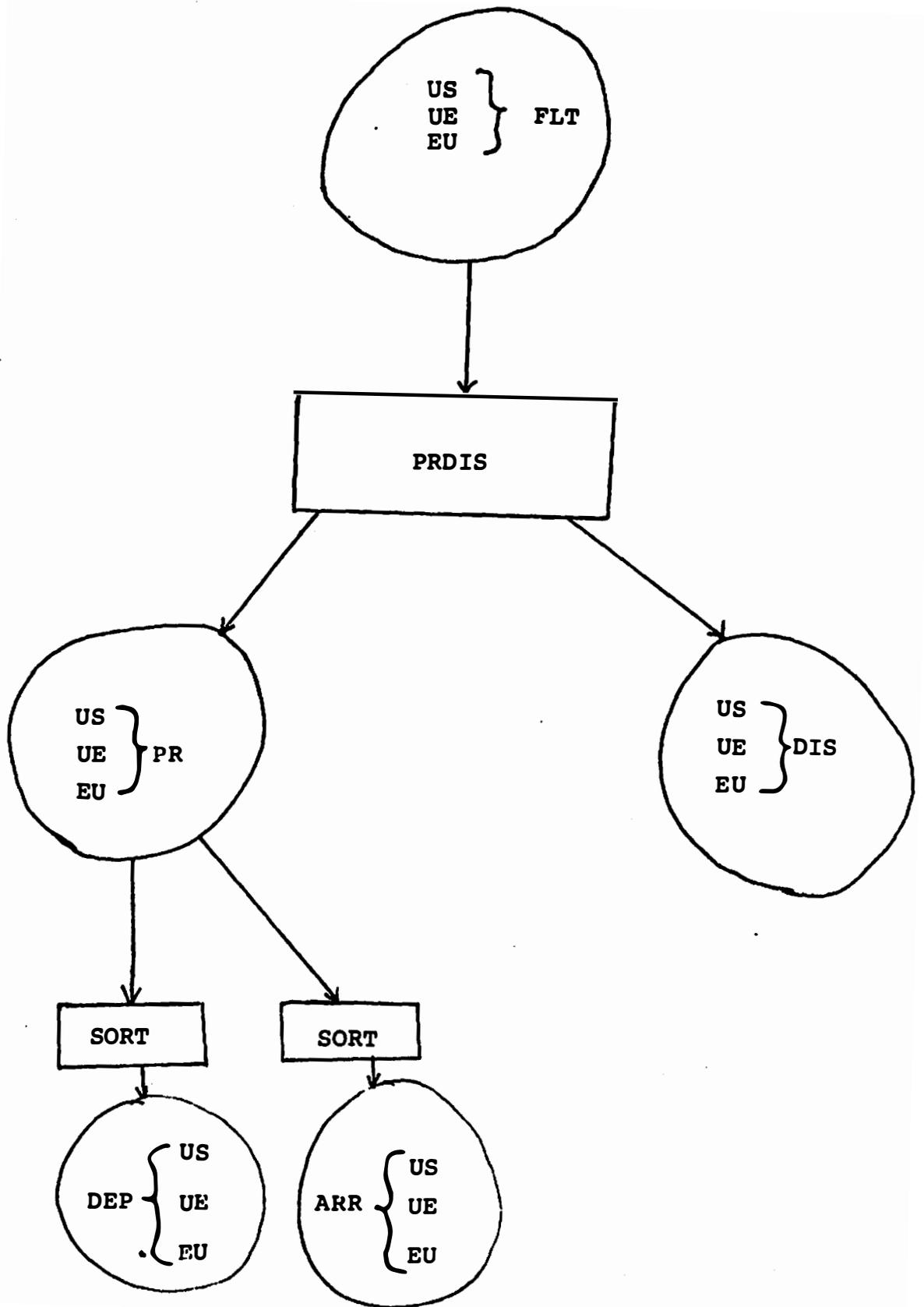


Figure 1b Flow Chart (contd.)

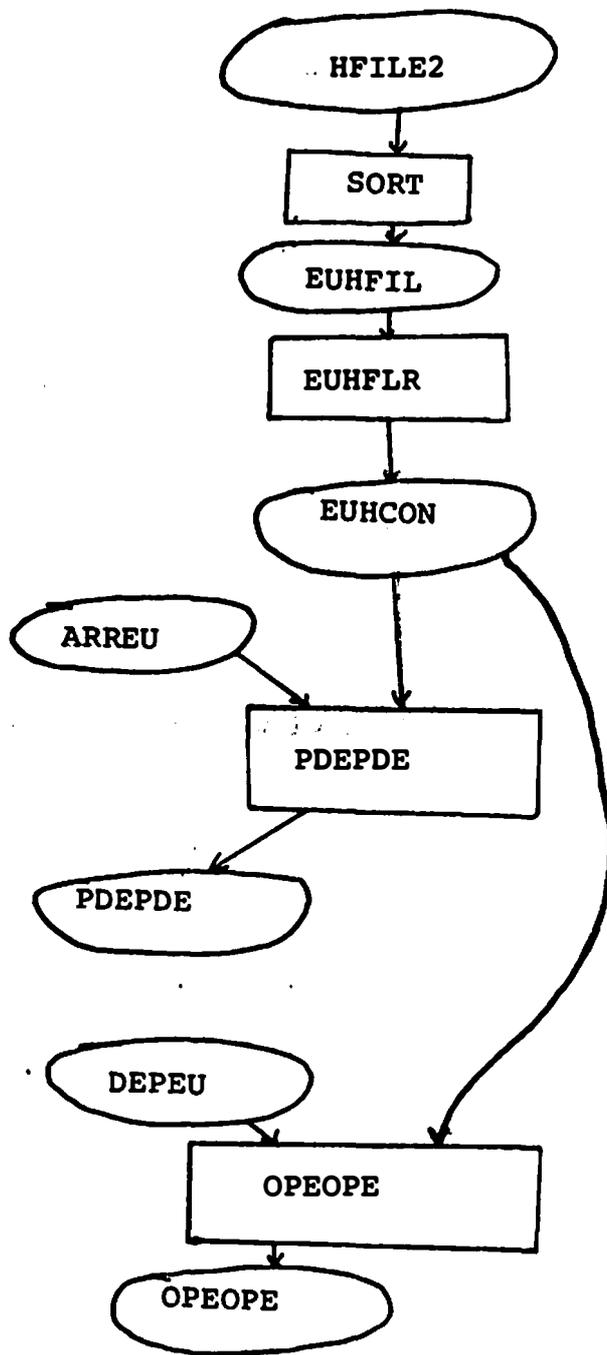
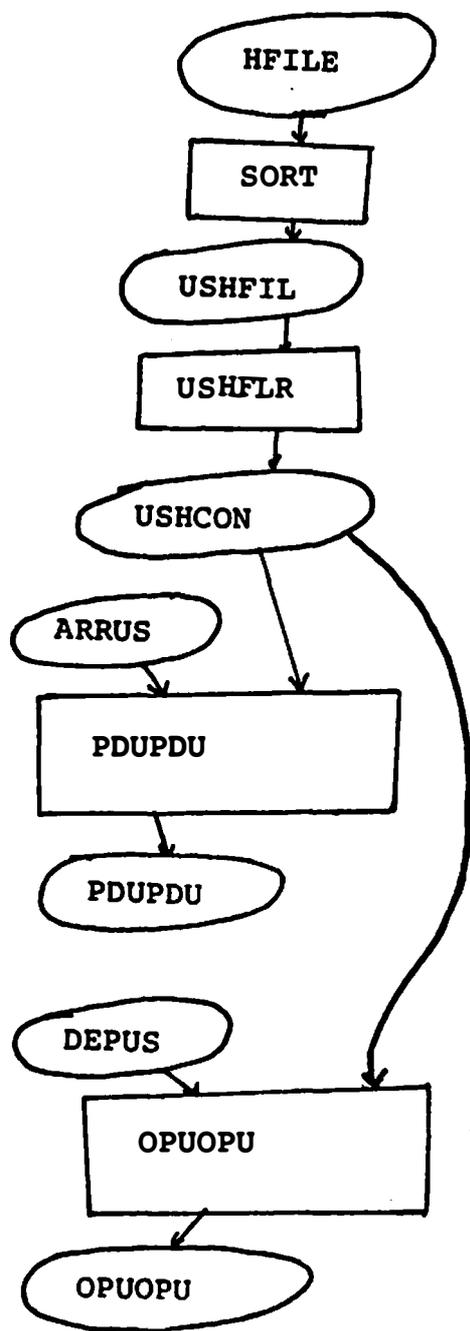


Figure 1c Flow Chart (contd.)

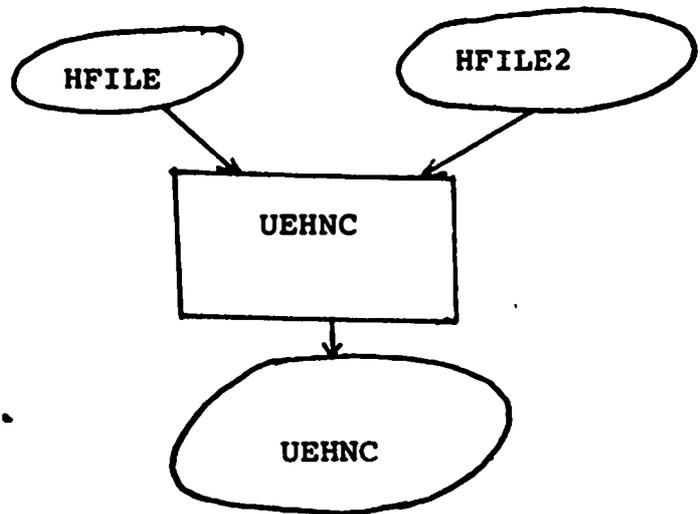
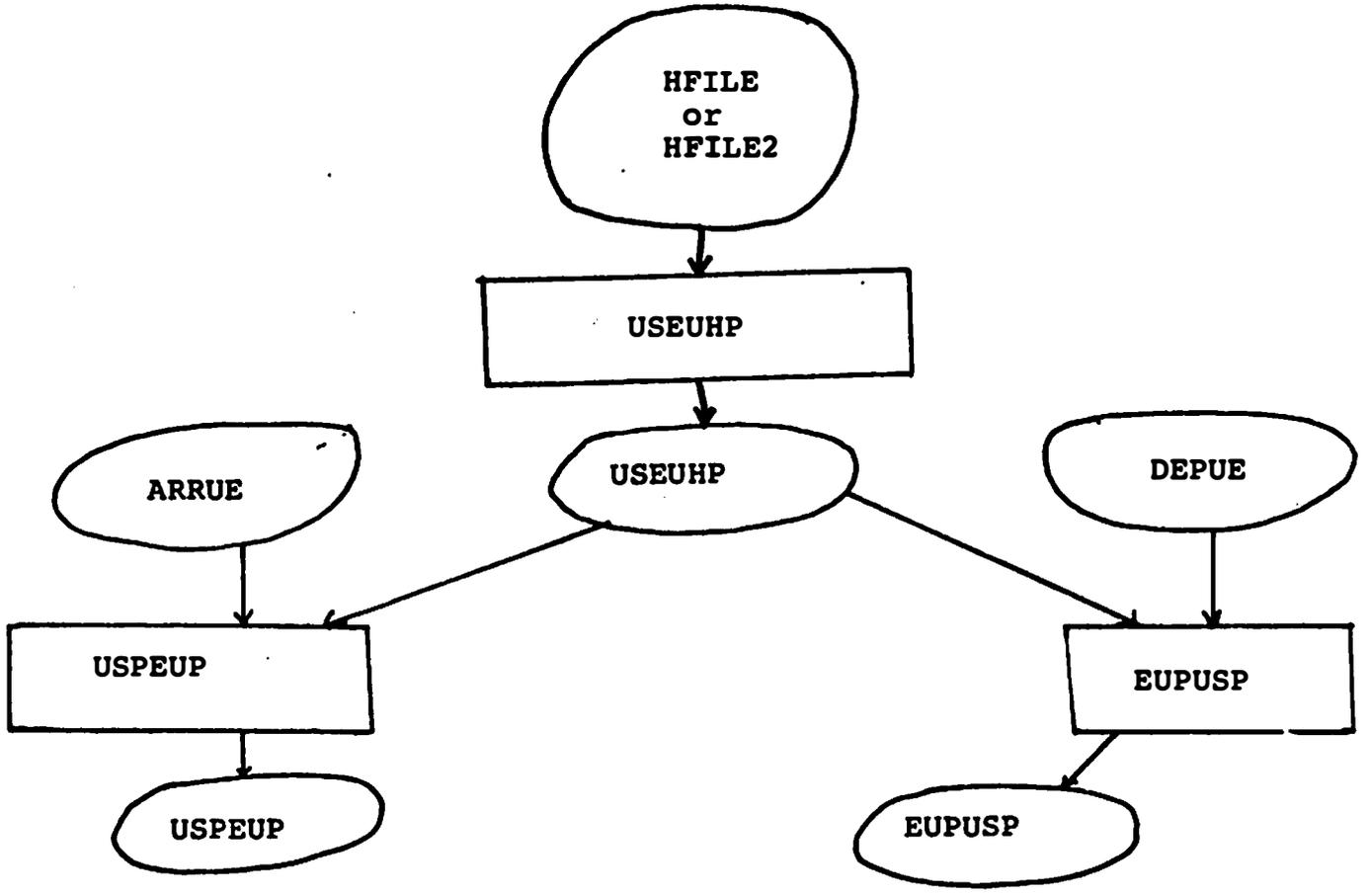
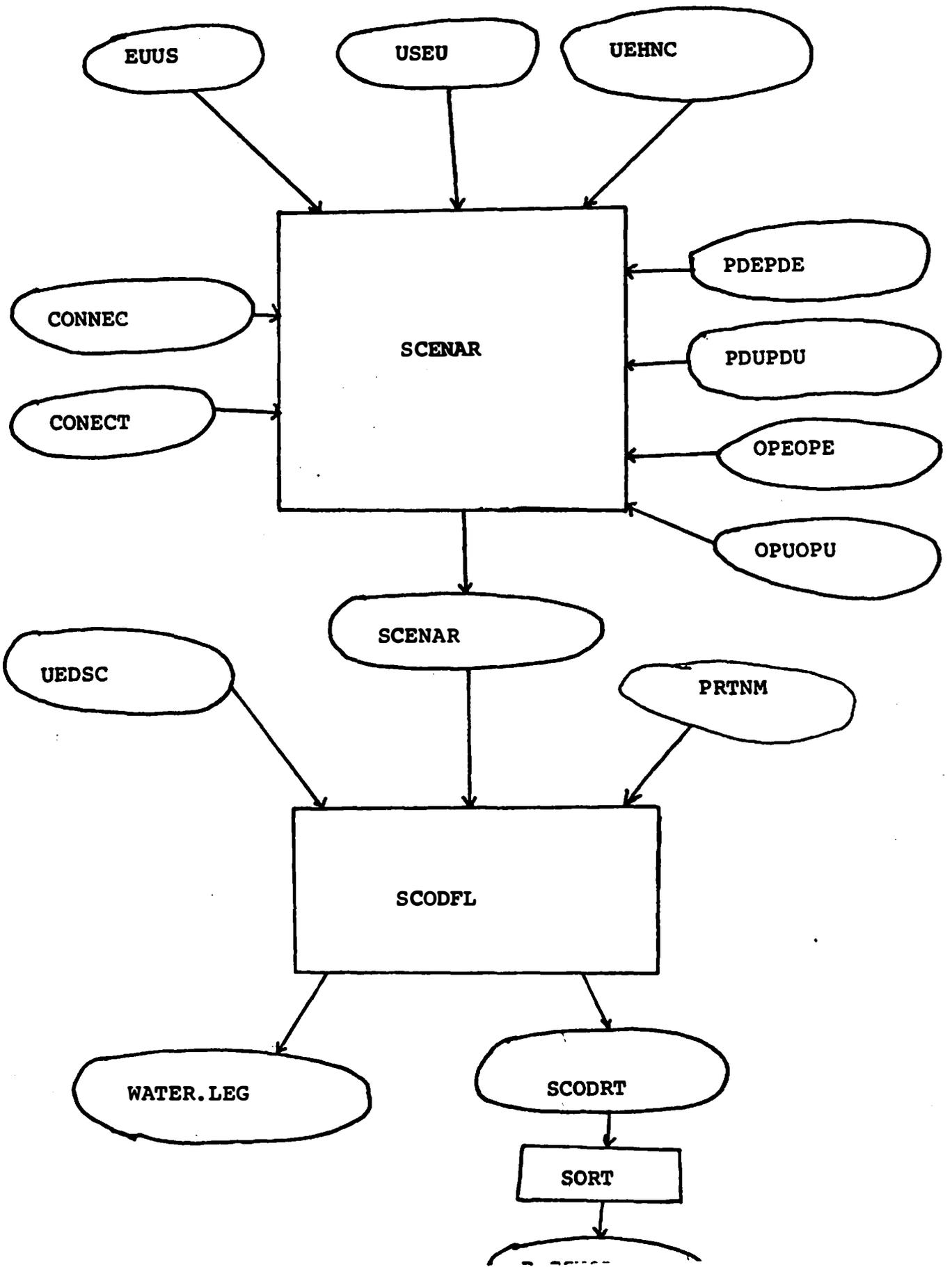


Figure 1d Flow Chart (contd.)



Program PT43:[3036,250] OAGCOP.FOR copies file of magnetic tape, logical unit 16, to PT43:OAGCOP.DAT, Nonpassenger flight segments (FARE =') are not copied. Total records processed and passenger links copied are output to the terminal.

US } FLT.FOR create US } FLT.DAT
EU } EU }
UE } UE }

These are files of connected flight segments of single flight numbers separated by variants. The input file is PT43: [3036, 250] OAGCOP.DAT. The files USLL.DAT and EULL.DAT give the airport three character and six digit numeric codes for the airports of interest. Each selected flight connects at least two of the specified airports from one or both files.

- 1) USFLT: US & US
- 2) EUFLT: EU & EU
- 3) UEFLT: US & EU

Flight segments before and after those of interest are suppressed.

The ground time between flight segments may not exceed 6 hours. The departure time may be up to 30 minutes before the arrival time, to handle the Dulles Airport Mobile Lounge Times.

Program PRDIS.FOR takes the file FLT, which is one of the files USFLT, UEFLT, or EUFLT and produces the files US } PR and
UE }
EU }

US } DIS. The file UEDIS is the desired international flight
UE }
EU }

file. The files USDIS and EUDIS are in the same format, but are not used. The "PR" files consist of one record for travel

between each pair of airports from the USLL and EULL files appearing in each flight variant. The information at the origin and destination plus summary information related to intermediate stops is given.

Each of the "PR" files is then sorted two ways from ARRival and DEParture.

The ARR files have the sort order:

- 1) departure city numeric code (Port)
- 2) arrival city numeric code (Destination)
- 3) arrival date minus departure date
- 4) arrival time
- 5) days of arrival

The DEP files have the sort order:

- 1) arrival city numeric code (Port)
- 2) departure city numeric code (Origin)
- 3) arrival date minus departure date
- 4) departure time in descending order
- 5) days of departure in descending order

USHFIL consists of HFILE sorted by

- 1) US Port city numeric code
- 2) US origin/destination city numeric code

Program USHFLR.FOR saves unique occurrences of these numeric codes in USHCON.

A similar discussion applies to EUHFIL, HFILE2, EUHFLR.FOR and EUHCON

Program PDUPDU.FOR passes records from ARRUS to PDUPDU if the port and destination occur in file USHCON.

Program PDEPDE.FOR passes records from ARREU to PDEPDE if the port and destination occur in file EUHCON.

Program OPUOPU.FOR passes records from DEPUS to OPUOPU if the port and origin occur in file USHCON.

Program OPEOPE.FOR passes records from DEPEU to OPEOPE if the port and origin occur in file EUHCON.

Program USEUHP.FOR creates a file, USEUHP, of unique US port city/EU port city pairs.

Program USPEUP.FOR passes records from ARRUE to USPEUP if the US departure and EU arrival appear in USEUHP.

Program EUPUSP.FOR passes records from DEPUE to EUPUSP if the EU departure and US arrival appear in USEUHP.

Program UEHNC gets from HFILE one record for each US connection city for each US/EU Port pair. It also gets from HFILE2 one record for each EU connection city for each US/EU Port pair. File UEHNC has the sort order:

- 1) US Port city numeric code
- 2) EU Port city numeric code
- 3) EU/US connection indicator flag
- 4) connection city numeric code

Program UEHFIL is similar to UEHNC, except that connection city records are created by airline. The two character carrier code is inserted as the second and third characters in file VEHFSR and is also the major sort.

Program IFCN lines 800, 5100-5300 are substituted for the corresponding lines in the start of SCENAR.

Connections will then be made only by airline of the international flight.

Program SCENAR.FOR takes the international flight water leg files USEU (USPEUP) and EUUS (EUPUSP) and the file of possible connection cities for a given water leg, UEHNC, and forms an intermediate file to efficiently search the connection files, OPUOPU, OPEOPE, PDUPDU, and PDEPDE. Up to 99 international flights involving the same port city and origin or destination of connecting flight are handled through a search of the appropriate portion of the connection file. The appropriate connecting times from the files CONNEC and CONECT are used to see if a connection is valid on at least one day of the international flight's operation. The sort order of the connection files is such that for any international flight, the first satisfactory flight found leads to the shortest travel time. Additional flights are examined to give online connections a two hour advantage. The output file, SCENAR, is sorted by international flight carrier and flight.

Program SCODFL is a version of the Gateway/Gateway LOS and QSI program. It takes UEDSC (UEDIS) and SCENAR, and calculates QSI's, outputting them for international flights in an image file, WATER.LEG, suited for the water leg summary report programs. All international and connection flights are output in file SCODRT. After appropriate sorting the file is suitable for input to the Foreign Carrier Demand Routing and merged Gateway/Gateway Demand Routing Programs.

Alternative versions are input to the updating programs.

File Formats

Unless otherwise indicated all files have a .DAT extension and reside in PT43: [3036,250]. They should be copied into PT52: before running the programs.

Format of Tape Data Base, OAGCOP, and US
UE
EU } BAD

	<u>Name</u>	<u>format</u>	<u>description</u>
1	dwac	a1	departure world area code digit
2	drac	a2	" region area code digits
3	dum	a1	" not referenced
4	dapt	a3	" airport alphabetic code
5	duml	a2	not referenced
6	dtl	a4	" (time (local))
7	dtg	a4	" " (GMT)
8	awac	a1	arrive world area code digit
9	arac	a2	" region area code digits
10	aum	a1	" not referenced
11	aapt	a3	" airport alphabetic code
12	dum2	a2	" not referenced
13	atl	a4	" time (local)
14	fc	a1	flag code
15	atg	a4	arrive time (GMT)
16	etec	a5	equipment type, equipment code
17	car	a2	carrier
18	fn	a5	flight number
19	fare	a5	class of service
20-26	freq(7)	7i1	days of operation
27	dum3 (11)	a2	suppress code, ATIS code
28	ELPT	a4	elapsed time
29	EFFD	A4	effective date
30	DISCD	A4	discontinued date
31		I6	leave latitude (records + 324,000)
32		A5	leave longitude magnitude (10 seconds)

Format of Tape Date Base, OAG/COP, and $\left. \begin{array}{l} \text{US} \\ \text{UE} \\ \text{EU} \end{array} \right\} \text{BAD contd.}$

<u>Name</u>	<u>Format</u>	<u>Description</u>
33	A1	leave longitude sign zone
34	I6	arrive latitude (seconds +324,000)
35	A5	arrive longitude magnitude (10 seconds)
36	A1	arrive longitude sign zone
37	A5	not referenced

Format of USLL, EULL

<u>Name</u>	<u>format</u>	<u>description</u>
LST (1,I)	A3	airport alphabetic code
LtD	I2	degrees of latitude
LTM	I2	minutes of latitude
LTS	I2	seconds of latitude
LTSG	A1	hemisphere of latitude (N,S)
LND	I3	degree of longitude
LNM	I2	minutes of longitude
LNS	I2	seconds of longitude
LNSG	A1	hemisphere of longitude (E,W)
LST (2,I)	I6	airport numeric code

Format of US } FLT, page 1 of 3
UE }
EU }

2 record types

Type 1, for each flight number variant

<u>Name</u>	<u>Format</u>	<u>Description</u>
	Ih0	Fortran print format double space
CAR	A2	Carrier
FN	A5	Flight number
JJ	I1	Flight number variant sequence number
NF	I2	Number of days of operation per week
KK	I2	Number of flight stages

Each type 1 record is followed by KK type 2 records for the flight number variant.

Type 2, KK for each flight number variant

<u>Name</u>	<u>Format</u>	<u>Description</u>
	1X	Single space
MDAPT	I6	departure airport numeric code
MAAPT	I6	arrival " " "
EQP	A3	equipment code
ELPT	1X,A4	elapsed time
GTIM	5x,I5	ground time
DWAC	A1	departure world area code digit
DRAC	A2	" region " " digits
DUM	A1	not referenced
DAPT	A3	" airport alphabetic code
DT1	I4	" time (local)
DTG	I4	" " (GMT)
AWAC	A1	arrive world area code digit
ARAC	A2	" region " " digits
AUM	A1	not referenced
AAPT	A3	" Airport alphabetic code
AT1	I4	" time (local)
FC	A1	" flag code
ATG	I4	" time(GMT)
EQT	A1	equipment type
CAR	A2	carrier

Type 2, contd.

<u>Name</u>	<u>Format</u>	<u>Description</u>
FN	A5	flight number
FARE	A5	class of service
FREQ	7I1	days of departure (local time)
	A2	suppress code, ATIS code
EFFD	A4	effective date
DISCD	A4	discontinued date
	I6	leave latitude (seconds + 324,000)
	A5	leave longitude magnitude (10 seconds)
	A1	leave longitude sign
	I6	arrive latitude (seconds + 324,000)
	A5	arrive longitude magnitude (10 seconds)
	A1	arrive longitude sign
AFREQ	7I1	days of arrival (local time)
IDA	I1	arrival date minus departure date

Format of UEDIS, page 1 of 2

2 record types, type 1: for each flight number variant

<u>Name</u>	<u>Format</u>	<u>Description</u>
H0	A1	0 for double space listing
CA	A2	carrier
FL	A5	flight number
FLS	A1	flight number variant sequence number
NFR	I2	number of days of operation per week
NSEQ	I2	number of flight stages

Each type 1 record is followed by NSEQ type 2 records for the flight number variant.

Format of UEDIS, page 2 of 2

Type 2, NSEQ for each flight number variant

<u>Name</u>	<u>Format</u>	<u>Description</u>
	1x	single space
NDC	I6	departure airport numeric code
NAC	I6	arrival " " "
EQP	A3	equipment code
TT	I5	segment elapsed airborne time
DIS	I5	segment distance (statute miles)
GT	I5	ground time before next segment departure
D1	A3	departure airport alphabetic code
A1	A3	arrival " " "

Format of $\left. \begin{matrix} \text{US} \\ \text{UE} \\ \text{EU} \end{matrix} \right\}$ PR, DEP $\left\{ \begin{matrix} \text{US} \\ \text{UE}, \text{USPEUP}, \text{EUPUSP}, \text{USnEU}, \text{EUUnUS} \\ \text{EU} \end{matrix} \right.$

ARR $\left\{ \begin{matrix} \text{US} \\ \text{UE} \\ \text{EU} \end{matrix} \right\} \cdot \left(\begin{matrix} \text{OP} \\ \text{PP} \end{matrix} \right) \left\{ \begin{matrix} \text{E} \\ \text{U} \end{matrix} \right\}^2$

<u>Name</u>	<u>Format</u>	<u>Description</u>
	1x	single space
CA	A2	carrier
FL	A5	flight number
FLS	A1	Flight number variant sequence number
SQ	I2	pairs sequence number for this variant
NFR	I2	number of days of operation per week
NSTOP	I2	number of intermediate stops
NDC	I6	departure airport numeric code
NAC	I6	arrival " " "
EQP	A3	equipment code for segment with largest elapsed time
TTSUM	I5	sum of segment airborne times
DISUM	I5	sum of segment distances
GTSUM	I5	sum of intersegment ground times
DI (1)	A4	departure area code
(2)	A3	departure airport alphabetic code
(3)	I4	departure time (local)
(4)	A4	" " (GMT)
(5)	A5	} days of departure (local time)
DI (6)	A2	
AI (1)	A4	arrival area code
(2)	A3	" airport alphabetic code
(3)	I4	" time (local)

<u>Name</u>	<u>Format</u>	<u>Description</u>
AI(4)	A4	arrival time (GMT)
AI(5)	A5	} days of arrival (local time)
AI(6)	A2	
FCVAL	I1	largest value of flag code
ET	A1	equipment type for segment with largest elapsed time
SC	A5	class of service for segment with largest elapsed time
SC2SUM	I1	su.. of suppress codes
OP	A1	ATIS code for segment with largest elapsed time
EDVAL	A4	effective date of last segment with an effective date
DDVAL	A4	discontinued date of last segment with a discontinued date
DADSUM	I1	arrival date minus departure date

Format of HFILE, USHFIL

<u>Name</u>	<u>Format</u>	<u>Description</u>
IUP (1)	I6	US Port city numeric code
(2)	I2	US " airport code digit
(3)	I4	area code (not used)
	1x	not used
IAL	A2	transatlantic carrier
IEP (1)	I6	EU Port city numeric code
(2)	I2	EU Port airport code digit
(3)	I4	area code (not used)
ISEQ	I9	sequence number (not used)
IUC (1)	I6	US origin/destination city numeric code
(2)	I2	US " " airport code digit
(3)	I9	area code (not used)

Format of HFILE2, EUHFIL is the same as for HFILE, except that the last three fields now refer to EU origin/destination.

Format of USHCON, EVHCON

<u>Name</u>	<u>Format</u>	<u>Description</u>
JUP	I6	Port city numeric code
JUC	I6	Origin/destination city Numeric code

Format of USEUHP

<u>Name</u>	<u>Format</u>	<u>Description</u>
JUP	I6	US city numeric code
JUC	I6	EU city numeric code

Format of UEHNC

<u>Name</u>	<u>Format</u>	<u>Description</u>
IR(1)	lx A5	US Port city numeric code
(2)	A5	EU Port city numeric code
(3)	A1	{ U = US connection E = EU connection
(4)	A5	Connection city numeric code

Format of CONNEC, CONECT

two record types, type 1: airport connections

<u>Name</u>	<u>Format</u>	<u>Description</u>
APT	A3	airport alphabetic code
CITY	I5	city numeric code
AP	I1	airport numeric digit
OF (1,1,I)	I4	off line transatlantic to connection
ON(1,I)	I4	on line transatlantic to connection
OF(1,2,I)	I4	off line connection to transatlantic
ON(2,I)	I4	on line connection to trans- atlantic

**A record with OF (1,1,I).EQ.0 terminates the type 1 records.
All subsequent records are type 2 records.**

Format of CONNEC, CONECT

type 2: interairport connections

<u>Name</u>	<u>Format</u>	<u>Description</u>
A1	A3	first airport alphabetic code
C1	I5	city numeric code
AP1	I1	first airport numeric digit
A2	A3	second airport alphabetic code
C2	I5	city numeric code repeated
AP2	I1	second airport numeric digit
PD	I4	transatlantic to connection
OP	I4	connection to transatlantic

Format of SCENAR, OPDCON

<u>Name</u>	<u>Format</u>	<u>Description</u>
	1x	
CA1F	A2	international flight carrier
1FLT	A5	international flight number
1FLTS	A1	int'l flt. no. variant sequence no.
NC1F	I5	port city numeric code
APT	I1	port airport numeric digit
NCCN	I5	connection city numeric code
CAPT	I1	connection airport numeric digit
TTSUM	I5	connection sum of segment air- borne times
DISUM	I5	connection sum of segment distances
GT	I5	connection sum of intersegment ground times
MA	I1	Multi airport flag (0=same,1= different)
EQPLTT	A3	connection equipment code for segment with largest elapsed time
NSTOP	I2	connection number of intermediate stops
CA	A2	connection carrier
DAPT	A3	departure airport alphabetic code
AAPT	A3	arrival airport alphabetic code
ACTGT	I5	ground time between international and connection flight
SC2SUM	I2	connection sum of suppress codes

Format of PRTNM

Name	Format	Description
	5x	US alphabetic code (ignored)
UI	I5	US city numeric codes
	5x	European alphabetic code (ignored)
E1	I5	European city numeric codes

Exactly 31 records are read by SCODFL.FDR

Format of SCODRT, BSCnOD

<u>Name</u>	<u>Format</u>	<u>Description</u>
	1x	space
ODPR(1)	I5	origin city numeric code
(2)	I1	origin airport digit
(3)	I5	destination city numeric code
(4)	I1	destination airport digit
(5)	I5	first waterleg city numeric code
(6)	I1	first waterleg airport digit
(7)	I5	second waterleg city numeric code
(8)	I1	second waterleg airport digit
(9)	I5	sum of segment distances
(11)	I2	frequency
(12)	I1	front connection carrier
(13)	I1	international
(14)	I1	back connection
(17)	I6	flight number and variant sequence number
(18)	A2	front connection carrier code
(19)	A2	international " "
(20)	A2	back connection " "
(32)	I1	US (1) or foreign (2) origin
QDPR(1)	F10.4	QSI Market Share
(2)	F10.4	QSI Stimulation

} 0=none
 } 1=US
 } 2=foreign

List of variables in image mode
file, WATER.LEG

<u>Name</u>	<u>Type</u>	<u>Description</u>
ODPR(1)	I	origin city numeric code
2	I	origin airport digit
3	I	destination city numeric code
4	I	destination airport digit
9	I	sum of segment distances
10	A	equipment code for segment with largest elapsed time
11	I	frequency
12	I	front connection carrier=0
13	I	international carrier
14	I	back connection carrier =0
17	I	flight number
19	A	international carrier code
32	I	US(1) or foreign (2) origin
45	I	travel time (in minutes 1st segment
46	I	" " 2nd "
47	I	" " 3rd "
48	I	" " 4th "
49	I	" " 5th "
50	I	" " 6th "
51	I	" " 7th "
52	I	" " 8th "
53	I	" " 9th "

1 = US
2 = foreign

List of variables in image mode

file, WATER.LEG, (contd.)

<u>Name</u>	<u>Type</u>	<u>Description</u>
ODPR(56)	I	Ground time (in minutes) 2nd city
57	I	" " 3rd "
58	I	" " 4th "
59	I	" " 5th "
60	I	" " 6th "
61	I	" " 7th "
62	I	" " 8th "
63	I	" " 9th "
QDPR(1)	F	QSI Market share

IV.4 Financial Analysis Model

FNANCE is a financial model for allocating revenues and expenses of passenger aviation. It has three main purposes:

1. To allocate revenues among specific carriers and flights;
2. To allocate costs among various cost categories for specific flights or specific carriers, or all carriers;
3. To compute load factors and revenue/cost ratios.

The program is in two parts. One part is "ROUTE", which reads in flight and passenger origin/destination data and produces from them, for each flight, the flight route and link distances, block times, and passenger loading. The other part is the main program FNANCE, which uses the above results, along with cost and revenue parameters, to estimate load factors and revenue and cost breakdowns for individual flights and carriers.

The input and output data of these two programs is as follows:

A. Input to ROUTE

These data come from the file DAVE.DAT. For each origin-destination pair of a given flight for a given carrier, ROUTE uses the following from DAVE.DAT:

origin airport
destination airport
distance from origin-to-destination (statute miles)
aircraft type used
frequency of flight (per week)
flight number
carrier
direction of flight
flight time from origin to destination (minute)
passengers flying from origin to destination (per quarter)

The origin-destination pairs are sorted in the following order:

1. airline
2. flight number
3. origin airport
4. distance to destination (in decreasing order)

The passenger data is broken down into three parts, (passengers making round trips originating in the U.S., passengers making round trips originating in Europe, and other passengers) which ROUTE adds to obtain total passenger use. Each part is obtained according to the following procedure:

For each carrier and each origin-destination pair,

1. Aggregate all appropriate passengers using the carrier, and originating at or connecting into the given origin and disembarking at or connecting out of the given destination.

2. Take all flights of the carrier from the origin to the destination and find their QSI index.

3. Apportion the passengers over the various flights in proportion to the QSI indices.

B. Output from ROUTE

The output from ROUTE, which is also an input to FNPANCE, is a route description for each flight, consisting of:

route of flight

number of stops

number of links

for each link:

block time

distance

passenger loading

C. Input to FNPANCE

In addition to the output from ROUTE, the main program FNPANCE requires financial parameters (which are stored in DATA statements). These are obtained from Form 41 cost and

revenue data. For each carrier, and, in some cases, flight equipment each of the various cost and revenue amounts as well as block-time, passenger, passenger-mile, etc., data is aggregated. Appropriate calculations are then carried out to obtain each of the following parameters (for carrier I, equipment J, and particular flight link K):

- UBAC - Aircraft Direct Operating Costs
(including depreciation, fuel, and oil)
 $ADC(K) = UBAC(I,J) * Blocktime(K)$
- UBCC - Cabin Crew Cost
 $CC(K) = UBCC(I,J) * Blocktime(K)$
- UATS - Aircraft and Traffic Services
 $ATS(K) = UATS(I)$
- URS - Reservations and Sales
 $RS(K) = URS(I) * Passenger-loading(K)$
- UPC - Passenger Commissions
 $PC(K) = UPC(I) * Passenger-revenue (K)$
- UCP - Non-passenger revenue/passenger revenue ratio
 $Non-passenger revenue (K) = UCP(I) * Passenger-revenue(K)$
- UCG - Cargo Commissions
 $CC(K) = UCG(I) * 0.95 * Non-passenger-revenue (K)$
(Note: The 0.95 reflects an assumption that
95% of non-passenger revenue is cargo
revenue)

UAP - Advertising and Publicity
 $AP(K) = UAP(I) * Passenger-revenue (K)$

UIPE - Incidental Passenger Expenses
 $IPE(K) = UIPE(I) * Passenger-miles(K)$

UDEP - Depreciation
 $DEP(K) = UDEP(I,J) * ADC(K)$
 (ADC = Aircraft Direct Operating Costs)

UFO - Fuel and Oil
 $FO(K) = UFO(I) * ADC(K)$

UGA - General and Administrative
 $GA(K) = UGA(I) * (TOTAL(K) - DEP(K) - FO(K))$
 (TOTAL = ADC+CC+ATS+RS+PC+AP+IPE)

YLD - Revenue Yield
 $Passenger-revenue(K) = YLD(I) * Passenger-Miles(K)$

SEATS - Number of Seats
 $Number\ of\ seats(K) = SEATS(I,J)$

D. Output from FNANCE

The output from the financial model provides information for each specific link, for each flight, for each carrier, and for all carriers as follows:

1. For each link:

flight number

equipment

frequency

origin airport

destination airport

block time

distance

passenger loading (per quarter)

load factor

passenger revenue

total revenue

aircraft direct operating cost

cabin crew cost

aircraft and traffic service cost

reservations and sales cost

passenger commissions

cargo commissions

advertising and publicity cost

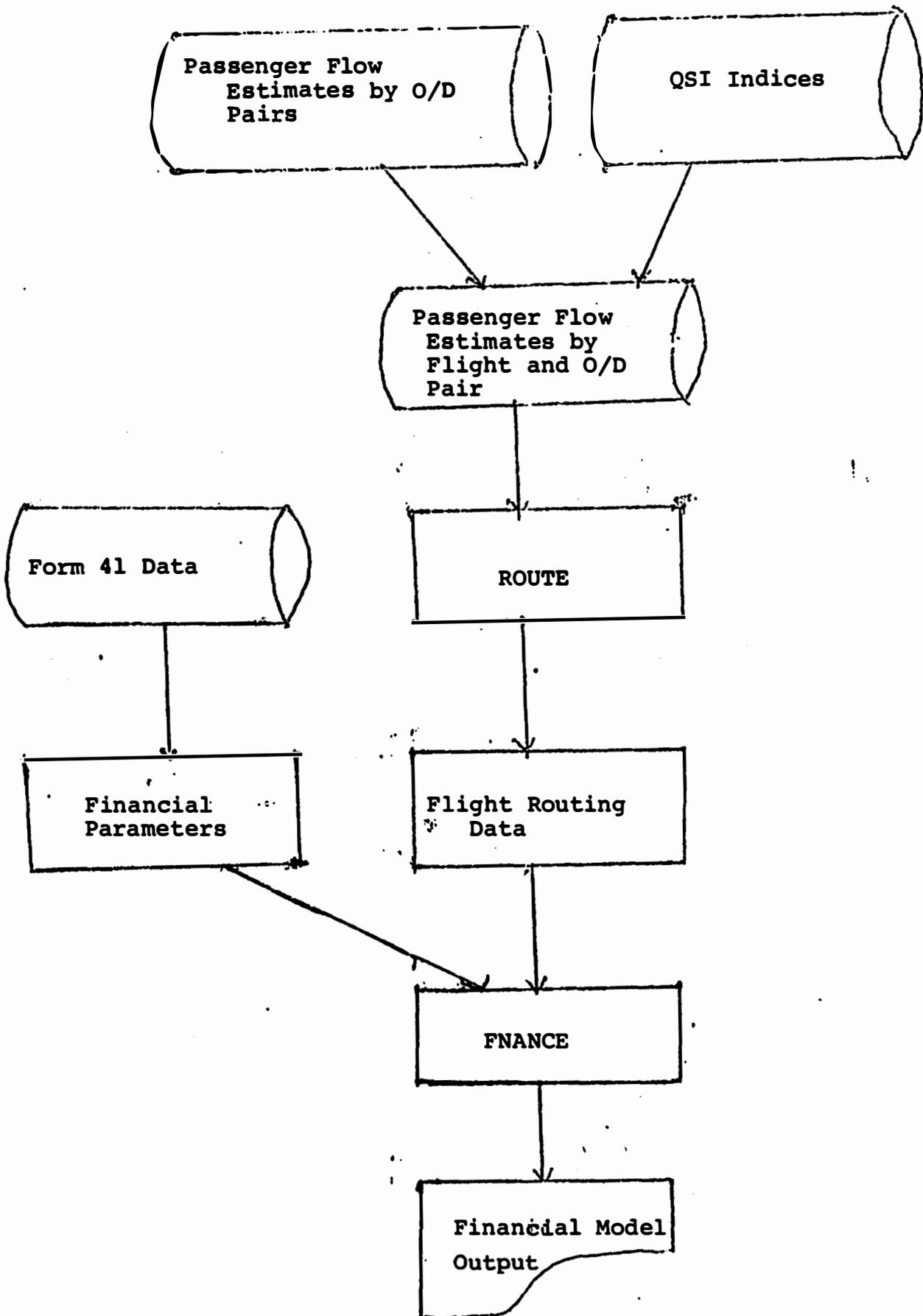
incidental passenger expenses

general and administrative costs

total costs

total revenue/total costs ratio

DATA FLOW DIAGRAM



Note, however, that the passenger loadings, revenues, load factors, and some of the costs are based on international traffic only, not domestic. Since in actual fact the domestic legs include sizeable domestic traffic, the preceding values, as well as the revenue/cost ratio, will be underestimated for these legs, though not for the over-the-water legs. Note also that revenue and cost information is not provided for foreign carriers.

2. For each flight, the totals for each revenue and cost category listed above, along with the average load factor and the average revenue/cost ratio.

3. For each carrier, a summary table containing, for each flight, the information (except for the origin and destination airports) outlined in category 1, for the over-the-water link of that flight (for foreign carriers, total passengers is shown instead of the revenue and cost figures).

4. For each carrier, the totals for each revenue and cost category listed above, along with the average load factor and the average revenue/cost ratio. Two such totals are shown, one including all links, and one including only the over-the-water links.

5. A summary for all carriers, showing for each carrier the over-the-water links summary described in category 4, and also showing a full summary consisting of total flights and

average load factor for all carriers combined and the totals for each revenue and cost category, as well as the average revenue/cost ratios, for all domestic carriers combined.

V. U.S. - FRANCE BILATERAL ANALYSIS

This section contains the results of two alternative methods of analyzing one particular issue in the U.S./France bilateral case study: the designation of an additional gateway for Air France in the U.S. After a brief discussion of the history of U.S./French bilateral agreements, manual and computer assisted analyses of several air service options are presented. [The computer analysis is not complete and is therefore not included in this version of the draft report.]

The scenarios studied consist of three potential service options involving nonstop and onestope Air France flights connecting San Francisco and Paris. The three options are:

1. Non-stop service from San Francisco to Paris, three times a week, using B-747 aircraft.
2. One-stop service through Chicago, seven times a week, using B-747 aircraft.
3. Two triangular routes connecting Los Angeles, San Francisco and Paris: four times a week originating in San Francisco through Los Angeles, three times a week originating in Los Angeles through San Francisco, using B-747 aircraft.

V:1 French Bilateral Agreement Background

Soon after the Bermuda I agreement with the United Kingdom, the United States and France signed an air transport service agreement on March 27, 1946. France was granted transatlantic rights to Boston, New York, Washington, Chicago, and Puerto Rico. The New York route had beyond traffic rights to Mexico; Chicago was to be served via Montreal; and Puerto Rico was to be served from Martinique via Guadeloupe with beyond rights to Haiti via the Dominican Republic. In addition, service was authorized to Manila via China and Hong Kong with the appropriate permission of the Government of the Philippine Islands.

The United States was granted transatlantic authority to Paris and beyond via intermediate points in Switzerland, Italy, Greece, Egypt, the Near East, India, Burma and Siam to Hanoi, and from there to China and beyond. The second route extended via Spain to Marseille and beyond via Milan, Budapest, and Turkey. The third route extended via Spain to Algiers, Tunis, and beyond to Egypt. The fourth route extended to Dakar, Pointe Noire, Brazzaville, and beyond to the Union of South Africa. The fifth route extended to Guadeloupe, Martinique, and beyond to French Guiana and South America. The sixth route covered the Pacific Ocean and New Caledonia and beyond to Australia and New Zealand. The seventh route extended to Manila, Saigon, and beyond to Singapore and Batavia. Finally, the eighth route contained Manila, Hong Kong, Macao, and China to Hanoi, and beyond via Siam, Burma to India and beyond.

The Bermuda capacity clauses were included in the agreement such that the capacity had to be related:

- (1) to traffic requirements between the country of origin and the countries of destination,
- (2) to the requirements of through airline operations, and
- (3) to the traffic requirements of the area through which the airline passes after taking account of local and regional services" (1)

The capacity was subject to ex post facto review. The fares charged had to conform with the procedures of the IATA traffic conference machinery. Furthermore, they were subject to the approval of the aeronautical authorities of the contracting parties and their level had to take into account all relevant factor such as the cost of operation, reasonable profit, the rates charged by other carriers, and the characteristics of the service provided.

On January 25, 1950, the agreement was amended; for the French carrier(s) the route from Martinique to Haiti (via Guadeloupe, Puerto Rico, and the Dominican Republic) was extended to Miami; for the U.S. carrier(s) the second via Spain to Marseille and beyond now had the option of service to Marseille or Nice.

In 1950 President Truman approved the merger between Pan Am and Overseas National and also asked the Board to authorize Pan Am to operate service into Paris (and Rome) in competition with TWA².

¹ Air Transport Services Agreement Between the United States and France. March 27, 1946.

² "Trans-Atlantic Test: PAA vs. TWA", Aviation Week, July 24, 1950. p. 45.

The certification of Pan Am into Paris caused the French to call for a consultation in order to protect Air France against excessive competition. The French government suggested the pre-determination of frequency but the U.S. negotiator insisted on leaving the frequency decision to the carrier.

In 1951 the agreement was amended again; Air France received Houston as an intermediate point on its Paris-New York-Mexico City run. The stop at Houston was granted by the U.S., presumably, to make up for the fact that France could not offer service to the Philippines (as authorized in the original agreement) since the Philippines became independent.³ In addition, the U.S. agreed to submit disputes (that could not be settled through normal consultations) to a tribunal of three arbitrators. Each Contracting Party was to designate one with the third to be chosen by the two arbitrators so chosen, provided the third arbitrator was not a national of either Contracting Party.

In July of 1958, the French threatened to terminate the existing bilateral agreement with the U.S. because of failure to obtain additional operating rights. The French government contended that Air France should be authorized to serve all U.S. cities from which U.S. flag carriers operate into Paris. The French action was the result of CAB's certification of TWA and PAA in 1957 to operate the Polar route from the West Coast to London and Paris. France was offered the Polar route but it was rejected as not being enough.

³ "U.S.-French Pact Clears the Air," Aviation Week, April 8, 1951 p.52.

Some observers felt that Air France was attempting to duplicate TWA's domestic routes; others felt that France was attempting to obtain for TAI, a privately-owned French carrier, the authority to operate service from Australia to the West Coast via Honolulu.⁴ Some of the U.S. carriers suggested not to take the French threat too seriously first, because of all international traffic carried by Air France, 26 percent is U.S. traffic; and second, because France has nothing to offer in exchange. France was, however, basing its threat on the fact that it is an important tourist area. An agreement was reached in 1959 when Air France was given access to the West Coast from Paris (Polar route to Los Angeles via Montreal without traffic rights between Montreal and Los Angeles). In return, the U.S. carriers were granted the right to serve Paris via London (without traffic rights between London and Paris) for service from the West Coast.

In 1962 there was a dispute between the United States and France that could not be resolved through the normal consultation procedure. Basically, the issue related to the fifth freedom traffic between Paris and Turkey on the one hand and between Paris and Iran, on the other hand. The issue was submitted to a tribunal for decision.

In 1969, the agreement was amended to include access to Philadelphia. In addition, minor changes were made to the routes in the Pacific. Finally, all-cargo service was authorized between the two countries.

⁴Doty, L.L., "U.S. Carriers Gird for Bilateral Battle", Aviation Week, August 11, 1958, p.31.

V.2 Manual Analysis of U.S.-French Bilateral: Air France Gateway

Table V.1 shows the passenger traffic data between the United States and France by U.S. port. The first column shows the on-board data extracted from the U.S. INS international travel statistics. These data include arrivals and departures, U.S. flag and foreign flag, and scheduled plus charter traffic. The second column shows that O-D data from the CAB files. In the third quarter 1977 Air France offered direct or nonstop service in the following markets:

- Anchorage - Paris (Nonstop B-747)
- Chicago - Paris (Onestop at Montreal B-747)
- Houston - Paris (Nonstop B-747) -- Beyond to Mexico
- Los Angeles - Paris (Onestop at Toronto B-747)
- New York - Paris (Nonstop B-747 and B-707)
- Washington - Paris (Nonstop SSC)

Subsequently the service between Chicago and Paris, and between Los Angeles and Paris was upgraded to nonstop. The question now is, which new city or cities would be of interest to Air France?

A quick glance at Table V.1 column 1 shows that based on INS data, the French should be interested in Boston, particularly since they already have the rights to serve this city in the existing bilateral agreement. From these data it would appear that Boston is as important as Chicago, Los Angeles, and Washington, D.C. This inference is further supported by the CAB data. However, Boston is presently served by TWA and Braniff. Therefore, whereas the current level of traffic may be sufficient for the existing carriers, introduction of nonstop service by Air France may fragment

Table V.1

U.S. - FRANCE PASSENGER TRAFFIC - 3RD QTR 1977

	INS Onboard Data	CAB O-D Data
Anchorage	632	30
Atlanta	---	860
Boston	25,649	7,900
Chicago	31,853	5,410
Dallas	147	1,490
Denver	---	1,290
Detroit	1,754	1,800
Honolulu	---	480
Houston	13,496	1,600
Los Angeles	30,286	10,750
Miami	14,111	6,620
Minn/St.Paul	---	830
New Orleans	155	1,530
New York	266,507	30,540
Newark	531	
Philadelphia	172	1,430
San Francisco	---	8,180
San Juan	245	400
Seattle	24	1,200
Washington, D.C.	24,859	9,460

the traffic base to make it unattractive for three carriers to offer such service.

The next alternative, again based on the data shown in Table V.1 alone, would be to consider Miami. Again, Miami is presently served by two carriers, National and Aeromexico; the latter offers nonstop service as well as onestop through Madrid. Therefore, Air France would be sharing the total traffic among the three carriers, only this time the total base is smaller than in the case of Boston.

The third option would be to consider San Francisco. The INS traffic data shows no information because there was no non-stop service in the third quarter of 1977. The CAB O-D data, on the other hand, show a significant potential, almost at the level of Boston, and Washington, D.C. It is less than Los Angeles but more than Miami. In May of 1979, San Francisco still did not have nonstop service; TWA served the market with onestop at JFK; moreover, TWA's flight calls for a change of aircraft at JFK. Therefore, at first glance, it would appear reasonable that Air France would be interested in serving San Francisco either nonstop or onestop with one of its existing flights through Chicago, Montreal, or Toronto. One must, however, consider two possibilities; first, in order to compete more effectively, TWA may decide to upgrade its service to nonstop; and second, with improved service available from San Francisco, traffic at other cities such as Los Angeles, Houston, Chicago, New York, and Boston may decline. After all, a large percentage of the total originating traffic at San Francisco is presently making connections at these cities.

On the other hand, nonstop San Francisco-Paris flight will be able to attract some passengers from the San Francisco-London Pan Am nonstop, passengers who are ultimately destined for Paris with connection at London.

Let us examine these three cases another step. First, take the case of Boston-Paris. Out of a total of 25,289 passengers, charter carriers transported 9,706 passengers leaving 15,582 for scheduled service. TWA carried this traffic on 182 flights averaging approximately 86 passengers. This produces an average load factor of about 61% with a B-707 accommodating say 140 passengers. Assume that traffic growth has been 15% per year in the last two years. This would provide a total of 20,600 passengers for the third quarter 1979 for scheduled service. This traffic must now be shared with Braniff which presumably will go to at least four nonstops per week and three onestops, thus providing daily service. The carrier presently has started with service three times a week (2 nonstop + 1 onestop) using B-747. In addition, TWA has substituted a larger aircraft, namely the L-1011. Therefore, given everything remains the same, it is doubtful that Air France would be interested in Boston, despite the fact that it has had traffic rights here since 1947. This analysis can be taken one step further by considering traffic beyond Paris. However, such data are not readily available.

Consider now the case of Miami. In the third quarter 1977, scheduled traffic consisted of 13,868 passengers. This traffic was handled by primarily National with 106 flights averaging a load factor of about 47% with 280 seats in the DC-10. Again, as

in the case of Boston, Miami-Paris can not sustain another carrier, especially since Aeromexico is also authorized to serve this market. Once could make a case for service by Air France based on beyond traffic on either or both ends. There is however another factor at play here. Air France is presently serving the Caribbeans from Miami; for example scheduled service is offered in the Miami-Haiti-San Juan-St.Maarten-Guadeloupe-Martinique markets. In addition, Air France serves the Martinique-Paris market. It may therefore be possible to link these two services (Caribbeans) with Paris-Miami service to make the latter service economically viable.

The third case concerns service in the San Francisco-Paris market, presently served by TWA with onestop at JFK. From San Francisco connecting service is available at Houston, Chicago, New York, Miami, Montreal, Boston, Dallas Fort Worth, London, and Los Angeles. If nonstop or onestop service is offered by Air France in the San Francisco-Paris market, then each of these connecting flights would loose a small share; however the loss for each would be insignificant. TWA might, however, institute a nonstop service to compete more effectively with Air France. Stimulation would also be insignificant.

The question now remains as to whether the San Francisco-Paris market can accommodate two effective carriers. Unfortunately, there are no INS data to answer this question. There are, however, the CAB O-D data that showed a passenger count of 8,180 during the third quarter of 1977. Given all the limitations of these data, such as U.S. carriers representation only, one would assume that

such a level is sufficient to warrant two carriers. For example, Los Angeles-Paris market, which has two carriers (TWA and Air France), shows the CAB's reported data to be 10,750. In this market, TWA's onestop competes with the nonstop of Air France. Therefore, based on this back of the envelope examination, it appears that it would be in the interest of Air France to seek San Francisco, either with nonstop authority, or with one stop authority. The stop can either be in the United States, such as Chicago, or in Canada, such as Toronto or Montreal. The ideal solution may well be with a stop in Montreal but including local traffic rights between Montreal and San Francisco.

For the first cut assume that the ratio of CAB and INS data is the same in the Los Angeles-Paris market as in the San Francisco-Paris market. This would have provided a total of 23,045 passengers in the San Francisco-Paris market. Assuming the ratio of charter to scheduled traffic is the same as in the case of Los Angeles provides a total of 17,678 passengers for scheduled service. This base provides about 200 passenger per day between San Francisco and Paris. Based on this traffic two carriers cannot support daily nonstop service in each direction. Therefore both carriers are likely to offer onestop service. Furthermore since the United States and Canada are unlikely to grant fifth freedom rights, the most likely choice by Air France would be to serve Paris-San Francisco with onestop at Chicago.

V.3 Specific Scenario Analysis

Option I - SFO-CDG Nonstop service by AF three days/wk.

Since there are no INS data for this market, it is necessary to estimate the traffic potential in the SFO-CDG market. For a first estimate assume that LAX-CDG and SFO-ODG are comparable markets.

STEP 1. LAX-CDG 3rd QTR 1977

Origin-Destination CAB data = $10750 + 700 = 11,450$

(700 pax. is the estimated traffic on AF)

INS scheduled traffic = 23,233

Ratio of INS/CAB traffic = $23,233/11,450 = 2.029$

Step 2. Estimate of SFO-CDG "INS" traffic = $2.029 \times 8,180 = 16,600$
where SFO-CDG "O-D" traffic is 8,180

Step 3. Assume that TWA will go to daily nonstop service with L-1011 (280 seats) while AF will offer three nonstops/week with B-747 (350 seats)

LOS: TWA 7/10; AF 3/10

Step 4. Traffic Potential - Assume market share is directly proportional to frequency share

, TWA pax = $(7/10) 24,200 = 16,940$

AF pax = $(3/10) 24,200 = 7,260$

Step 5. TWA daily pax = $16,940/180 = 94$ assuming 180 flights/quarter

AF daily pax = $7,260/78 = 93$ assuming 78 flights/quarter

TWA Load factor = $94/280 = 34\%$

AF Load factor = $93/350 = 27\%$

Based on these assumptions AF option does not appear to be economically viable.

OPTION II AF Daily onestop service to SFO via Chicago while TWA would upgrade to nonstop daily service

STEP 1. The 24,200 passengers will now be shared:
(7/11.9) x 24,200 = 14,235 for TWA
(4.9/11.9) x 24,200 = 9,965 for AF
Assuming that a onestop flight is worth 70% as a nonstop flight from the viewpoint of pax. attraction.

STEP 2. TWA Load factor = $\frac{14,235}{180 \times 280} = 28\%$
AF Load factor = $\frac{9,965}{180 \times 350} = 16\%$

STEP 3. However, AF would have a higher load factor on the CDG-SFO segment.

3rd QTR 1977 - CHI CDG Traffic

AF Arrivals = 6,107
Departures = 5,374
Total = 11,481

1979 Traffic Potential = 11,481 x (1.15)² = 15,184

	<u>CDG-CHI</u>	<u>CHI-SFO</u>
Total pax.	25,149	9,965
Daily pax.	140	55
L.F.	40%	16%

∴ AF Service to Chicago is economically viable, but it is marginal to SFO.

OPTION III

4 Days/wk Nonstop to LAX
 Onestop to SFO
 Nonstop to CDG

3 Days/wk Nonstop to SFO
 Onestop to LAX
 Nonstop to CDG

Assuming the traffic from both cities can be combined, the total potential between Los Angeles and San Francisco, and Paris represents 58,000.

$$\text{LAX-CDG} = 23,233$$

$$\text{SFO-CDG} = \underline{16,600}$$

$$\text{Total 3rd QTR 1977} = 39,883$$

$$\begin{aligned} \text{Total 3rd QRT 1979} &= 39,883 \times (1.15)^2 \times (1.10) \\ &= 58,000 \end{aligned}$$

Assuming that both TWA and AF offer daily service (either nonstop or onestop or some combination) between the West Coast market and Paris, each will have access to 29,000 passengers.

$$\text{TWA Load factor} = \frac{29,000}{180 \times 280} = 58\%$$

$$\text{AF Load factor} = \frac{29,000}{180 \times 350} = 46\%$$

This level of traffic and service would produce economically viable operations for both carriers.

VI. RECOMMENDATIONS FOR CONTINUED DEVELOPMENT

The International Air Analysis model, in its current state of development, can best be described as a preliminary working version of the prototype model system. All of the basic computational components of the model have been programmed, integrated and initially tested and debugged. Continued planned development of the prototype system is needed in order to improve and enhance the data bases, refine model algorithms and make the computer code and system interface work more efficiently.

Beyond these tasks, there exists significant potential to greatly improve the validity of the modeling approach and to increase the model's capacity to provide a broader range of impact measurements under a wider range of air service scenario contexts. These model enhancements would move the International Air Analysis model from a prototype system toward a fully usable and reliable policy analysis tool.

The specific tasks needed to implement these changes are described below. They have been listed roughly according to TSC's perception of priority. Initial cost estimates are provided for use in making estimates of resource requirements and in grossly costing out alternative work programs.

VI.1 Expand the North Atlantic Data Base

In reducing the size of the original CAB 10% Sample of International Air Travel Tickets, certain records which represented travel from smaller, regional airports and travel on infrequently used itineraries were temporarily set aside. The first priority task is to develop methods (such as aggregation and summarization) to reintroduce the additional travel information contained in these records.

A second high priority item concerns the estimation of travel as air service itineraries in which only foreign carriers are involved. The current prototype model incorporates an algorithm in which the proportion of traffic on a foreign carrier itinerary is set equal to the proportion of QSI represented by that itinerary. The proposed improvement would use as control totals the on-flight traffic statistics generated from the INS I-92 data base. The actual foreign carrier traffic would be apportioned to representative foreign carrier only flights and itineraries with domestic U.S. connections. The method to be employed would be proportional scaling of international traffic to a known set of control totals.

VI.2 Operationalize and Improve the Supply Submodel

The existing supply level of service generation routines manipulate data contained in the automated OAG data base to produce estimates of the Quality of Service Index for international flight itineraries. A significant amount of consolidation and streamlining of currently available functions is warranted. In addition, a methodological improvement in which level of service parameters calculated only for travel itineraries represented in the demand/routing file would replace a more computational inefficient routine which calculates LOS figures for all possible combinations of connecting itineraries.

The final task under this heading is to develop a new routine for determining which origin and destinations should be connected by a new international flight. The method to be analyzed would use a circuitry rule such that a city would have a connection with the new international flight if the extra distance (or travel time) needed to make the connection is not greater than some percentage of the total O/D distance (travel time).

VI.3 Model Validation

Up to this point in the model development process the analyst has no clear indication as to the degree of accuracy of the model's travel impact estimates. It is

extremely important that a validation study be undertaken prior to the commitment of significant amounts of additional resources to continued model development. Two types of validation may be feasibly undertaken. The first is to repeatedly execute the model in such a way as to produce estimates of travel impacts due to changes in key parameters. The results of this sensitivity analysis can be compared to outcome predicted in other studies and/by informed professional opinion.

The second type of validation is to perform a before/after analysis of specific changes in the provision of air service so that the models predictions can be compared to actual experience.

Both types of validation are valuable. It is suggested that if funding is a problem that only sensitivity analysis using the prototype model be undertaken initially and before/after validation be delayed until after more substantial changes are made to the model's structure.

VI.4 Demand Model Reestimation

Once the machinery of the demand data base and the supply data base are in place they will constitute an unprecedented test bed for calibrating international air travel market share demand models. The market share QSI can be retailored from the ground up or, at the other extreme, the proper way to include a single extra factor in concern with the present QSI can be determined. The need for a new market share model, similar to QSI but based on more factors and calibrated for the international air markets of interest has probably been long appreciated. The validity or quality of performance of the current QSI will be readily exhibited and for comparison other formulations may be similarly tested. The form of the data would be very amenable to standard analytic estimation techniques. The supply characteristics for thousands of routings for hundreds of O/D pairs will be readily available and matched with observed demand levels. This is the form needed for calibrating a demand model.

The share of traffic which should be expected for new service offerings can only be estimated accurately when one has an accurate, quantitative, characterization of the

TABLE VI.1

Demand Model Components

- o In Vehicle Travel Time
- o Transfer Time
- o Airport Access and Egress Time and Cost
- o Fare
- o Flight Frequency and Schedule
- o Aircraft Type
- o Number of Intermediate Stops and Connections
- o Probability of Delay (Airport Congestion)
- o Probability of a Booked Flight (Schedule Delay)
- o Carrier Market Appeal
- o Trip Purpose
- o National Origin of Travelers
- o Traveler Socioeconomic Characteristics
- o O/D Socioeconomic Characteristics

VI.5 Financial Model Improvements

Two basic improvements to the financial impact assessment routines are to extend the analysis to foreign carriers, if feasible, and to develop routines which take capacity limitations into account when assigning passengers to flights. The financial data currently employed by the model is readily available from the CAB Form 41 data base. These data extend only to US carriers, however, and suitable foreign carrier information has been, so far, impossible to obtain. In order to develop financial impact information for foreign carriers some, more or less, stringent simplifying assumptions about the cost structures of the foreign air industry have to be made. Of course, all available data sources, including CAB files will be investigated. In the event that little or no useful foreign carrier cost information can be obtained, the model will be modified to produce financial impacts based on a user specified cost structure.

The second model modification involves recalibrating the algorithm which assigns passengers to specific flights. The 10% sample data base does not in every case uniquely identify which flights constitute a travel itinerary. Therefore, a routine is required to assign passengers to specific flights when more than one flight serves the same water leg (defined as two origin/termination points and the carrier of an international flight). The proposed change would make the algorithm

sensitive to airplane capacity so that the model would not attempt to load flights beyond their capacity.

VI.6 Case Study Analysis and Extension of Model to New World Areas

The extension of the International Air Analysis Model to a new world area, either Latin America or Asia, involves repeating the same process that was applied to Europe to a new set of air service locations. The European case required the development, from scratch, of a complete set of computer programs. For a new world area only minor modifications of these programs will be needed. The major expense is involved in reprocessing the 10% Sample and OAG data bases in order to derive a base case description of air service and traffic patterns.

The analysis of a bilateral case study in an existing world area requires the definition of air service scenarios, execution of the International Air Analysis model and analysis and interpretation of results. Only minor modification is required to output reporting routines for the purpose of specifying data extraction parameters and customizing report formats.

VI.7 Other Model Improvements

Included under this heading are the following model improvements and feasibility studies:

1. Estimation of 5th and 6th Freedom Traffic
2. Impacts Assessment for U.S. Domestic Feeder Carriers
3. Estimating annual Air Travel Impacts
4. Charter Operation Feasibility Study
5. Fare Class Demand Analysis Feasibility Study

Fifth and sixth freedom traffic refers to the second and third country (in the present contest, the intra-European) traffic that is picked up along the route of a multi-stop international flight. An example would be the traffic between Paris and Rome taking TWA flights 848 with itinerary ORD/CDG/FCO/TLV. This traffic often is quite important to the economic viability of international air routes. The proposed work task involves the extraction of the data for U.S. carriers from the CAB 10% Sample data base, its processing and incorporation into the International Air Analysis Model's financial calculations.

A second task would be to measure the traffic impact on U.S. domestic feeder carriers caused by changes in international air service. Because the travel demand data base contains information about complete itineraries, estimates of change in traffic on connecting carriers can be readily determined. To accomplish this a new computer routine (producing a suitable

report) will be written and integrated into the model system.

The International Air Analysis model currently operates on data for only the peak quarter of 1977. In order to produce annualized traffic and financial impacts resulting from air service changes two alternative strategies can be employed:

1. Develop an off peak analog to the peak period model
2. Develop factors which represent the ratio of annual levels of traffic and air service to peak period levels, as based on historical experience.

One or both of these methods could be pursued as a development tasks.

Two feasibility studies are identified as tasks for continuing model development: charter operations and fare class demand analysis. Because very little previous analytical work has been done in these areas, it is appropriate that preliminary studies be undertaken to define the methodological possibilities and constraints for future R&D efforts. The feasibility studies would identify available data sources and methodological approaches and also would define a work program for incorporating charter and fare class analysis into the International Air Analysis system.

attractiveness which results from the characteristics of each competing flight or route. It seems very likely that the current QSI is inadequate for the accuracy that will be needed to provide certain types of information (such as load factors or even market share for foreign carriers) to the accuracy that will be desirable in the negotiation process. The degree to which the current QSI is inaccurate can only be fully assessed with a comprehensive data base such as these models will represent when fully developed.

Conversely, the effort and resources which go into developing the comprehensive data base and joining programs, as discussed in Chapters II, III, and IV together with improvements discussed above in this section, depend for their usefulness on an accurate market share formula. This formula would most likely be similar in type to the QSI methodology, but would need to be recalibrated and expanded to include more factors such as some of the ones listed in Table VI.1. At that point the fidelity of the demand model would be consistent with the accuracy and detail of the demand data base (from the 10% sample and I92), the supply data base (derived from the international and domestic OAG).

Similar statements can be made about that aspect of the demand model which calculates traffic stimulation due to changes in the provision of international air service. However, for stimulation analysis a new data base which includes before and after market traffic and flight level of service data must be constructed. In addition, the structure of the stimulation relationship and the factors which it incorporates may differ but must be consistent with the market share algorithm.