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B-747 FLIGHT CONTROL SYSTEM MAINTENANCE AND RELIABILITY DATA BASE FOR COST EFFECTIVENESS TRADEOFF STUDIES

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1.0 SUMMARY

This study reviewed maintenance characteristics of the B-747 flight control system to establish a baseline for future avionic design tradeoff studies. Actual airline operations data were used.

Mechanical, electronic, and hydraulic elements of the Boeing Model 747 flight control system were studied. System reliability, maintenance and delay costs, and an appraisal of maintenance resources to support a B-747 fleet provided a data base that was used to support analysis of an active wing load alleviation concept for the B-747.

A baseline for flight control component failure rates and maintenance costs was established using B-747 data from previous studies that were verified by observing similarities in data between two airlines sources. Reliability analyses, using the CARSRA computer program for three functions combining automatic and primary flight controls, gave predicted results for two dual-channel systems and one single-channel system. Failure probabilities for a typical 4-hour B-747 flight were 0.58×10^{-2} for flight control using dual autopilot input and 0.11×10^{-5} for the dual yaw damper system. The single-channel autothrottle failure probability was 0.12×10^{-3} per flight. System failure probabilities showed little change when failures due to electrical wiring and connectors were included.

Pan American World Airways was selected to supply data on the B-747 operating environment and flight control maintenance resources. Data synthesis provided an inventory of airplane-installed hardware costs, spares cost, and ground support and test equipment costs. It showed that B-747 flight control electronic hardware cost is similar to that for primary mechanical flight controls, but that the spares and support and test equipment costs for flight control electronics were over six times the equivalent costs for primary mechanical flight controls.

Annual expenditure comprising direct maintenance, burden, outside service, and delay and cancellation costs for 1978 were 10% of the value of the hardware, spares, and support and test equipment.

The effects of installing an active wing load alleviation (WLA) system on a B-747 showed that the initial price of a WLA system was more sensitive than maintenance cost, as the concept produced an increase in flight control maintenance cost of 5% and an increase of 15% in installed hardware cost including spares. The reliability of the WLA was similar to that of the B-747 yaw damper system.

Data collected on a large and mature B-747 fleet and analysis conducted in this study have provided a broad data base on a current flight control system using mechanical, electronic, and hydraulic devices.

2.0 INTRODUCTION

The "B-747 Flight Control System Maintenance and Reliability Data Base for Cost Effectiveness Tradeoff Studies" was a 15-month effort sponsored by the Flight Electronics Division at NASA Langley Research Center. The purpose of the study was to provide a flight control system data base consisting of hardware costs, maintenance costs, and system reliability, and to use this data base to perform reliability and maintenance cost analyses of an active wing load alleviation concept for the B-747.

2.1 SCOPE

To satisfy the study purpose, the following tasks covering data collection and analyses provided the data base.

Perform reliability analyses using the CARSRA (Computer Aided Redundant System Reliability Analysis) computer program to determine failure probability and functional readiness of the combined primary and automatic flight control system that consists of mechanical, hydraulic, and electronic components including connectors and wiring.

Use the component maintenance data to determine labor, material, and delay and cancellation costs for the B-747 flight control system.

Collect airline maintenance and B-747 fleet operating data for a main base, large hub, turnaround, and en-route line stations in the following groups:

Aircraft Fleet Data

- Spares inventory costs
- Installed equipment cost, weight, and scheduled inspection intervals
- Maintenance training costs

Line Station Data

- Spares holding costs, pooling activity, and pipeline quantities and times
- Delays, cancellations, diversions, and air turnbacks
- Line labor and ground support equipment
- Aircraft turnaround time
- Maintenance manpower and skill levels

Main Base Data

- Shop overhaul and automatic test equipment
- Outside services and maintenance overhead
- Maintenance manpower and skill levels

Use the data base for predictive analyses using the CARSRA program of a wing load alleviation concept for the B-747 and make comparisons with the B-747 flight control system in terms of system reliability and maintenance costs.

2.2 STUDY APPROACH

The B-747 combined primary and automatic flight control system data base was accomplished in two parts. First, a component baseline containing failure rates and maintenance costs was established, sufficient to perform the reliability analysis and determine the combined flight control system maintenance cost. Second, data were collected from a B-747 operator to provide a description of the fleet operating environment and maintenance resources to support the combined flight control system. These data were used to assess hardware costs and annual maintenance and delay costs.

2.2.1 Previous Studies and Data Sources

Information on component reliability and maintenance data was assembled from two reports. The first report, "Flight Control Electronics Reliability/Maintenance Study," was sponsored under contract NAS1-13654 (ref. 1), a follow-on to the Airborne Reconfigurable Computer System, or ARCS, program. The second report, "B-747 Primary Mechanical Control Systems Reliability and Maintenance," contract NAS1-14742 (ref. 2), was conducted as part of the Energy Efficient Transport (EET) element of the Aircraft Energy Efficiency (ACEE) program. Connector and wiring data for the flight control system evaluation were obtained from Pan American World Airways, which is referred to as Pan Am throughout the remainder of this report. The data also covered 12 months of B-747 operation and included details on the fleet, the operating environment, and maintenance resources and costs pertaining to the flight control system.

The wing load alleviation analysis used a report titled "Conceptual Studies of Wing Tip Extensions, Winglets, and Wing Load Alleviation for the Boeing 747 Energy Efficient Transport," contract NAS1-14741 (ref. 3).

2.2.2 Component Maintenance and Reliability

Failure rates and maintenance labor and material cost data for electronic components came from two airlines, Pan Am and United Airlines. It was decided to retain the Pan Am data as the baseline because the airline was used for supplying additional information. For the mechanical and hydraulic elements of the flight control system, several airline sources were used. The reference 1 and 2 reports also provided descriptions of the flight controls.

The reliability analysis using the CARSRA program evaluated three control functions: flight control with autopilot input, stability augmentation from the yaw damper, and airplane speed control using the autothrottle. The reliability of flight control with autopilot input reflects a two-channel, fail-passive system; the yaw damper reliability reflects a two-channel, one-fail operational system; and the autothrottle reliability reflects a single-channel, fail-passive system. These functions are not required for dispatch. High reliabiliity performance is an economic rather than a safety consideration. The primary flight control system does require a high level of reliability that is achieved in part through dual load path mechanical elements and dual tandem hydraulic actuators with power from four independent hydraulic systems. The primary flight control system does not use digital computation for control.

A special study on flight control connector and wiring reliability and maintenance costs used pilot report information supplied by Pan Am. The existence of problems with connections between electronic equipment is well known, and this study was able to quantify these problems in terms of reliability and cost. The study concludes that particular attention may have to be paid to future designs if wiring use is expanded. Wiring and connector problems for the hydraulic control and indicating subsystem also were evaluated for comparison with the flight control environment. The system reliability analysis was recycled to include wiring and connector failures and a determination made as to the sensitivity of the system to connector and wiring failures.

2.2.3 Pan Am B-747 Data Collection

The data collection task in this study primarily involved an assembly of costs relating to hardware and operations of the 747 combined flight control system sufficient to provide an economic appraisal of current technology. Operational data were collected from Pan Am on their 747 route network, scheduling pattern, and resources required to support the operation. The data included information regarding Pan Am's 747 fleet composition, its operating system of stations, flight frequencies by stations and airplane type, and airplane transit times. Resource and cost data for these stations included the number of assigned maintenance personnel, allocated spares and pooling involvement, flight delays and labor costs. Delays and cancellation costs were determined using algorithms from the "Primary Flight Control System" (ref. 2) report.

The resources and costs for main-base operations included maintenance and engineering functions, an inventory of spares, ground support equipment, automatic test equipment, component repair, and training costs. This last item is one of many activities included in maintenance burden: that portion of operating costs not directly related to specific airplane or component maintenance. Burden includes such items as mechanic's sick leave, vacation, and cost of facilities.

2.2.4 Wing Load Alleviation

As part of the ACEE, EET program, Boeing investigated application to the B-747 of modified wing tips to improve aerodynamic efficiency and the use of outboard ailerons for active wing load alleviation (ref. 3). The objective was to improve fuel efficiency that could be realized either in terms of fuel saved for fixed range or an increased payload capability. The EET study results showed the principal economic benefits of WLA for 747 derivative applications would accrue from an airplane operational weight reduction relative to the same model without WLA. However, the fuel saved through weight reduction did not produce an attractive return on investment for the 747 EET airplane.

For comparison with a baseline combined flight control system, this study evaluated the WLA portion of the 747 EET modified airplane in terms of reliability and maintenance cost.

2.3 REPORT ORGANIZATION

The reliability and maintenance data base for the combined automatic and primary flight control systems is found in section 4.0 and is presented at the component level. This section also includes the reliability analysis for flight control, stability augmentation (yaw damper), and speed control (autothrottle) functions involving both mechanical and electronic elements.

The operating environment and maintenance resource data from Pan Am were synthesized and are presented as a discussion and cost summary in section 5.0. Data supporting this section are contained in the appendixes.

Prediction for reliability and maintenance cost of the WLA system is included in section 6.0

3.0 ACRONYMS AND ABBREVIATIONS

A/C	aircraft
ACS	aileron control system
ADF	automatic direction finder
ADI	attitude direction indicator
ADP	air-driven pump
AFCS	automatic flight control system
ALT	altitude
A/P	autopilot
APU	auxiliary power unit
ARCS	Airborne Reconfigurable Computer System program
ASTU	automatic stabilizer trim unit
ATA	Air Transport Association
ATC	air traffic control
ATE	automatic test equipment
ATR	air transport radio
CADC	central air data computer
CARSRA	Computer Aided Redundant System Reliability Analysis computer program
CB	circuit breaker
CCA	central control actuator
CDI	course deviation indicator
CDU	control display unit
CIWS	central indicating warning system
C/P	Cannon plug
DH	decision height
DMC	direct maintenance cost
DME	distance measuring equipment
EDP	engine-driven pump
F/C	flight control
FCS	flight control system
F/D	flight director
FH	flight hours
F/O	flight officer
G/S	glide slope
GSE	ground support equipment
HDG	heading
HSI	horizontal situation indication
IAS	indicated airspeed
IATP	International Airlines Technical Pool
I/B	inboard
ILS	instrument landing system
IND	indicator
INS	inertial navigation system
INU	inertial navigation unit

LAT	lateral
LCLU	landing control logic unit
LH	left hand
LOC	localizer
LRRA	low-range radio altimeter
LRU	line replaceable unit
LVDT	linear voltage displacement transducer
MAN	manual
MEL	minimum equipment list
MFG	manufacturing
MHRU	magnetic heading reference unit
MLU	monitor and logic unit
MSP	mode select panel
NAV	navigation
O/B	outboard
O/R	overrotation
PCU	power control unit
PFCS	primary flight control system
P/N	part number
PTW	pitch trim wheel
QTY	quantity
RH	right hand
R/T	radio transmitter
S/O	shutoff
SP	special performance
STIU	stabilizer trim interface unit
T/E	trailing edge
T/O	takeoff
TOD	top of descent
T/R	transmitter receiver
VOR	visual omni range
VS	vertical speed
WIT	work integrated training
WLA	wing load alleviation
WT	weight
WTE	wing tip extension
WTW	wing tip winglet
WYPT CHG	waypoint change
XCVR	transceiver
XMTR	transmitter
XTK	crosstrack distance

4.0 COMBINED FLIGHT CONTROL RELIABILITY AND MAINTENANCE COST

This section draws on results of the reference 1 and 2 reports on the 747 flight control system. Mechanical, electrical, and hydraulic elements of the 747 flight control system are included.

Reliability analysis was conducted during this study on the combined automatic and primary flight controls, with failures of electrical wiring and connectors treated separately.

Maintenance costs at the component level were extracted from the reference 1 and 2 reports and assembled in a common cost per flight hour and a common base year.

4.1 COMBINED FLIGHT CONTROL BASELINE SUMMARY

FCS Reliability—The combined automatic and primary flight control system functions (including mechanical elements, hydraulic elements, and electronic elements with associated wiring and connectors) were analyzed using the CARSRA program for the following functions:

- Flight control with autopilot input
- Yaw damper system
- Autothrottle system

The failure probability of the flight control function with autopilot input is 0.58×10^{-2} per 4-hour flight. The autopilot can operate on either one of two channels, but common components within the system preclude complete channel independence. The yaw damper system failure probability is 0.11×10^{-5} for the same flight length. This system has two independent channels and results in the lower failure probability. The autothrottle only operates during the last stages of a flight and has a failure probability for its single channel system of 0.12×10^{-3}.

The effect of combining wiring and connector failures with the associated component failures resulted in increasing black-box failure rates by an average of 16%. Flight instrument failure rates increased by 10%. System failure probabilities increased by 8%.

Flight Control Maintenance and Delay Cost—The cost of $7.85 per flight hour is split evenly for the flight control electronic elements and the primary mechanical control elements. Main base component repair accounts for $4.91 or 62% of the total, with delay and cancellation cost at 30% and line maintenance at 8%.

Correcting wiring and connector problems adds less than two cents per flight hour to flight control maintenance costs.

4.2 COMBINED FLIGHT CONTROL FUNCTION DEFINITION AND OPERATING REQUIREMENTS

The two previous studies pertaining to flight control electronics (ref. 1) and primary flight controls (ref. 2) collected reliability data and analyzed the following functions:

1. Category II autoland using the electronic elements of the automatic flight control system.

2. Rudder control, elevator control, lateral control, stabilizer trim and speed brakes using mechanical and hydraulic elements of the primary flight control system.

In the present study the automatic and primary flight control systems were combined. With a view to structuring the analyses in a manner that would form a baseline for comparison with future flight control concepts, the following flight control functions were analyzed.

Flight Control Using Autopilot—This system includes the electronic elements of the automatic flight control system (sensors, computers and servos), the mechanical elements (including the mechanism and cables from the servo actuator to the control surfaces), and the hydraulic elements (including the actuators).

Yaw Damper—This stability augmentation system provides natural yaw oscillation damping and also trim coordination; both functions using the rudders. Again, sensors, computers, servos, and actuators are included.

Autothrottle—This system provides speed control using engine thrust control during the approach and landing phases and consists of sensors, and a computer and servo to automatically move the throttle levers.

The components for these three functions are listed in table 1.

Table 1. Combined Flight Control Components

	Flight control using autopilot	Yaw damper	Autothrottle
Control/ display units	Mode select panel (MSP) Autopilot controller Flight mode annunciator Attitude director indicator (ADI)	Control panel	Mode select panel (MSP)
Sensors	Accelerometer Stabilizer trim interface unit (STIU) Accessory boxes 1 and 2 Inertial navigation unit (INU) VOR/ILS navigation receiver Compass coupler Low-range radio altimeter (LRRA) Central air data computer (CADC)	Linear voltage displacement transducer (LVDT)	Accelerometer
Computers	Roll Pitch Monitor and logic unit (MLU) Automatic stabilizer trim unit (ASTU)	Yaw	Autothrottle
Servo components and actuation	Central control actuator (CCA) servo Aileron power control unit (PCU) Spoiler power control unit (PCU) Elevator power control unit (including servo) Stabilizer trim control module Stabilizer trim motor and jackscrew	Rudder power control unit (PCU) (servo and actuator)	Autothrottle servo

Operating Requirements—For flight control using autopilot, the operating requirements differ according to flight phase. Control can be achieved by manual means using turn knobs or automatically using navigation sensor commands.

Autopilot commands are coupled into the primary flight control system via parallel servo actuators. Thus, the control wheel and column, as well as the control surfaces, move in response to autopilot commands.

Single channel autopilot operation is used in all modes except LAND, which requires both A and B channel operation. In single channel operation, either the A channel or B channel autopilot may be selected. The pilot can overpower the autopilot at any time by applying modest force at the control wheel.

During dual channel operation, both autopilot actuators are coupled to the manual controls via respective force detents. The airplane will track the autopilot command having the lesser value. If one autopilot fails passive, the resultant output is nearly zero. Thus the dual channel servo actuator system provides true "fail passive" operation for use in the LAND mode.

Appendix A is a description of a typical flight using the autopilot and includes the various autopilot modes, the various flight phases, and a glossary of modes. Based upon this description, a typical flight can be broken down into phases and equipment requirements for different flight times. Table 2 shows these flight phases and exposure times for 1-, 4- and 8-hour flights.

Table 2. Flight Phases for Combined Flight Control Systems

Flight phase	System operation[a]			Flight phase exposure times (min)		
	Yaw damper	Autopilot	Auto-throttle	1-hr flight time	4-hr flight time	8-hr flight time
Takeoff	√	–	–	1.00	1.00	1.00
Climbout to 1500 ft	√	–	–	2.00	2.00	2.00
Climb to cruise altitude	√	Single channel ↓	–	15.00	24.00	24.00
Cruise	√		–	25.50	190.50	430.50
Descent	√		–	9.00	15.00	15.00
Initial approach	√		√	5.00	5.00	5.00
Final approach	√	Single or dual channel	√	2.25	2.25	2.25
Landing (flare to touchdown)	√	Single or dual channel	√	0.25	0.25	0.25

[a]See table 1 for elements included in the system.

Failure probabilities were computed for each flight phase and the total flight. Functional readiness was computed at the beginning of the final approach phase together with failure probabilities during this phase.

The yaw damper is required for stability augmentation throughout the flight and the analysis determined the failure probability during flight time.

Functional readiness for the autothrottle was computed at beginning of the approach and land phase and the failure probability during this phase. Table 2 identifies flight phase requirements and times.

4.3 COMPONENT FAILURE RATES

The data sources for the primary mechanical controls were several airlines' component removal reports, covering the years 1970 through 1976, and repair shop records. This long time period was necessary because of the low removal rates for these items. The high removal rate of the electronic components permitted a valid data base to be obtained from a single airline, Pan Am, over a 1-year period. Observing a strong similarity of United Airlines rates with Pan Am lent confidence in the validity of selecting Pan Am data. Table 3 shows the failure rates that were used in the reliability analysis for this study.

Table 3. Component Failure Rate Summary

Component	Failures/ 10^6 unit hr
Flight control electronics	
Major computers	
Pitch computer	438.0
Roll computer	400.9
Yaw computer	202.4
Monitor and logic unit	258.3
Automatic stabilizer trim unit	372.9
Autothrottle computer	122.7
Dedicated sensor, servo, and display elements	
Mode select panel	660.6
Autopilot controller	85.2
Normal accelerometer	0.0
Stabilizer trim interface unit	24.7
Automatic flight control system access box 1	22.0
Automatic flight control system access box 2	4.8
Linear voltage displacement transducer	1.7
Autothrottle servo	0.0
Attitude direction indicator	160.1
Shared sensor system	
VOR/ILS receiver	151.3
Low-range radio altimeter	136.7
Inertial navigation system	654.9
Central air data computer	328.5
Compass coupler	154.2

Note: Data source—Pan Am (1977), excludes wiring and connector failures

Component	Failures/ 10^6 unit hr
Primary mechanical controls	
Elevator	
Inboard elevator autopilot servo	11.7
Inboard elevator power control unit	1.6
Outboard elevator power control unit	0.5
Stabilizer trim	
Hydraulic motor	10.2
Hydraulic brake	1.7
Shutoff valve	3.2
Control module (hydraulic)	0.7
Control module (electrical)	2.1
Lateral control	
Central control actuator	7.0
Inboard aileron power control unit	1.2
Outboard aileron power control unit	0.7
Inboard spoiler power control unit	0.3
Outboard spoiler power control unit	0.4
Rudder control	
Rudder servo	1.8
Rudder power control unit	1.6

Note: Data source—several airlines (1970–76)

The methodology for evaluating failure probability and functional readiness of the three functions was to model each function for the specific analysis tool called CARSRA; a general purpose reliability analysis program that handles modular redundant systems, CARSRA is described in the reference 2 study.

The system to be analyzed is partitioned into stages and modules, where a module is a set of elements performing a specified function. Each stage is modeled by a Markov model describing the different redundancy states of the stage. Dependencies between stages are indicated by lines connecting the stages and the direction of a dependency is indicated by an arrowhead.

The reliability analysis was recycled to include the wiring and connector failures evaluated in section 4.6. Table 4 shows the revised failure rates, which include connector and wiring failures apportioned to the component.

Table 4. Component, Connector, and Wiring Failure Rates

Component	Component failures/ 10^6 unit hr	Component plus connector and wiring failures/ 10^6 unit hr
Major computers		
Pitch computer	438.0	540.3
Roll computer	400.9	471.3
Yaw computer	202.4	218.9
Monitor and logic unit	258.3	310.4
Automatic stabilizer trim unit	372.9	394.8
Autothrottle computer	122.7	128.2
Dedicated sensor, servo, and display elements		
Mode select panel	660.6	666.1
Autopilot controller	85.2	85.2
Normal accelerometer	0.0	0.0
Stabilizer trim interface unit	24.7	38.4
Automatic flight control system	26.8	32.3
Linear voltage displacement transducer	1.7	1.7
Autothrottle servo	0.0	0.0
Attitude direction indicator	160.1	168.3
Shared sensor system		
VOR/ILS receiver	151.3	195.2
Low-range radio altimeter	136.7	142.2
Inertial navigation system	654.9	708.8
Central air data computer	328.5	414.9
Compass coupler	154.2	173.4

4.4 COMBINED FLIGHT CONTROL RELIABILITY ANALYSIS

Analyses for the three flight control functions are contained in section 4.4.1, Flight Control Using Autopilot; section 4.4.2, Yaw Damper; section 4.4.3, Autothrottle.

4.4.1 Reliability Analysis—Flight Control Using Autopilot

The first step in the CARSRA analysis is to assemble the required equipment modules in the form of a dependency tree shown in figure 1. Each module is shown as a rectangular block, with the "angle" at the top right corner indicating another module of the same component name. The dependency tree represents the system configured for single channel operation in the cruise and descend flight phase. Module dependencies change according to flight phase. Table 5 lists the requirements for both single and dual channel operation for the sensors. Three distinct flight phases can be identified. The first phase is climb; the second phase cruise, descend, and initial approach; the third phase final approach and land. Thus, the dependency tree drawn for the climb phase does not include the accelerometer modules. For the approach and land phase, the VOR/ILS and compass coupler modules will be connected with lines from the roll and pitch computer modules establishing dependencies between channel A and module number one and between channel B and module number two.

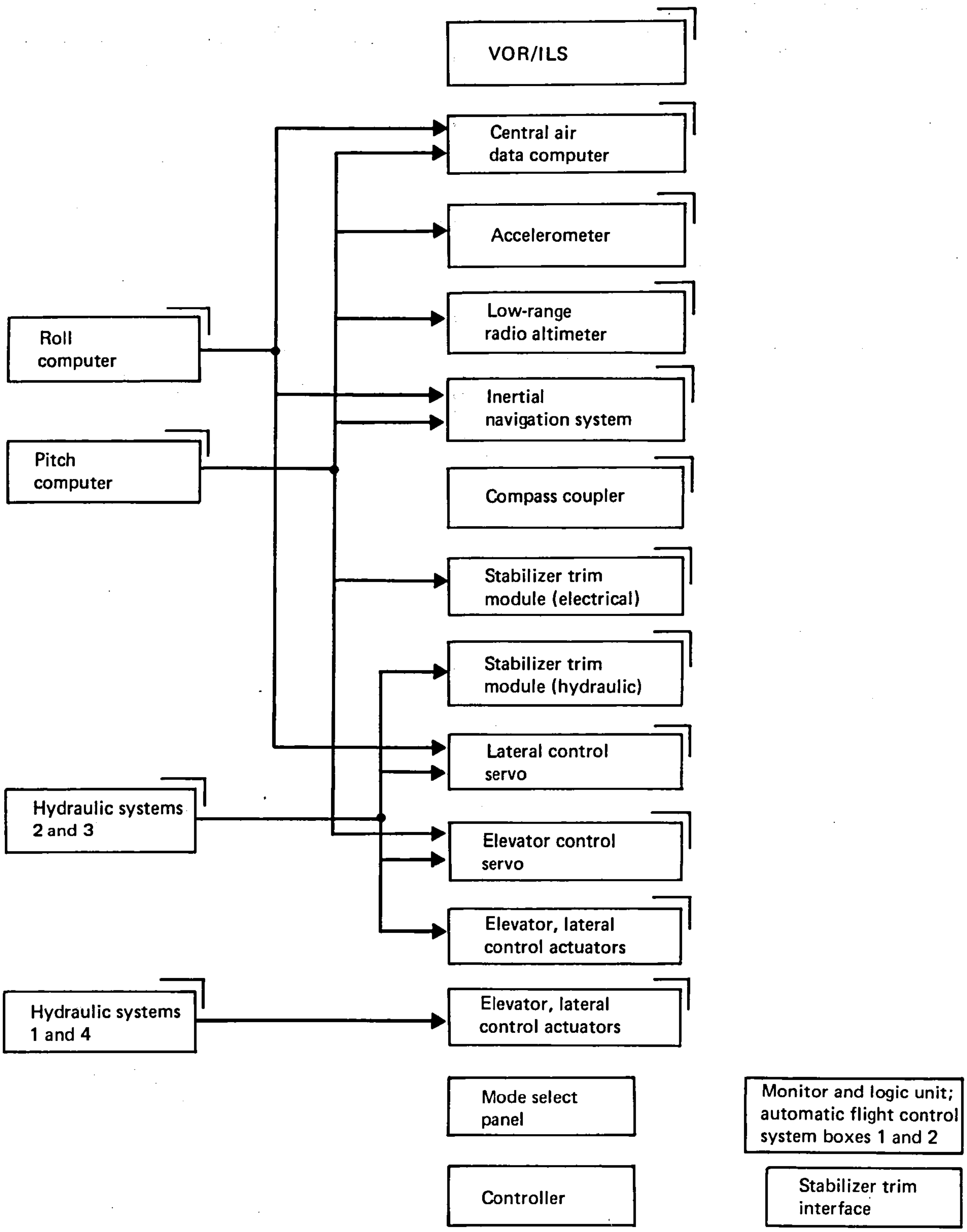


Figure 1. Dependency Tree for Flight Control Using Autopilot

Table 5. Flight Control Sensor Dependencies

Sensor	Flight phase	Autopilot channel		
		A	B	A or B
Inertial navigation system 1 Inertial navigation system 2	All	√ –	– √	–
Central air data computer 1 Central air data computer 2	All	√ –	– √	–
VOR/ILS 1 VOR/ILS 2	Climb, cruise, and descent	–	–	√ √
VOR/ILS 1 VOR/ILS 2	Approach and land	√ –	– √	–
Compass coupler 1 Compass coupler 2	Climb, cruise, and descent	–	–	√ √
Compass coupler 1 Compass coupler 2	Approach and land	√ –	– √	–
Low-range radio altimeter 1 Low-range radio altimeter 2	Approach and land only	√ –	– √	–
Normal accelerometer 1 Normal accelerometer 2	All except climb	√ –	– √	–

The hydraulic and mechanical elements of the figure 1 dependency tree are detailed in figure 2. Hydraulic system numbers two and three are the main flight control actuation power sources and are modeled as a stage separate from hydraulic system numbers one and four.

Failure probabilities for three different flight lengths were computed using the CARSRA program. A flight time of 4 hours was chosen as it is the average flight length for all 747's in service. Flight times of 1 hour and 8 hours were also evaluated as being typical of many 747 operations.

The reliability results for total flight time and each phase are shown in table 6. This table also shows the results with and without wiring and connectors. Failure probabilities are increased by about 8% when wiring and connector failures are included.

Functional Readiness—One feature of the CARSRA program is the ability to compute functional readiness: the availability of a function at a particular time in flight, given that the function was operating at the beginning of the flight.

Autoland is a function that is required at the beginning of the final approach phase. Full category II and restricted category II functional readiness were analyzed in the reference 1 study for the electronic portion only. The functional readiness was computed again by including the hydraulic and mechanical elements plus wiring and connector failures.

The results are shown in figure 3. Functional readiness for a single channel landing is shown for comparison. During the landing phase, the probability of completing the landing in that category is shown in table 7.

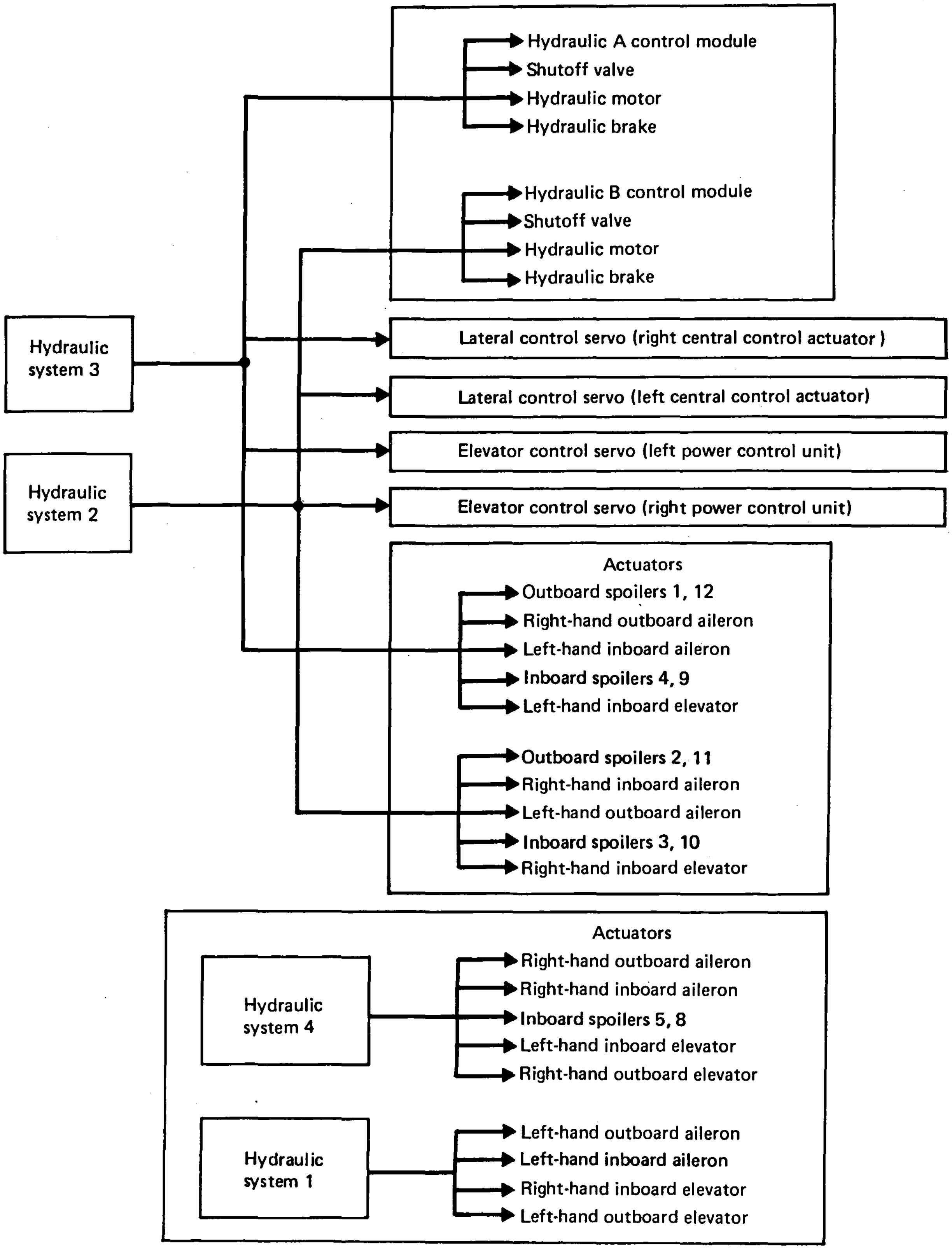


Figure 2. Flight Control Hydraulic System Dependencies

Table 6. Reliability for Flight Control Using Autopilot

Flight phase	Exposure time (hr)	Failure probability	
		Without connectors and wiring failures	With connectors and wiring failures
Total flight	1.0	0.135×10^{-2}	0.146×10^{-2}
Climb	0.25	0.338×10^{-3}	0.364×10^{-3}
Cruise and descent	0.65	0.122×10^{-2}	0.131×10^{-2}
Approach and land	0.10	0.136×10^{-3}	0.146×10^{-3}
Total flight	4.0	0.544×10^{-2}	0.584×10^{-2}
Climb	0.50	0.675×10^{-3}	0.498×10^{-2}
Cruise and descent	3.40	0.461×10^{-2}	0.149×10^{-2}
Approach and land	0.10	0.138×10^{-3}	0.724×10^{-3}
Total flight	8.0	0.110×10^{-1}	0.118×10^{-1}
Climb	0.50	0.675×10^{-3}	0.728×10^{-3}
Cruise and descent	7.40	0.101×10^{-1}	0.109×10^{-1}
Approach and land	0.10	0.141×10^{-3}	0.153×10^{-3}

4.4.2 Reliability Analysis—Yaw Damper System

The yaw damper is an example of a current stability augmentation system. It consists of two identical systems, one controlling the upper and the other controlling the lower rudder. Each system monitors airplane yaw rate and positions the rudder to compensate for dutch roll.

The yaw damper components are identified in table 1 and are shown in a functional diagram together with the dependency tree in figure 4. Failure probability for a typical 747 flight of 4 hours is 0.98×10^{-6}, if wiring and connector failures are not considered. This figure increases to 1.1×10^{-6} when wiring and connector failures are included.

4.4.3 Reliability Analysis—Autothrottle System

The autothrottle maintains a preselected airspeed during approach and landing. It is a single channel system. Figure 5 shows the block diagram for autothrottle components. Since the system is required at the beginning of the approach phase of a flight, the functional readiness was computed. For a typical 4-hour flight length and a functional readiness criterion of any single module failure causing system failure, 99.65% of all flights will have autothrottle available at the beginning of approach.

The probability of system failure during the approach and land phases, a duration of 7.5 minutes, is 0.12×10^{-3}.

4.5 COMBINED FLIGHT CONTROL DIRECT MAINTENANCE AND DELAY COSTS

Maintenance and delay costs at the component, system, or airplane level are usually expressed as a function of airplane flight time. The costs for the primary mechanical controls (ref. 2) were expressed in 1978 dollars per 1000 flight hours. In order to show the flight electronics costs in equivalent rates, the labor man-hours per removal and

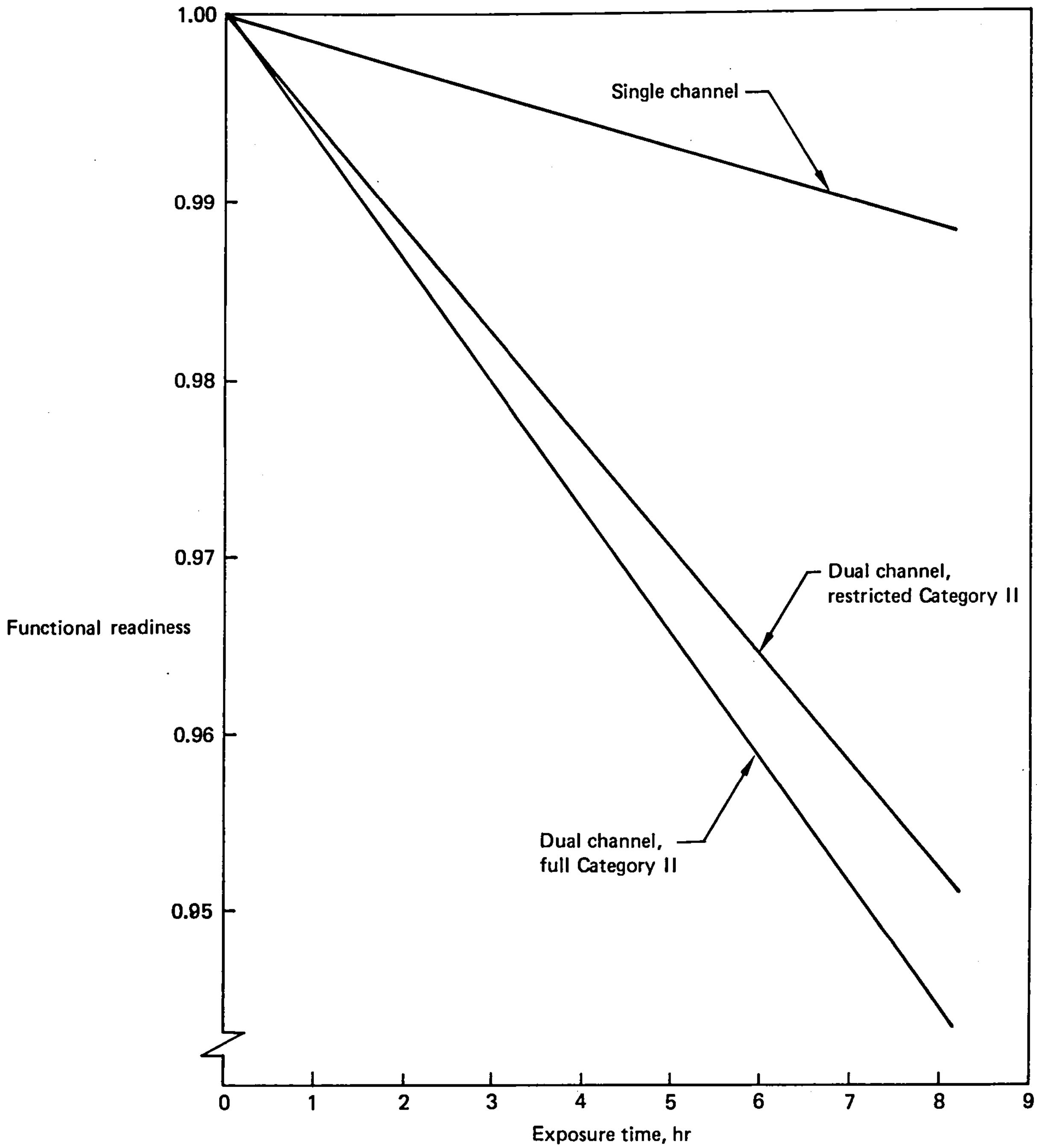
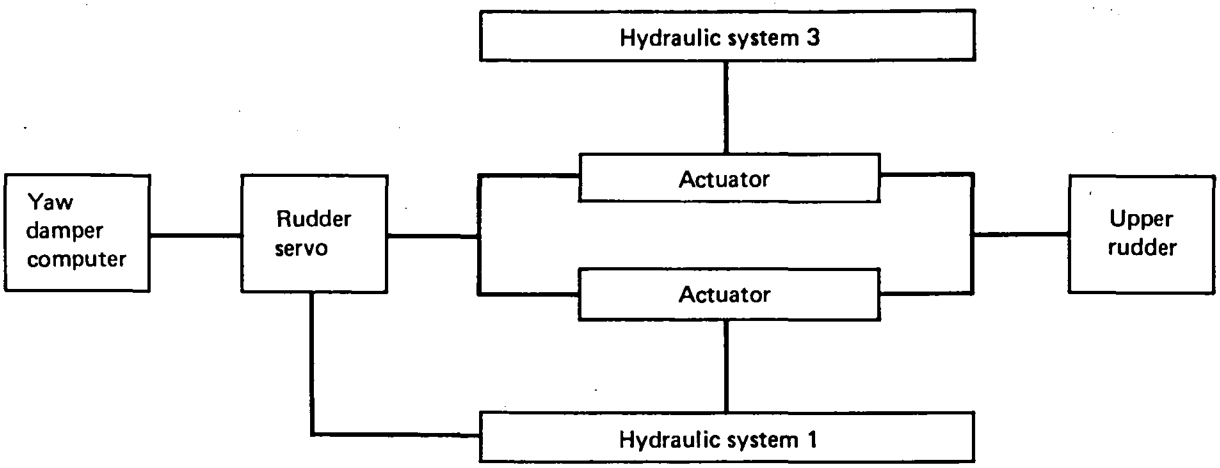


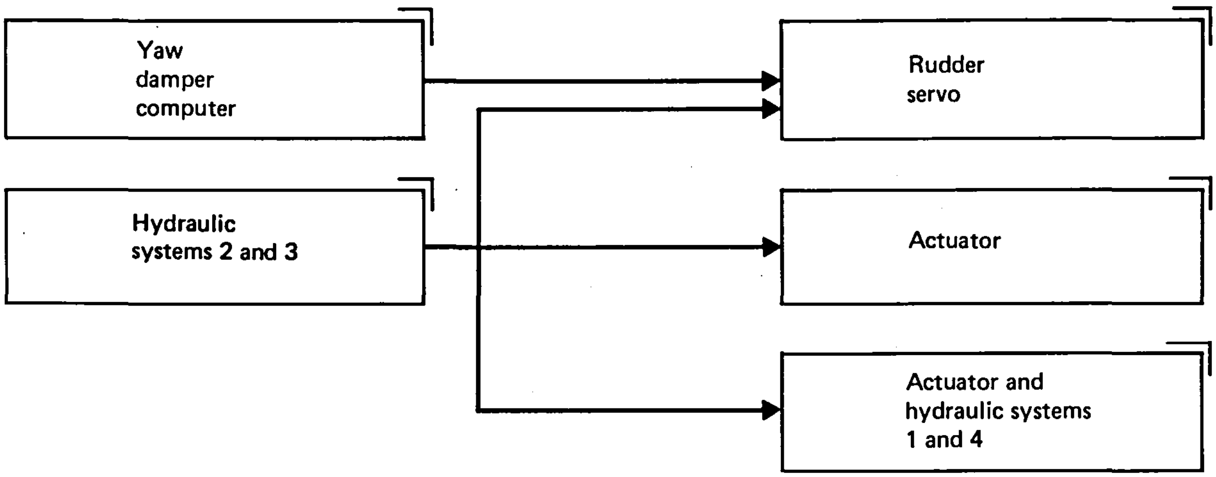
Figure 3. Functional Readiness for Automatic Flight Control at Final Approach

Table 7. Reliability for Flight Control Using Autopilot During Final Approach and Landing

Flight control configuration	Failure probability for 0.1-hr exposure during final approach and landing		
	1-hr flight	4-hr flight	8-hr flight
Single channel (A or B)	0.146×10^{-3}	0.149×10^{-3}	0.153×10^{-3}
Dual channel (A and B) restricted Category II	0.610×10^{-3}	0.724×10^{-3}	0.744×10^{-3}
Dual channel (A and B) full Category II	0.709×10^{-3}	0.709×10^{-3}	0.709×10^{-3}



● Functional diagram, upper rudder (lower rudder similar)



● Dependency tree, upper and lower rudder

Figure 4. Yaw Damper System Functional Diagram and Dependency Tree

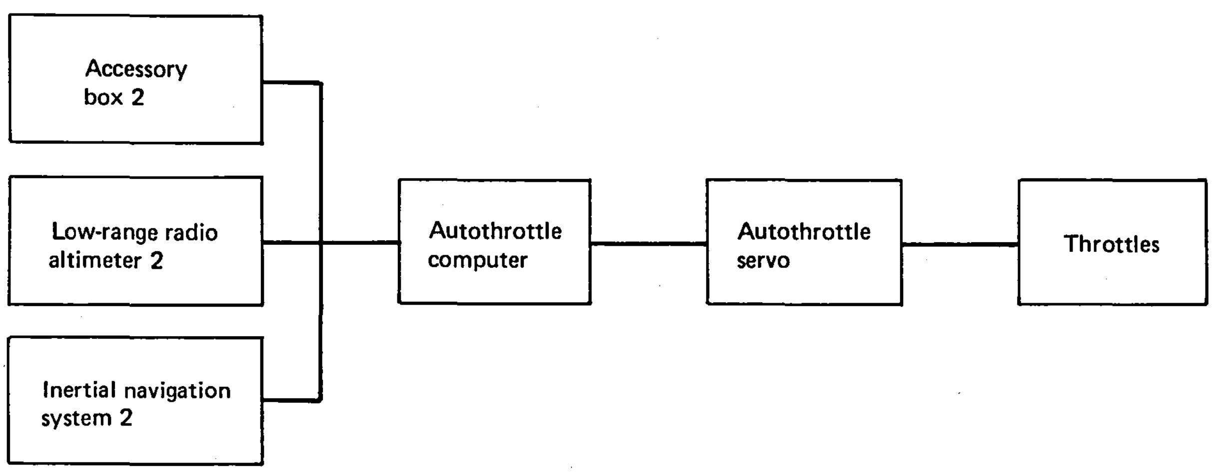


Figure 5. Functional Diagram for the Autothrottle System

material costs per failure identified in the reference 1 report were arranged accordingly. Values were expressed in the base year 1978 by applying an inflation factor of 1.07 to the 1977 material costs and a labor rate of $10.87 per hour.

1978 labor cost ($/1000 flight hours) = man-hours per removal x removals/1000 flight hours x 10.87 $/hour.

1978 material cost ($/1000 flight hours) = material cost per failure x failures/1000 flight hours x 1977 to 1978 inflation factor.

The elements of maintenance and delay cost are:

- Component repair shop labor and material costs
- Line station maintenance labor costs
- Line station delay and cancellation costs

A summary of combined flight control direct maintenance (including estimated inertial navigation system (INS) repair cost of $2.00 per flight hour) and delay cost is shown in table 8, followed by details at the component level for repair shop labor costs in table 9; repair shop material cost in table 10; line station maintenance labor costs in table 11; and line station delay and cancellation costs in table 12.

Repair shop costs for the INS were not available as those line replaceable units (LRU) were repaired by the vendor. An equivalent INS direct maintenance repair cost was estimated from the vendor charge to Pan Am during 1978 by factoring the charge by a ratio of flight control direct maintenance cost to total in-house maintenance cost (plus vendor markup) as shown in section 5.3.

4.6 CONNECTOR AND WIRING RELIABILITY AND MAINTENANCE COST

A separate study was undertaken to determine the significance of connector and wiring faults occurring outside black boxes and other electrical flight control components. With electronic systems becoming more predominant in aircraft systems, special attention may have to be directed to wiring and electrical connector design, specification, and location if the present environment produces poor reliability, high maintenance cost or both. Data were collected on unscheduled maintenance activity involving connector and wiring problems.

Table 8. Direct Maintenance and Delay Cost Summary

System	Cost (1978 $/flight hr)			
	Main base repair labor and material	Line station		Total
		Labor	Delay and cancellations	
Flight electronics (automatic flight control system)	4.71[a]	0.34	0.87	5.92
Primary mechanical controls (primary flight control system)	2.20	0.21	1.53	3.94
Total flight control system	6.91	0.55	2.40	9.86

[a]Includes $2.00 for inertial navigation system repair

Table 9. Primary Flight Control System and Automatic Flight Control System Repair Shop Labor Costs

Flight electronics	1978 $/1000 flight hr	Primary mechanical controls	1978 $/1000 flight hr
Pitch computer	$ 189.01	Aileron trim actuator	$ 3.31
Roll computer	154.30	Flight control shutoff valve	17.11
Yaw computer	31.30	Central control actuator	45.61
Monitor and logic unit	40.38	Outboard aileron lockout actuator	6.30
Automatic stabilizer trim unit	69.50	Aileron programmer	11.58
Autothrottle computer	29.93	Inboard aileron power control unit	23.41
Stabilizer trim unit	10.09	Outboard aileron power control unit	10.20
Accessory box 1	3.65	Spoiler mixer	11.40
Accessory box 2	1.32	Spoiler actuator	4.80
Mode select panel	54.41	Rudder power control unit	90.31
Autopilot controller	10.20	Ratio servo	14.10
Annunciator	0.00	Ratio control unit	26.41
Attitude direction indicator	0.00	Elevator feel actuator	1.80
Navigation receiver	48.80	Feel computer	10.20
Low-range radio altimeter	75.29	Elevator power control unit	49.81
Central air data computer	421.95	Stabilizer trim motor	5.20
Compass coupler	88.48	Control module	11.67
		Speedbrake sequencer	2.10
Inertial navigation system (not included)		Ground spoiler actuator	15.31
Total	$1,459.79	Total	$365.97

Table 10. Primary Flight Control System and Automatic Flight Control System Repair Shop Material Costs

Flight electronics	1978 $/1000 flight hr	Primary mechanical controls	1978 $/1000 flight hr
Pitch computer	$ 255.18	Aileron trim actuator	$ 0.00
Roll computer	207.59	Flight control shutoff valve	11.62
Yaw computer	19.14	Central control actuator	274.92
Monitor and logic unit	31.28	Outboard aileron lockout actuator	0.56
Automatic stabilizer trim unit	23.43	Aileron programmer	3.01
Autothrottle computer	42.16	Inboard aileron power control unit	195.74
Stabilizer trim unit	0.00	Outboard aileron power control unit	350.80
Accessory box 1	0.00	Spoiler mixer	6.31
Accessory box 2	0.27	Spoiler actuator	10.30
Mode select panel	74.87	Rudder power control unit	618.01
Autopilot controller	0.15	Ratio servo	2.55
Annunciator	0.00	Ratio control unit	56.66
Attitude direction indicator	137.96	Elevator feel actuator	2.26
Navigation receiver	25.99	Feel computer	6.24
Low-range radio altimeter	4.74	Elevator power control unit	153.86
Central air data computer	421.56	Stabilizer trim motor	0.00
Compass coupler	1.74	Control module	105.36
		Speedbrake sequencer	19.85
Inertial navigation system (not included)		Ground spoiler actuator	5.31
Total	$1,246.06	Total	$1,836.59

Table 11. Primary Flight Control System and Automatic Flight Control System Line Station Labor Costs

Flight electronics	1978 $/1000 flight hr	Primary mechanical controls	1978 $/1000 flight hr
Pitch computer	$ 33.46	Aileron trim actuator	$ 0.92
Roll computer	32.68	Flight control shutoff valve	3.32
Yaw computer	8.66	Central control actuator	8.09
Monitor and logic unit	24.63	Outboard aileron lockout actuator	0.61
Automatic stabilizer trim unit	29.44	Aileron programmer	0.00
Autothrottle computer	2.19	Inboard aileron power control unit	50.65
Stabilizer trim unit	3.94	Outboard aileron power control unit	0.00
Accessory box 1	1.46	Spoiler mixer	0.00
Accessory box 2	0.55	Spoiler actuator	10.82
Mode select panel	41.10	Rudder power control unit	4.77
Autopilot controller	2.40	Ratio servo	43.54
Annunciator	0.76	Ratio control unit	22.45
Attitude direction indicator	7.86	Elevator feel actuator	0.00
Navigation receiver	26.21	Feel computer	11.59
Low-range radio altimeter	11.58	Elevator power control unit	20.52
Central air data computer	40.57	Stabilizer trim drive	3.68
Compass coupler	8.43	Control module	7.74
		Speedbrake sequencer	0.00
Inertial navigation system	63.38	Ground spoiler actuator	2.11
		General	21.79
Total	$338.29	Total	$212.60

Table 12. Primary Flight Control System and Automatic Flight Control System Delay and Cancellation Costs

Flight electronics			Primary mechanical controls
ATA 22, autopilot system (1978 $/1000 flight hr)		ATA 34, shared sensors only (1978 $/1000 flight hr)	ATA 27, less high-lift devices (1978 $/1000 flight hr)
Delays	$113.06	$435.92	$1,415.97
Cancellations	0.00	318.30	111.92
Total	$113.06	$754.22	$1,527.89

4.6.1 Connector and Wiring Data Collection

The approach to obtaining connector wiring data was to obtain from Pan Am data on maintenance actions that corrected connector and wiring problems. Pan Am produces a statistical report that combines the daily pilot log of discrepancies (flight squawks) and the remedial action taken by the maintenance personnel. Details of maintenance actions that corrected connector or wiring problems were extracted and are listed in appendix B under ATA system, associated LRU, airplane location, action taken, and man-hour and material cost.

The scope of this data collection covered 12 months of 747 operation for Pan Am and included electronic and electrical devices in the primary and automatic flight control systems. The hydraulic power and associated indicating subsystems also were included for comparitive purposes.

Data Extraction—The procedure for screening and extracting data from the statistical report, relevant to connector and wiring problems, was as follows:

1. Extract all actions where the mechanic cleaned, repaired or replaced a connector and repaired wiring.

2. Extract all actions where black boxes or other equipment were swapped or reseated, only if this action corrected the problem. This was verified by monitoring data for the involved airplane for 30 days following the swap or reset fix. If the squawk did not repeat, then the problem was considered to be a connector failure. A version of Pan Am's statistical report sorted by airplane tail number and data facilitated this task.

4.6.2 Connector and Wiring Failure Definitions

A connector failure is defined as the loss of function of the connection; that is, the disruption of an electrical signal across the contacts. A wiring failure is defined as the disruption of an electrical signal due to a broken or shorted wire. The collected data in appendix B are connector or wiring failure occurrences as each maintenance action restored the electrical connection. The maintenance actions were categorized by the terms reseat, swap, clean, replace, or repair, and are described as follows.

If the mechanic suspects a connector problem, then he will either reseat the unit, in the case of an air transport radio (ATR) box, or swap like units depending on his familiarity with the pilot report and method of troubleshooting. While swapping or reseating the unit, the mechanic may inspect the connector itself. The connector may appear satisfactory or may require cleaning. Also a bent pin or damaged housing may require repair or even connector replacement. All wiring failures were assembled under the term "repair."

4.6.3 Connector and Wiring Data Evaluation

Evaluation Highlights—Connector failures are most significant for ATR black boxes. The average box failure rate increases 16% when its connector unreliability is included. Most connector problems are corrected by reseating the box in the receptacle. Flight deck equipment failure rate increases by 10% when connector failures are included.

Flight control wiring is more reliable. Wiring problems are outweighed by connector problems by a factor of 1 to 14. There were only 17 repairs to flight control wiring on Pan Am's 747 fleet during 1978.

In other systems having electrical components, connector and wiring reliability may be different. A brief survey of the hydraulic system wiring produced a total of 58 repair actions in 1978.

Maintenance costs for correcting flight control connector and wiring failures at 1.75 cents per flight hour are not significant. This compares with 55 cents per flight hour for flight control line maintenance.

Connector and Wiring Reliability—All flight control connector problems have been summarized in table 13 by listing the total number of maintenance corrective actions during 1978 under the headings previously identified. This table clearly shows that the ATR black boxes located in the electronics compartment have most of the connector problems. Most of these problems apparently are fixed by reseating the connector, either by exchanging boxes or merely unlatching a box and relatching it.

In comparison with connectors, the corrective actions for wiring problems are fewer, as seen in table 14. There were only 17 maintenance corrective actions in 1978 against 242 for connectors. Wiring reliability appears to be high compared with black box or connector reliability.

The summaries in tables 13 and 14 also show corrective actions for the hydraulic system connectors and wiring. As there are no black boxes in this system, a comparison can be made with the hydraulic components and components of the flight control system. For connectors (table 13) there were 92 actions for hydraulics against 35 for flight controls. For wiring (table 14) there were 58 actions for hydraulics against only 17 for flight controls. Although this is a comparison at the system level, it clearly identifies hydraulic wiring as a much bigger problem than for flight controls.

Connector and LRU Failures—To add perspective to the connector statistics, a comparison was made between LRU failure rates and the failure rates of the LRU connectors (table 15). For black-box LRU's where most of the connector problems were found, the total failure rate for all flight control electrical compartments LRU's is 7233 x 10^{-6} failures per hour compared with 1121 x 10^{-6} failures per hour for the associated connectors. Thus, black-box LRU failure rates are increased by an average of 16% when their connectors are included. For flight deck LRU's, the failure rates increased by 10%.

Table 13. Flight Control Connector Maintenance Actions

Connector location and associated unit	Total 1978 maintenance actions to correct connector problems, by action					
	Swap units	Reseat unit	Clean connector	Replace connector	Repair connector	Total
Electrical/electronics compartment						
Pitch computer	41.0	15.0				
Roll computer	26.5	12.0				
Inertial navigation system	23.0	4.5		2.0		
Yaw computer	3.0	3.0				
Central air data computer	15.5	15.0			1.0	
Navigation receiver	5.0	10.0	1.0			
Compass coupler	2.0	5.0				
Low-range radio altimeter		2.0				
Accessory box		2.0				
Automatic stabilizer trim unit		3.0		1.0		
Stabilizer trim interface unit		2.5				
Monitor and logic unit		9.5				
Autothrottle		1.0				
Overrotation computer		1.0				
Subtotal	115.0	86.5	1.0	3.0	1.0	207.0
Flight deck						
Attitude direction indicator		2.0		1.0		
Annunciator		6.0	2.0	1.0	5.0	
P73 (relay)					1.0	
Mode select panel			1.0			
Stall warning computer		1.0				
Stabilizer trim switch					2.0	
Autospeedbrake solenoid			1.0			
Stick shaker switch			1.0			
Subtotal	0.0	9.0	5.0	2.0	8.0	24.0
Empennage subtotal	–	–	6.0	1.0	–	7.0
Wing subtotal	–	–	2.0	2.0	–	4.0
Total flight control	115.0	93.5	14.0	8.0	9.0	242.0
Total hydraulics	7.0	21.0	44.0	10.0	10.0	92.0

Table 14. Flight Control and Hydraulic Wiring Maintenance Corrective Actions

Airplane location	Associated flight control system/component	1978 maintenance corrective actions for wiring repair
Flight controls		
Flight deck		
Instrument panel	Attitude direction indicator	1
Instrument panel	Flight director selector switch	1
Instrument panel	Inertial navigation system selector	1
Control column	Stick shaker	1
	Subtotal	4
Wing		
Canoe fairing 3	Flight control shutoff valve	1
Inboard sailboat	Flight control shutoff valve	1
Outboard trailing-edge wing	Aileron lockout	4
	Subtotal	6
Empennage		
Stabilizer trim	Control module	4
Elevator	Indication	1
	Subtotal	5
Landing gear bay		
Shock strut	Takeoff warning switches S334 and S763	1
Shock strut	Overrotation system	1
	Subtotal	2
	Total	17
Hydraulics	Pressure and indicating system	58

Table 15. Connector and Wiring Reliability

Component connector	Wiring and connector: Failures (maintenance corrective actions) per 10^6 flight hr (A)	Associated component: Failures per 10^6 flight hr (B)	Associated component: Removals per 10^6 flight hr (C)	Ratio $(\frac{A}{B})$	Ratio $(\frac{A}{C})$
Air transport radio boxes					
Pitch computer	306.9	1 314.0	2 389.0		
Roll computer	211.2	1 202.7	2 405.0		
Inertial navigation system	161.7	1 964.7	4 165.0		
Yaw computer	33.0	404.8	613.0		
Central air data computer	172.8	657.0	2 986.0		
Navigation receiver	87.8	302.6	1 663.0		
Compass coupler	38.4	308.4	646.0		
Low-range radio altimeter	11.0	273.4	888.0		
Accessory box	5.5	26.8	128.0		
Automatic stabilizer trim unit	21.9	372.9	888.0		
Stabilizer trim interface unit	13.7	24.7	290.0		
Monitor and logic unit	52.1	258.3	743.0		
Autothrottle computer	5.5	122.7	161.0		
Total	1 121.5	7 233.0	17 957.0	0.16	0.06
Flight deck					
Attitude direction indicator	16.4	320.2	516.0		
Annunciator	76.8	26.6	48.0		
Mode select panel	5.5	660.6	1 065.0		
Total	98.7	1 007.4	1 629.0	0.10	0.06

Connector and LRU Maintenance Actions—Table 15 also provides the LRU removal rate for comparison with the maintenance corrective action rate. The maintenance action rate for LRU removals; i.e., component removal rate, is increased by 6% when connector maintenance action rate is included. It is likely that some removals that were classified as unjustified were actually connector problems (for example, a reseat problem), so the true maintenance corrective action rate for connectors may be higher than the calculated rate shown in table 15. This cannot be verified.

Connector and Wiring Maintenance Cost—Each maintenance action recorded in appendix B shows the estimated man-hours to correct each problem. Table 16 shows the maintenance man-hours expended in 1978 to correct component connector problems and arrays the data according to each associated component under each corrective action type. Also shown are the man-hours when automatic test equipment (ATE) was used and material cost for connectors needing replacement or repair. Totals for the hydraulic system are included for comparative purposes.

The man-hours spent in using ATE for fault verification appear to be quite small. Also replacement costs for connectors are small, totaling only $270 for the year. The highest category for man-hours is the time spent reseating or swapping black boxes to correct faults. As this category is also the highest in terms of total maintenance

Table 16. Flight Control Connector Maintenance Man-Hours

Connector location and associated unit	Total 1978 maintenance man-hours and material costs to correct connector problems, by action					
	Reseat or swap unit	Clean connector	Replace connector	Repair connector	Automatic test equipment use	Material cost (1978 $)
Electrical/electronics compartment						
Pitch computer	34.25				1.0	
Roll computer	22.50				0.5	
Inertial navigation system	18.50		14.0			100.00
Yaw computer	4.00					
Central air data computer	20.75			2.0	7.0	2.00
Navigation receiver	8.50	1.5			4.0	
Compass coupler	3.50					
Low-range radio altimeter	1.00					
Accessory box	1.00				0.5	
Automatic stabilizer trim unit	3.00		4.0			21.42
Stabilizer trim interface unit	2.50					
Monitor and logic unit	6.00				0.5	
Autothrottle	0.50					
Overrotation computer	1.00					
Subtotal	127.00	1.5	18.0	2.0	13.5	123.42
Flight deck						
Attitude direction indicator			1.0			64.80
Annunciator		1.5	1.0	5.5		16.30
P73 (relay)				3.0		
Mode select panel		2.0				
Stall warning computer						
Stabilizer trim switch				3.0		
Autospeedbrake solenoid		1.0				
Stick shaker switch		1.0				
Subtotal	0	5.5	2.0	11.5	0	81.10
Empennage subtotal	0	6.0	1.5	0	0	22.37
Wing subtotal	0	2.5	3.0	0	0	43.09
Total flight control	127.00	15.5	24.5	13.5	13.5	269.98
Total hydraulics	31.25	61.5	16.5	18.0	–	–

actions, the actual time spent per maintenance action is no higher than for other corrective categories.

Wiring man-hours are identified in table 17 and show total man-hours in 1978 listed by the components associated with the wiring in terms of repair and troubleshooting. No data exist for actual troubleshooting times. It is generally known that more time is spent tracking down, verifying, and locating a wire problem than in the actual repair. An average troubleshooting time was established by reference to the few delay details where the cause was a broken or chafed wire. The delay time plus the ground time available between flight, less repair time, was attributed to troubleshooting time, which averaged 3.3 hours.

Table 17. Flight Control Wiring Maintenance Man-Hours

Airplane location	Associated flight control system/component	1978 man-hours to correct wiring problems	
		Troubleshooting	Repair
Flight controls			
Flight deck			
Instrument panel	Attitude direction indicator	3.3	3.0
Instrument panel	Flight director selector switch	3.3	2.0
Instrument panel	Inertial navigation system selector	3.3	3.0
Control column	Stick shaker	3.3	2.0
	Subtotal	13.2	10.0
Wing			
Canoe fairing 3	Flight control shutoff valve	3.3	2.5
Inboard sailboat	Flight control shutoff valve	3.3	2.0
Outboard trailing-edge wing	Aileron lockout	13.2	8.0
	Subtotal	19.8	12.5
Empennage			
Stabilizer trim	Control module	13.2	7.0
Elevator	Indication	3.3	3.5
	Subtotal	16.5	10.5
Landing gear bay			
Shock strut	Takeoff warning switches S334 and S763	3.3	2.0
Shock strut	Overrotation system	3.3	1.5
	Subtotal	6.6	3.5
Flight control total system man-hours		56.1	36.5
Hydraulics total system man-hours		191.4	132.0

Man-hours were converted into costs by using the 1978 labor rate of $10.87 per hour and a summary of the maintenance costs for flight controls and hydraulics wiring and connectors is shown in table 18. These costs are shown as a total for 1978 and as cost per flight time. At 2.687 cents per flight hour, the hydraulic system connector and wiring costs are more than flight control wiring and connector costs, which are 1.747 cents per flight hour. This compares with a total line maintenance cost for the flight control system of 55 cents per flight hour.

Table 18. Maintenance Cost Summary for Connectors and Wiring

System	1978 total costs (1978 $)	Costs (1978 $/1000 flight hr)
Flight controls		
Connectors	$2,179.43	$11.95
Wiring	1,006.56	5.52
Total	$3,185.99	$17.47
Hydraulics		
Connectors	$1,383.21	$ 7.59
Wiring	3,515.36	19.28
Total	$4,898.57	$26.87

5.0 OPERATING ENVIRONMENT AND MAINTENANCE RESOURCES FOR A B-747 FLEET

Flight control designs for operation in the mid-1980's will make expanded use of new technology digital techniques for control and display. Applications are automatic flight control, flight management, and limited active controls. Beyond the mid-1980's, applications using digital technology may include advanced active controls for stability augmentation and flutter mode suppression.

The new technology may impose requirements for airplane dispatch, equipment repair, material logistics, and line maintenance different from current practices. One purpose of this study is to identify and document those current practices as developed by a typical airline. This was accomplished by collecting and reviewing data on 12-month operation of Pan Am's 747 fleet, concentrating on the flight control system. B-747 characteristics are described in the following sections: Operating Environment, section 5.1; Maintenance Resources, section 5.2; Combined Flight Control Inventory and Maintenance Cost Summary, section 5.3.

5.1 OPERATING ENVIRONMENT

Pan Am operates on routes that radiate from the United States and extend worldwide. One route extends around the world. This airline operates a large and mature 747 fleet over a well developed route network and has years of fine tuning their logistics support and maintenance plan.

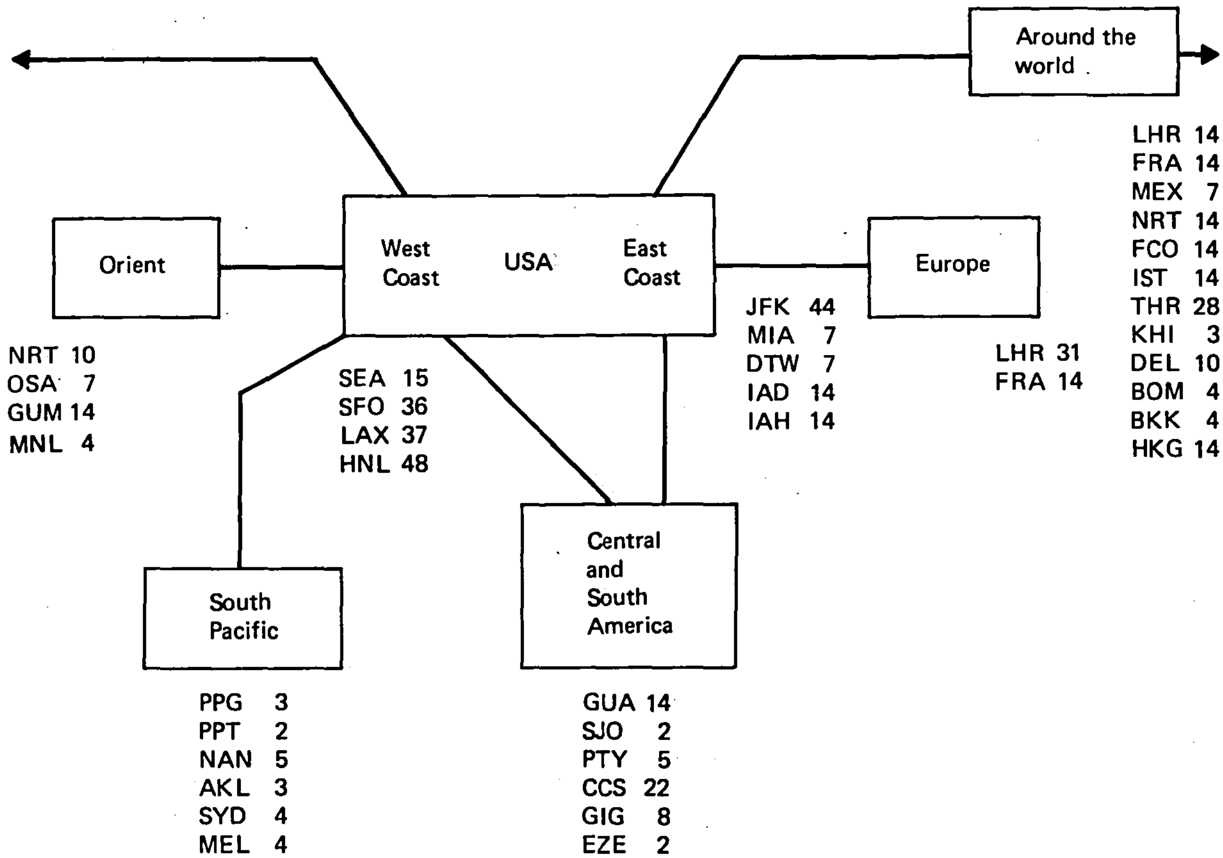
Fleet Composition—Apart from a small B-727 fleet operating in Germany to points within Europe, Pan Am operates two long-range airplanes, the B-747 and B-707. The B-747 fleet size is gradually increasing while B-707's are being slowly phased out. At the end of 1978 there were 43 B-747's in operation and 36 B-707's. The B-707's operate primarily to Africa and supplement B-747's on other routes. The B-747 fleet consists of the basic B-747-100 passenger model, a long-range special performance (SP) model and the freighter model. Although most flight control equipment is common to all three types, the daily utilization, flight-length and transit times are different. The SP fleet has upgraded autopilot computers that are maintained by outside contract.

Operating Network—The airline operates the B-747 in five main regions: South America, South Pacific, the Orient, Europe, and World Service. Figure 6 shows the network as a block diagram with routes radiating from the U.S.A. Apart from the World Service, no service exists between the regions, each outbound flight returning to a U.S. gateway. Airplanes are routed through New York or San Francisco for maintenance check visits. Appendix D includes additional details of Pan Am's operating network.

5.2 MAINTENANCE RESOURCES

5.2.1 Maintenance Personnel for Avionics Support

For purposes of this study, it was necessary to identify avionic maintenance manpower and skill levels. Because the departmental organization of the Maintenance and Engineering Division within Pan Am is not aligned along specific airplane types or aircraft systems, and because line station maintenance is carried out under a different organization, Marketing, it was necessary for Pan Am to estimate the manpower specifically assigned to avionic maintenance. This estimate was made in relation to the



- Three-letter station codes and flights per week—schedule for November 1978.
- Station codes are defined in appendix D.

Figure 6. Pan Am 747 Fleet Operating Network

total manning level for line stations and main base maintenance, together with some of the avionic support functions within each organization.

For maintenance servicing carried out at two main bases, New York and San Francisco, the avionics crew (not including supervisors) totals 100. The New York component repair shop for avionics has 72 technicians. All component repair is done either in New York or by suppliers. This manning level for direct avionics support is about 3% of the total New York and San Francisco Maintenance and Engineering organization. Other departments that contribute to avionic maintenance include:

Training
Quality Control—Inspection
Quality Assurance—Reliability programs
Industrial Equipment—Instrument and avionic calibration, Ground equipment overhaul
Aircraft Maintenance—Metal service, Technical service
Component Repair—Plating, welding, machining, metals shops, Instrument overhaul,
Wiring harness shop, Fiberglass shop
Material and Logistics—Inventory control, Purchasing, Material handling
Engineering—Aircraft electronics support

For line station support, 44 avionic specialists are assigned to specific locations, not including New York and San Francisco. Twenty-five of these specialists are located at U.S. gateway stations, three at Tokyo, two at Hong Kong, six at London, and eight at Frankfurt. There are an estimated 1,120 maintenance personnel including supervisors at line stations where capability exists for minor avionic troubleshooting. Appendix E contains a list of line stations with manpower levels by maintenance skill.

5.2.2 Spares Provisioning and Pooling

The allocation of spares to line stations is determined both by mathematical analysis and engineering judgment. The object, as stated by Pan Am, is

- "To provide, at the most reasonable cost, the spare parts needed to satisfy demands at specific locations in order to maintain schedules, provide for passenger comfort and ensure the mechanical integrity of the aircraft while operating away from main base locations."

- "To facilitate periodic re-analysis of parts levels, so that they reflect current operating requirements and removal rates."

The process by which Pan Am allocates spares is started by classifying each station by a number. The airline lists 27 factors that are considered for class number allocation. A further 19 factors are considered for the makeup of the spares kit at each station. Information for spares determination can come from 31 different sources. The list of factors and information sources is in the reference 2 appendix. Pan Am estimates that average pipeline time for replenishing station stock is 13 days.

Actual spares kits for flight controls allocated to Pan Am's 747 operating stations are contained in appendix E. Spares are also available at line stations through the spares pooling organization, which comprises airline groups operating similar airplane types. A list of those flight control LRU's that are provided through the pooling organization is found in appendix E.

Spares Coverage—An assessment of the actual spares coverage to satisfy demands for 747 operation was made for the major flight control computers: pitch, roll, monitor and logic unit, and the autostabilizer trim unit. The following observations were made on spares levels and dispatch with inoperative equipment.

The pitch computer, roll computer, monitor and logic unit, and autostabilizer trim unit are each allocated to 15 stations, but not all at the same stations. Pan Am's dispatch requirements are fairly restrictive for allowing departure with these LRU's inoperative. It appears that this quantity of spares distributed among a total of 46 line stations provides adequate coverage to meet the provisioning objectives.

An airplane can be dispatched with one of two yaw damper computers inoperative according to the minimum equipment list (MEL) and is therefore allocated to only five stations. Although the MEL list is only one out of 19 factors for provisioning consideration, it is dominant in reducing the spares allocation quantities.

Spares Availability—Flight delay and cancellation data for the B-747 fleet were collected for 1978 operations for delay rate calculation. These data also provided information on the replacement of LRU's. A survey was made by grouping the data into delays where no LRU's were replaced and delays where a spare LRU was required. A further breakdown identified the source for these spare LRU's.

From the survey of 145 delays, 42% or 61 delays involved replacing a unit with a spare. The delay causes may have been troubleshooting time, waiting for the spare part or time spent for replacement, but were not considered important for this survey. A breakdown of these 61 delays, (table 19) shows that in 70% of the cases, a spare was available from the Pan Am stock, or available from the pool group, if Pan Am was a pool member at that station for that item. This figure is actually higher as the survey only included spare replacements resulting in delays.

Table 19. Spares Availability

Siutation	Number of delays		
	Primary mechanical controls	Flight electronics	Total
1. No spares required (deferred maintenance or problem corrected)	46	38	84
2. Spares replacement required—available (in stock)			
From Pan Am kit	11	26	
From pool	4	2	
Total for spares available	15	28	43
Not available (not in stock)			
Borrowed—nonpool	7	2	
Replacement flown in	1	2	
Swapped unit from incoming Pan Am flight	1	5	
Total for spares not available	9	9	18
Total for spares replacement required	24	37	61
Total delays (1 and 2)	70	75	145

The remaining 30% of the delays, those that required a spare but for which a spare was not available from stock, were remedied in various ways. On nine occasions Pan Am was able to borrow a spare from another airline at that station. Six occurrences involved swapping the bad LRU with a good LRU from another Pan Am airplane in transit through that station, and in three instances a spare part had to be flown in. Obviously this last case is undesirable as a lengthy delay is certain.

A further breakdown of table 19 data into flight control elements shows that 61% of delays requiring spares were electronic related and only 39% were mechanical related. Also, when a spare was not in stock, more electronic units than mechanical units were swapped from incoming flights and less borrowing from other airlines occurred. Ease of access and quick disconnect features for electronic equipment may account for this.

Spares Pooling—The merits of spares pooling were evaluated from Pan Am's participation in the 747 and avionics pool groups. Appendix E explains the pooling system and includes a list of spares that are pooled.

From the viewpoint of income and expense during pool group participation, Pan Am had a net income of $22,143 from spares pooling activities in the 1978 summer season for flight control units. Appendix E, table E4, includes the income and expense for each pooled component. This net income, however, does not take into account any costs that Pan Am incurred for administration, material logistics, and warehousing. The airline is a major pool provider probably through evolution. Since Pan Am was the first B-747 operator and in addition operates a large B-747 fleet, their initial spares purchase was substantial. Other B-747 operators soon entered the scene, many of whom operated small fleets. Spares pooling became an advantageous concept and Pan Am was in a position to be the major contributor.

Pooling is effective in reducing investment costs. Pan Am would have to increase its spares investment by an equivalent 8.7% of its own line station holdings if a spares pool did not exist. Pooled spares available to Pan Am represent a value of $719,000 that would otherwise have to be spent to meet provisioning requirements.

5.3 COMBINED FLIGHT CONTROL INVENTORY AND MAINTENANCE COST SUMMARY

Flight control cost details contained in appendixes E and F have been extracted and summarized as total costs for Pan Am's 43-airplane 747 fleet. The highlights from this summary show that the total flight control inventory costs of installed hardware, spares and ground support and test equipment, are $46.7 million. The 1978 maintenance and delay cost, which includes in-house and contracted maintenance and delays and cancellations, totals $4.5 million or nearly 10% of the inventory.

Flight Control Inventory—Costs are presented as an inventory of equipment installed on the airplane, spares, ground support equipment, and shop test equipment. It was necessary to estimate the installed equipment costs since the accounting system does not identify or prorate the price paid when the airplanes were first delivered. The installed equipment costs used are those quoted in Pan Am's books for 1978, the price for which the airline would buy them. Costs for spares, support equipment, and shop test equipment are the prices for such items for 1978. Table 20 shows flight control inventory costs for Pan Am's fleet as it existed at the end of 1978, the current spares on hand, the ground support equipment, and shop test equipment.

Table 20. Combined Flight Control Inventory Costs

	Inventory costs for a 43-airplane 747 fleet (1978 $)			
	Primary mechanical controls		Flight electronics	Total cost
	Controls	Actuators		
Fleet-installed equipment	$4,597,000	$11,507,000	$19,936,000	$36,040,000
Total spares inventory	403,000	519,000	8,210,000	9,132,000
Ground support equipment	–	8,000	44,000	52,000
Shop test equipment	–	599,000	887,000	1,486,000
Totals	$5,000,000	$12,633,000	$29,077,000	$46,710,000

Electronic equipment and mechanical equipment costs are shown separately. Further, the mechanical equipment is divided into controls and actuators to show what proportion of the mechanical system cost is attributed to cables, pushrods, and mechanisms, and what proportion is attributed to power control units, including servo actuators. Thus the appropriate data have been segregated such that a total cost estimate for electric flight controls from the sensors to the control surfaces can be made for fly-by-wire conversions in which the mechanical controls will be removed but the actuators will remain.

Table 20 shows a total inventory value of nearly $47 million for B-747 flight controls and support equipment. Electronics make up 62%, actuators 27%, and mechanical controls 11%.

Maintenance and Delay Costs—Flight control maintenance, burden, and delay and cancellation costs during 1978 for Pan Am's B-747 fleet were determined by system, such as mechanical and electronic; and by maintenance category, such as line station labor, and repair shop labor and material. The costs are summarized in table 21, which displays them by system in-house maintenance, outside services (maintenance contracted outside Pan Am), and delay and cancellation costs.

Table 21. 1978 Fleet Maintenance and Delay Costs Attributable to Flight Control Failures

Item	Cost (1978 $)
Direct maintenance cost (labor and material)	$1,004,900
Labor burden	1,770,700
Total in-house maintenance cost	$2,775,600
Outside services	1,178,800
Delays and cancellations	498,900
Total maintenance and delay cost	$4,453,300

Burdened in-house maintenance accounts for 62% of the total $4.5 million. Table 22 shows a listing of those cost centers that make up burden. The labor burden rate for 1978 was $35.53 per man-hour and with $10.87 per man-hour for direct labor, gives a total burdened rate of $46.40 per man-hour.

Costs for one burden item, training, were asked for in particular. Appendix F contains a detailed estimate of the costs for providing training. Pan Am's cost for flight controls maintenance training in 1978 was $49,600, a very small portion of the $1.8 million labor burden total.

Pan Am contracted outside for $1.2 million of component overhaul, which represents 27% of the maintenance and delay cost. The remaining 73% included 11% for delays and cancellations.

Flight electronic maintenance costs are three times those for primary mechanical controls, as shown in table 23.

Outside maintenance for mechanical elements is negligible compared with flight electronics, which is confined to B-747SP computer repair and all B-747 INS repair.

Table 22. Maintenance Burden Categories

1. Premium labor	7. General staff payroll
2. Mechanics' indirect	Maintenance operations
Contractual time off	Industrial engineering
Sick leave	Quality control
Vacation	Division controller
Holiday	Engineering
Training	8. General staff related payroll expense
Other assignments	9. General staff expense
Temporary supervision	10. Noncontrollable burden
All other unallocated	Utilities
Stock chasing	Guards
Lost time	Rental
Maintenance ground property	Depreciation
3. Mechanics' related payroll expense	11. Service departments
4. Shop expense	Kennedy base support
5. Shop supervision	Facilities
6. Shop supervision related payroll expense	Materiel
	Communications
	General and administrative allocation

Table 23. 1978 Maintenance Costs for Automatic Flight Control System and Primary Flight Control System

Item	12-month costs (1978 $)	
	Primary mechnical controls (primary flight control system)	Flight electronics (automatic flight control system)
Material	$ 231,700	$ 231,200
Labor—fully burdened	773,100	1,539,600
Outside services	1,600	1,177,200
Total maintenance	$1,006,400	$2,948,000

In-house burdened labor costs for flight electronics are double those for mechanical controls due in part to many more units going through the avionics shops. By comparison, the material costs for mechanical controls and electronic equipment are similiar.

A further breakdown of the primary mechanical system into controls and actuators is shown in table 24 with flight electronics shown for comparison.

Actuator overhaul maintenance costs, although lower than those for electronics, are higher than the control costs. One reason is a high cost per shop visit for an expensive and intricate device. The line station costs for actuators, however, are the lowest.

Table 24. Line Station and Repair Shop Costs for Mechanical and Electronic Flight Controls

Item	12-month costs (1978 $)		
	Controls	Actuators	Electronics
Component repair shop	$152,700	$216,300	$549,400
Line labor—unscheduled	4,700	3,900	42,700
Line labor—scheduled	28,200	7,000	0
Delays and cancellations	323,700	36,000	139,200

High reliability of actuators accounts for the low unscheduled maintenance and delay cost. Acutator scheduled maintenance includes functional checks every 4000 flight hours. The scheduled maintenance costs were obtained from the reference 2 study and include inspection and checks of all cables and mechanisms of the primary controls. Delay and cancellation costs for the controls are relatively high due to dispatch criticality and long delay times. Appendix E includes details of all 1978 delays and cancellations and a summary of delay rates, cancellation rates, and average delay times. The costs associated with delays and cancellations were calculated using the reference 2 algorithms, which are based upon factors such as lost passenger revenue, passenger handling costs, and extra crew costs.

6.0 B-747 WITH WING LOAD ALLEVIATION

The B-747 EET study, reference 3, examined feasibility, benefits and costs of wing tip modification and a wing load alleviation (WLA) system employing active outboard ailerons. In this section, the WLA description and predictions for system reliability using the CARSRA computer program, hardware cost, and maintenance cost are presented. WLA was not considered for B-747 production because the predicted fuel savings were not sufficient to provide a favorable economic return on typical passenger routes.

6.1 WING LOAD ALLEVIATION DESCRIPTION

The wing load alleviation system concept of the 747-EET study is mechanized as a dual channel digital one-fail-operational system. Figure 7 shows the location of the components. Dual self-monitoring digital computers are the central components. They are packaged in two one-half air transport radio boxes installed in the electronics bay. Control law computation is dual redundant in each channel and resembles a dual-dual scheme. The computers also manage failure detection and isolation, system reconfiguration after failures, and preflight and maintenance tests.

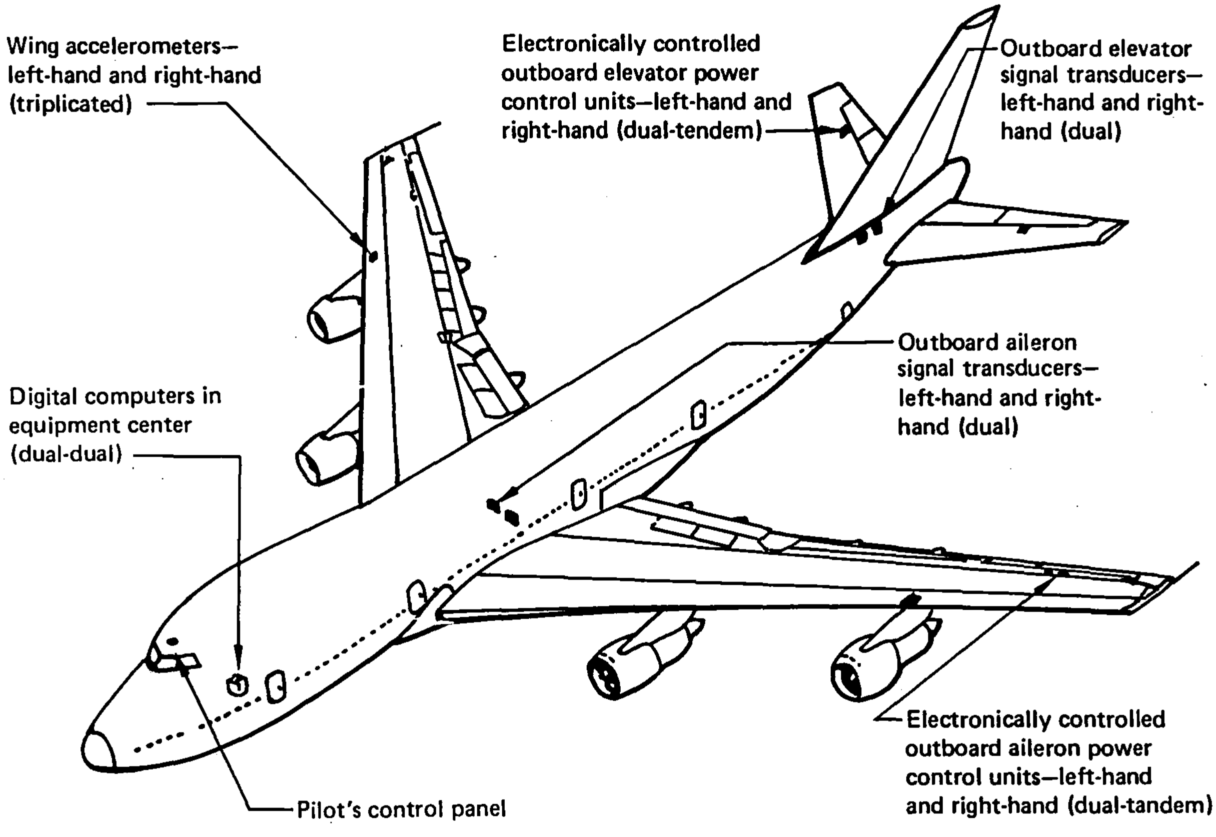


Figure 7. Component Location for Wing Load Alleviation-Equipped 747

Wing motion is sensed for control law computation. A triple redundant set of accelerometers is located in each wing where the outboard engine nacelle strut attaches to the front spar.

Pilot or autopilot commands to the elevators are sensed by two self-checking linear voltage displacement transducers mounted on the inboard elevator power control units. During pilot or autopilot maneuvers, the outboard elevators also receive WLA commands. The flap position is sensed by a triplicated set of switches that provide discrete signals for different flap positions. In the flaps-down configuration, the WLA authority is reduced during pilot or autopilot lateral maneuvers.

The functional diagram (fig. 8) shows the elements of the system for one control surface. Each sensor set is cross-strapped to the two computers. Signal selection and failure detection are performed in each computer. The WLA computers command symmetric deflection of the outboard ailerons and outboard elevators. At each power control unit, the WLA and pilot or autopilot commands are electrically summed. The electrohydraulic actuators are dual tandem with electrical and hydraulic fail-operational capability.

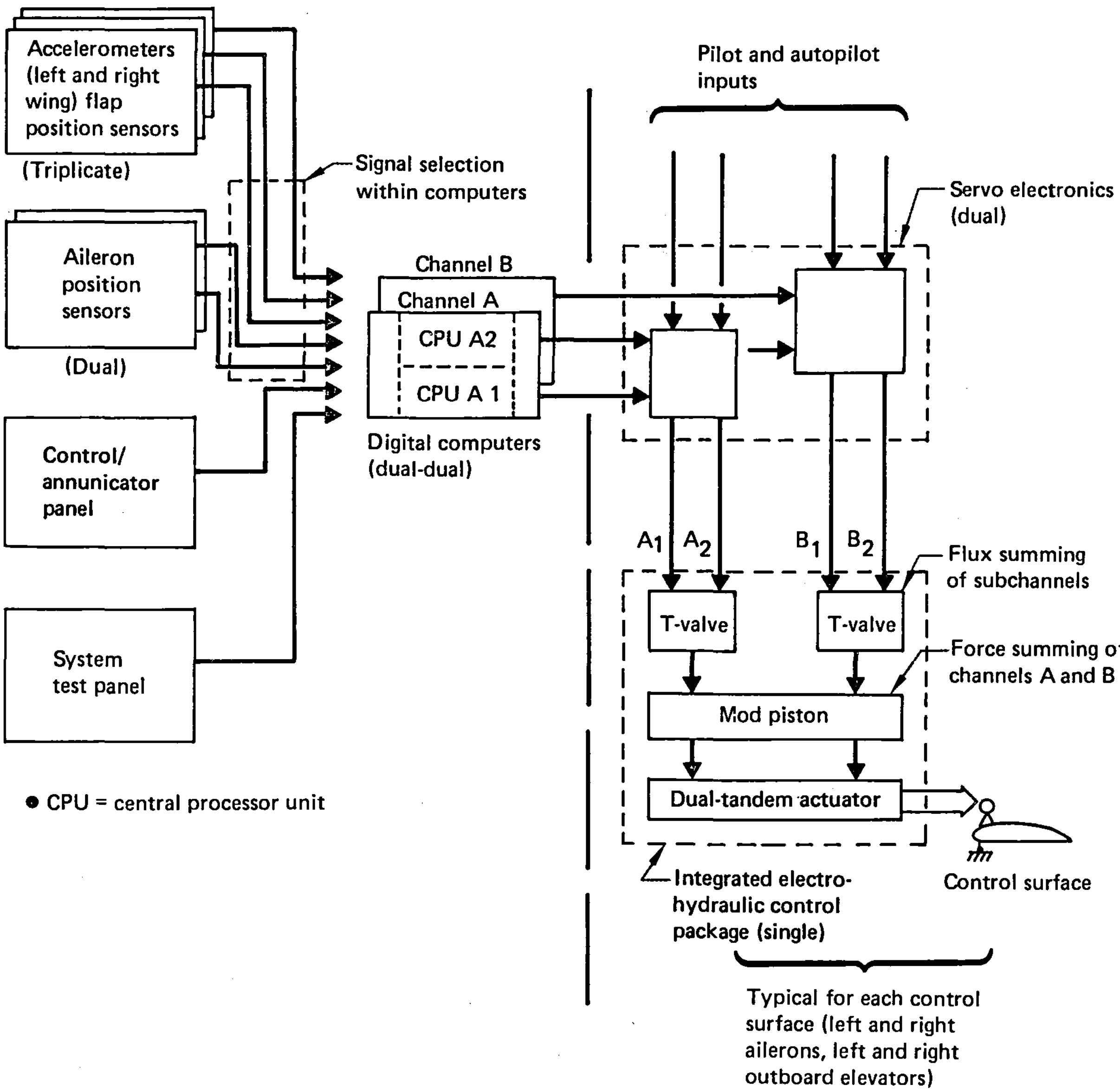


Figure 8. Wing Load Alleviation Functional Diagram

Each power control unit consists of two electrical and two hydraulic channels. In each electrical channel two servo amplifiers receive commands from one WLA computer and electrically transduced pilot or autopilot commands. The two servo amplifiers drive a T-valve that positions a modulating piston and also the main control valve.

The outboard aileron and outboard elevator power control units are new units replacing the existing units. Also, the existing aileron lockout system including control cables and linkages is removed. A detailed weight breakdown showing items removed and items installed on the basic 747 is found in appendix C.

6.2 WLA SYSTEM RELIABILITY

During dual channel operation, force summing in the actuator provides failure protection. Inline monitors detect and isolate the failure, and the affected channel is deactivated. Component failure rates, shown in table 25, include wiring and connector failures derived from the flight control system reliability analysis.

Table 25. Wing Load Alleviation Component Reliability

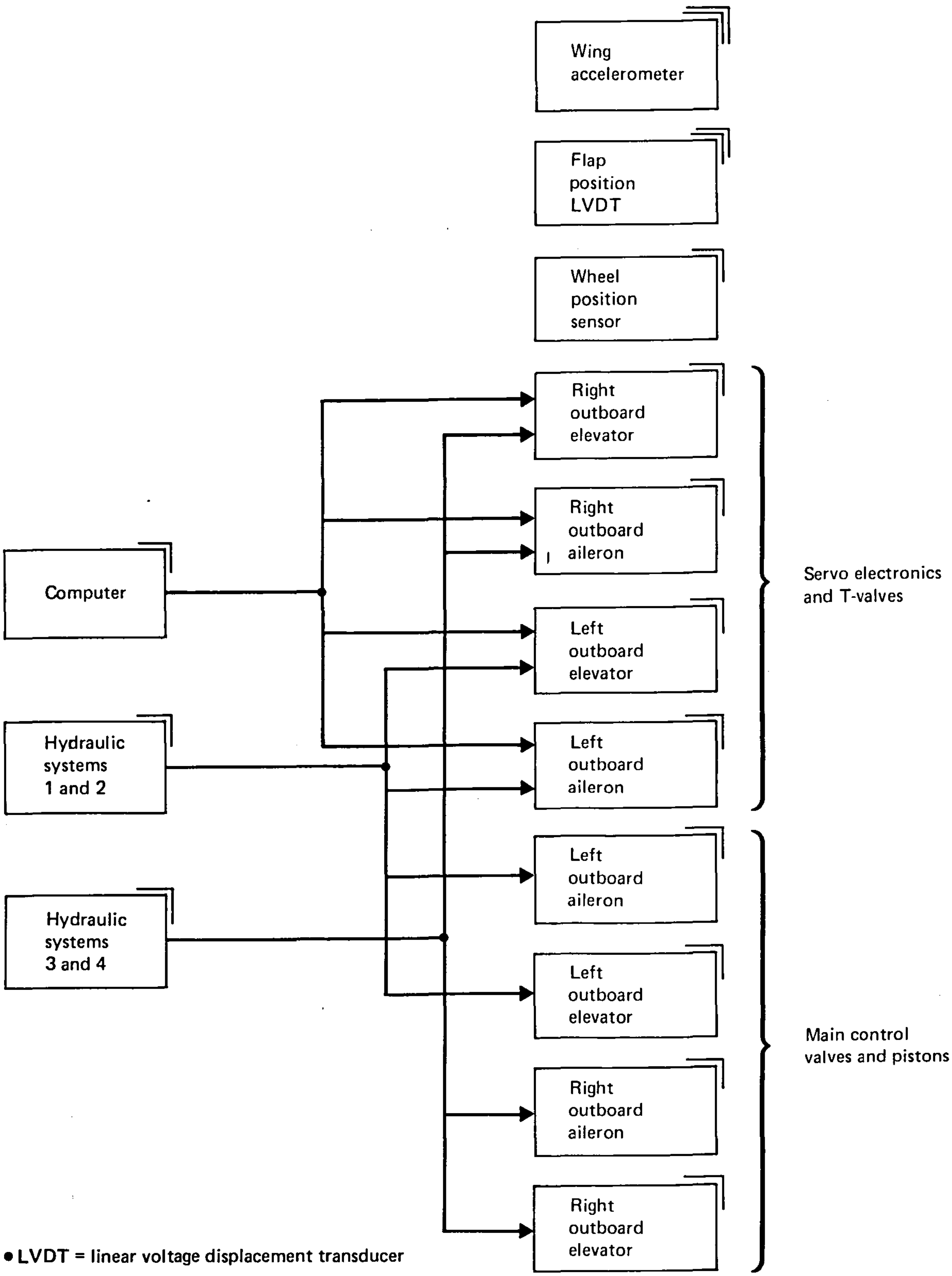
Component	Component failures per 10^6 unit hr	Combined component connector and wiring failures per 10^6 unit hr
Computer	200.0	244.9
Outboard aileron servo	10.0	21.9
Wing accelerometer	34.0	45.9
Flap sensor	17.0	28.9
Outboard elevator servo	10.0	13.4
Wheel position sensor	62.0	68.0
T-valve and mod piston	10.0	10.0
Actuator	0.5	0.5
Hydraulic system	43.5	43.5

The dependency tree for the WLA system is shown in figure 9. The method for showing the levels of redundancy by the number of corner marks at the top right edge of each module is the same as that used for the combined flight control system analysis in section 4.4. Failure combinations that do not result in loss of the WLA function are as follows:

- Any sensor stage
- Any one hydraulic system
- Any two hydraulic systems except Nos. 1 and 2 and Nos. 3 and 4
- Any one servo electronic element
- Any one T-valve module
- One outboard elevator stage
- One computer

The probability of failing both channels in a given flight, assuming departure with both channels operating, is shown in table 26 for different flight lengths.

To provide a WLA reliability comparison with an existing airplane system, the 747 yaw damper was selected as a basis for comparison since it performs a function similar to WLA. The failure probability of the yaw damper system is 0.11×10^{-5} for a 4-hour



• LVDT = linear voltage displacement transducer

Figure 9. Wing Load Alleviation System Dependency Tree

Table 26. Wing Load Alleviation System Reliability

Wing load alleviation system (includes wiring and connector failures)	Failure probability during flight		
	1-hr duration	4-hr duration	8-hr duration
	0.13×10^{-6}	0.21×10^{-5}	0.86×10^{-5}

flight. The equivalent failure probability for WLA is 0.21×10^{-5}. WLA connector and wiring failures were estimated from the failure data used in section 4.2 and included in the failure probability computation.

6.3 WLA INVENTORY AND MAINTENANCE COST PREDICTION

The inventory costs of installed hardware, spares, and support equipment for the wing load alleviation system were estimated in similar format to the cost data received from Pan Am.

Inventory Costs—The estimated cost from the reference 3 study for installing WLA on a production 747 was $120,000. Part of this cost was to provide structural provisions and installation. The cost breakdown of the equipment at the component level is shown in table 27, with corresponding spares quantities as a percentage of installed units. The spares requirements were based on the ratio of spares to fleet-installed quantities for similar equipment.

Table 27. Inventory Costs for Wing Load Alleviation Additions

Wing load allevation system	Price per airplane (1978 $)	Fleet cost for 43 airplanes (1978 $)	Spares quantity as % of fleet	Spares cost (1978 $)
Computers	$ 50,000	$2,150,000	30	$ 645,000
Sensors	10,000	430,000	15	64,500
Servo electronics	8,000	1,376,000	30	412,800
Maintenance test panel	2,500	107,000	30	32,250
Mode control panel	500	21,500	50	10,750
Actuator additions	40,000	1,720,000	5	86,000
Total	$111,000	$5,805,000		$1,251,300

The WLA system has a maintenance test panel that provides all troubleshooting needs for detecting and isolating faults at the LRU level. It is assumed that no requirement exists for unique ground support equipment.

Total WLA inventory cost for a fleet of 43 airplanes (equivalent to Pan Am's fleet size used throughout the study) consisting of installed hardware and spares is $7,056,300. This figure represents an addition of 15% to the total flight control system inventory cost.

Main Base Costs—The major element of operating cost for the main base is component repair. Table 28 shows the labor and material expenses for each component.

Table 28. Wing Load Alleviation Direct Maintenance Costs

Wing load alleviation component	Direct maintenance costs (1978 $/1,000 flight hr)		
	Component repair		Line station maintenance
	Labor	Material	Labor
Control panel	$ 9.94	$ 7.08	$ 2.03
Maintenance test panel	1.37	0	3.19
Sensors	60.11	21.78	23.38
Digital computers	98.15	27.41	30.99
Servo electronics	5.30	8.68	1.86
Total	$174.87	$64.95	$61.45
Total direct maintenance costs = $0.30/flight hr			

Maintenance training for the WLA system beyond initial introduction of a new system is not expected to impact the general recurring training schedule for airplane flight controls. Therefore, a separate cost for maintenance training was not considered.

Line Station Costs—The direct maintenance cost at the line station is the labor included in troubleshooting and replacing suspected components. These costs are shown in table 28.

It was concluded that since the airplane can be dispatched with only one channel of the WLA system operating, delay and cancellation costs would be insignificant. The fact that there were no Pan Am B-747 delays or cancellations attributed to a comparable system, the yaw damper system, for 1978 lends credence to that conclusion.

6.3.1 WLA Maintenance Cost Summary

The WLA annual maintenance cost in 1978 dollars for a 43-airplane fleet is $195,800, fully burdened (table 29). This represents only 3.4% per year of the WLA inventory cost. In comparison, the flight control maintenance cost per year is 8.7% of the total flight control system inventory cost. This represents an addition of 5% to the combined flight control system annual maintenance and delay costs. For cost-benefit analyses, the initial price of a WLA system is more sensitive than maintenance cost because the WLA hardware and spares cost is 15% of the total flight control system hardware and spares cost.

Table 29. Wing Load Alleviation Maintenance Cost Summary

	Annual operating cost for a 43-airplane fleet (1978 $)
Direct maintenance	
Shop material	$ 11,800
Shop labor	31,900
Line labor	11,200
Burden	140,900
Total	$195,800

7.0 REFERENCES

1. NASA CR-145271, "Flight Control Electronics Reliability/Maintenance Study", contract NAS1-13654, December 1977.

2. NASA CR-159010, "747 Primary Flight Control Systems Reliability and Maintenance", contract NAS1-14742, April 1979.

3. NASA CR-3164, "Conceptual Studies of Wing Tip Extensions, Winglets, and Wing Load Alleviation for the Boeing 747 Energy Efficient Transport", contract NAS1-14741, November 1979.

APPENDIX A

AUTOMATIC FLIGHT CONTROL DESCRIPTION

Contents

1.0 TYPICAL PILOT ACTION FOR DIFFERENT FLIGHT PHASES

Takeoff and Initial Climb

The autopilot may be engaged during the climb to minimize the workload and enhance safety by allowing the pilot flying to broaden his scan and watch for other traffic. When the autopilot is used during initial climb, it may be used in heading or VOR/LOC mode with altitude select set for cruise altitude or clearance altitude and the pitch mode set for IAS. Figure A1 shows the various modes on the mode select panel.

The pilot may select altitude hold for clean-up. The flight engineer will set climb thrust when flap retraction is initiated. When the airspeed reaches V2 + 80, select IAS and altitude select and continue climbing to clearance limit altitude or cruise altitude if maximum angle of climb is required.

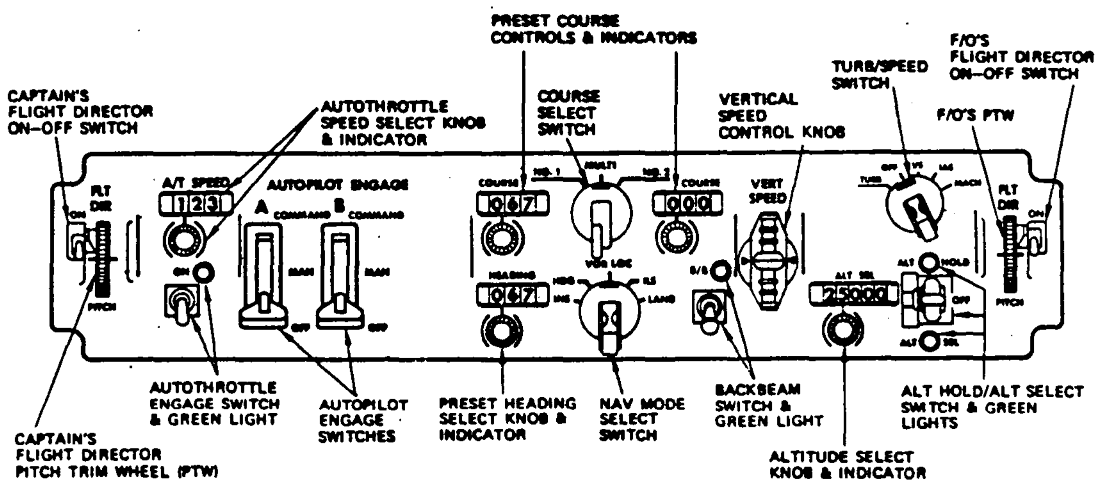


Figure A1. Mode Select Panel Functions

Enroute Climb
Maintain V2 + 80 (best angle of climb) until clear of obstacles or above minimum crossing altitude for close-in radio fix. If there are no altitude or regulatory restrictions, accelerate in level flight to the desired climb schedule and select IAS and altitude select if desired. The heading or course select knobs may be used to navigate.

Approaching Top Of Climb
A smooth transition from the constant IAS climb to the constant Mach can be made on autoflight by switching the speed mode switch from IAS to V/S at the climb airspeed to climb Mach crossover point. The vertical speed control wheel will stop moving when V/S is selected and will indicate the climb rate.

Top of Climb
At the top of the climb, the altitude select annunciator light will change from amber to green. Maintain climb thrust until cruise Mach number is exceeded by approximately M.01 and then the flight engineer will set cruise thrust.

Initial Cruise
After cruise thrust is set, check lateral directional trim. If cross-trim is suspected, check engine parameters for indication of unequal thrust. Zero the aileron and rudder trim. If trim is required, hold the wings level with the control wheel using the ADI for a reference. Trim the rudder to maintain heading. When heading is stabilized, trim out any force that is being held on the control wheel.

INS PROCEDURES

Airways Navigation:
While flying on radio defined airways, the INS readouts may be utilized to show ground speed and drift angle. Other parameters are available as desired.

Departing Outbound Radio Fix:
Over the outbound radio fix, check the accuracy of each INS by comparing the crosstrack distance (XTK) and time of waypoint change with actual station passage.

Enroute
Transition from radio to INS navigation. Switch the autopilot to MANUAL, if in use. Place the Radio/INS switch to INS. Place the NAV mode selector switch to INS. Intercept the desired track if required or if cleared present position direct to next waypoint, press WYPT CHG. Select 0 to the desired waypoint and insert it into the INS. Turn the airplane to the desired track indicated on the HSI. Repress WYPT CHG and INSERT to recenter the

CDI and flight director. Place the appropriate autopilot in COMMAND.

The three INS's should be monitored for possible navigation deviations. The No. 3 INS CDU should normally display XTK-TKE to provide a continuous check of track deviation. An autopilot will normally be flying one INS and the remaining system can be checked on the appropriate HSI.

Transition INS To Radio Navigation:
Switch the autopilot in use to MANUAL. Place the navigation mode switch to HDG and the Radio/INS switch to RADIO position. Position the HDG Bug to agree with the airplane heading. Place the autopilot engage switch back to COMMAND.

Rerouting:
Insert the new latitude and longitude into a waypoint not being used by the autopilot. Change FROM-TO to indicate from 0 to the desired waypoint using the WYPT CHG and INSERT key.

Approaching Top Of Descent
Monitor the destination weather. Plan Top of Decent (TOD) time and distance based on anticipated or known ATC delays, turbulent or icing conditions forecast or reported in the area of descent, weather to be avoided during decent, etc. If delays are known or anticipated, request holding at optimum holding altitude.

Enroute Descent
The INS can be used for descent planning by monitoring the time to go to destination, present rate of descent, and altitude change required.

Set the navigation and communication radios for terminal area arrival. Use DME, INS, ground radar and any other means to accurately fix distance out before commencing descent. reduce thrust by smoothly retarding thrust levers to the throttle bar (if used).

Holding Procedure
Hold in the published holding pattern or according to instructions from air traffic control. Reduce airspeed to the desired holding speed and place the autothrottle engage switch to ON. A suggested autoflight descent while holding with autothrottle would be: altitude selector, set desired altitude; altitude mode switch, ALT SEL; speed mode switch, V/S; vertical speed control, desired descent rate.

ILS Approach Preparations
Complete the approach preparations before arrival in the terminal area. Check that the Radio/ INS switch is in the radio position. Tune and identify the ILS and

associated compass locators as soon as practical. Check ADF Mode switch in ADF position. Check VOR/ADF switches and set ADF. Set the published inbound course in the course selectors so that the proper airplane heading/localizer course relationship is displayed. Initially set the radio altimeters at their highest setting. After descending through the initial setting, reset radio altimeters to decision height.

Localizer Intercept
The HSI course deviation indicator (CDI) will remain at a full-scale deflection until the airplane is approximately 2-1/2 degrees off course. The magnetic bearing information on the RMI should be used to supplement the CDI during initial course interception. Begin the turn to the inbound localizer heading at the first movement of the CDI.

Final Approach
Adjust to final approach configuration and airspeed as the glide slope is intercepted. Smooth corrections should be made on the ADI based on the ILS course and glide slope indications.

Decision Height (DH)
Do not continue the approach below decision height unless the airplane is in a position from which a normal approach to the runway of intended landing can be made and adequate visual reference can be maintained.

During area arrival for ILS appraoch, both flight directors should be ON and the NAV mode selector switch placed in HDG. On final vector or procedure turn inbound, check that NAV mode is selected to ILS or LAND and that NAV and G/S annunciators are AMBER, indicating intercept circuits are armed. When the NAV light turns green, indicating automatic capture has started, the intercept angle will be commanded by the flight director. (Heading settings will no longer control heading command.) Set heading Bugs to inbound localizer course for use in HDG mode in the case of a missed approach. When the glide slope indicator centers, the glide slope annunciator light will turn green and the flight director will command glide slope tracking. During descent, keep the flight director bars centered. Monitor glide slope and localizer. Respond to flight director commands with coordinated aileron and rudder.

Autoland
The autopilot may be engaged in either the manual or command mode. Automatic approach functions are provided only in the command position. Dual channel operation (A and B) is possible only in the land mode. Hydraulic pressure must be available from hydraulic system 2 or 3 for single channel operation, and from both systems for dual channel operation. Control during single channel

operation provides the same intercept and approach as the dual channel, but does not incorporate the monitor or flare functions. Dual channels provide fail-passive operation below 455 m. (1,500 ft) radio altitude for automatic landings. The autopilot utilizes airspeed, altitude, and altitude rate information from the central air data systems. Normal rudder control is available to the pilot throughout the approach and flare.

Final Approach
The autopilot functions as a dual system only after the localizer and glide slope have been captured and the radio altimeters are reading less than 455 m. (1,500 ft). Activation of dual channel operation is indicated by the illumination of the amber flare "arm" light. A disconnect will occur if both channels are not engaged by 45 m. (150 ft) and the mode selector is in LAND. At an altitude of about 15 m. (50 ft), the flare coupler initiates a flare and the flare light changes from amber to green. At flare initiation, normally the control column will move slightly to command a slight increase or decrease in pitch attitude.

Landing
The autothrottles will be slowly retarded during flare. Disengage the autopilot and the autothrottle immediately after touchdown.

2. EXPLANATION OF AUTOPILOT COMMAND MODES

Manual Mode
In this mode the roll autopilot responds to bank commands inserted via the turn knob. When zero bank is commanded (turn knob in detent) wings leveling occurs after which the autopilot holds airplane heading. If the pilot desires to change the airplane pitch attitude, the pitch wheel on the flight controller is used. The pitch wheel produces an altitude command proportional to wheel displacement.

Command Mode
When engaged in COMMAND, the pilot has the option of control by any of the following modes:

Roll Channel
- Heading Select
- VOR/Localizer
- INS
- ILS
- Land

Pitch Channel
- Altitude Hold
- Altitude Select
- Vertical Speed
- IAS Hold
- Mach Hold
- ILS
- Land

Heading Select Mode

This mode allows the pilot to use the autopilot to fly a desired heading and is engaged by placing the NAV mode select switch in HDG and positioning the autopilot engage switch in COMMAND. The command signal is the heading select error (instantaneous heading of the airplane minus the selected heading). The gain is scheduled as a function of true airspeed to maintain consistent system performance throughout the flight regime.

Localizer Mode

Use of this mode requires the following pilot procedures:

1. Tune in the localizer receivers.
2. Dial in the runway heading with the course selectors on the mode select panel.
3. Position the mode select switch in VOR/LOC.
4. Dial in the desired localizer beam intercept heading displayed on the Heading Select window.
5. Position the Automatic pilot engage switch in COMMAND.

The autopilot is in the Heading Select Mode until the localizer capture sensor operates and the capture mode is initiated. After capture, the system switches to the localizer on-course mode when the on-course logic is satisfied.

VOR Mode

The procedure for the pilot to engage this mode is identical to that of the localizer except that the VOR frequency has to be selected rather than the LOC frequency. The autopilot, with VOR mode selected, will steer the airplane to the desired intercept angle established with the heading select control on the Mode Select Panel. If the pilot desires to make a course change while over the station, he may dial in the change in course setting and the system will track out-bound on the new radial.

INS Mode

The autopilot may be used to capture and track any of the great circle routes that have been programmed into the INS computer. The INS mode is armed by placing the NAV mode selector switch of the autopilot mode select panel in the INS Position. Cross-track deviation and track angle error outputs of the INS are used to compute the desired steering command. There are three INS modes: Capture, On-course and Way Point Switching.

ILS Mode

Glideslope control is armed by this mode and the autopilot continues to fly towards the glideslope beam on either pitch altitude, vertical speed, altitude or IAS hold until a predetermined glide slope signal level is reached.

LAND Mode

The autopilot LAND mode provides the airplane with a dual-channel automatic approach and landing system. The LAND mode features dual ILS and flare coupling. The LAND mode is properly selected when the following prerequisites are satisfied:

1. NAV Mode Selector switch in LAND.
2. Both course controls set to the runway heading.
3. Heading select control set for the desired angle with the localizer.
4. VHF/NAV receivers set to the proper localizer frequency.
5. Both autopilot engage switches in the command position.

Upon selection of this mode, single channel operation, identical to that for the ILS mode, is initiated. Dual channel operation does not begin until after the autopilot is on LOC approach, glide slope capture is completed and the airplane is less than 455 m. (1,500 ft) altitude.

Altitude Hold

This mode holds the airplane at the altitude existing when the mode is engaged. If the mode is engaged with the airplane climbing or descending at a reasonable rate, the airplane returns to and holds the engage altitude.

Altitude Select

The altitude select mode allows the pilot to select a desired flight altitude. If the selected altitude is more than 360 m. (1,200 ft) from actual altitude, the pilot also selects the desired mode of climb or descent. With these selections made and the mode engaged, the autopilot maneuvers the airplane to smoothly capture and hold the selected altitude. This mode is particularly useful when a number of successive altitude changes are required.

Vertical Speed

This mode is selected by the Turbo/Speed switch on the mode select panel. Prior to selection, the vertical speed wheel on the mode select panel is synchronized to airplane vertical speed.

IAS Hold

This mode gives the pilot automatic indicated airspeed hold capability.

Mach Hold

The Turbo/ Speed select switch on the Mode Select Panel selected for Mach Hold will automatically maintain airplane Mach.

APPENDIX B

CONNECTOR AND WIRING PROBLEMS ON PAN AM'S B-747 FLEET

This appendix contains details of maintenance actions to correct all flight control and hydraulic system connector and wiring problems on Pan Am's B-747 fleet during 1978.

Problem details are listed by ATA system, associated connector LRU or airplane location, problem description, action taken, and the manhours to correct the problem, together with any automatic test equipment time and cost of materials used.

MAINTENANCE ACTIONS RELATING TO WIRING AND CONNECTORS
12 MONTHS 747 OPERATION

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
34-12	73460	"A" A/P causes porpoising in altitude hold	Swapped CADC	1.0
22-13	72202	A/P wailer sounds when transferring from APU to ships power	Swapped roll computer	.5
22-11	42213	Capt. & F/O "B" A/P disengage light flashes	Reseated LCLU	1.0
22-12/3	72201/2	F/O flight director both needles out of view on "B" computer	Reseated roll & pitch computer	1.0
34-12	73460	"B" A/P & alt. selected, capt 1000' below sel. A/C pitches up	Swapped CADC	.5
22-11	72204	A/P auto disengage & warning flag out of view	Reseated MLU	.5
22-12	72201	"B" A/P in ins mode gives erratic nose up	Swapped "B" & "C" pitch computer	.5
22-13	72202	F/O course bar gives erratic commands on ILS	Reseated roll computer	.5
22-13	72202	"A" A/P took off to left on approach	Swapped "A" and "C" roll computer	.5
22-11	73422	A/P warning light does not light on F/O flight	Reseated annunciator	.5

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
		director test		
22-13	72202	A/P warning light on steady with "A" channel engaged	Swapped "A" & "C" roll computer	.5
22-12	72201	When turb mode selected "B" A/P does not drop to manual	Swapped "B" & "C" pitch computer	1.0
22-12 34-12	72201 73460	"A" A/P in command alt hold on, A/C started to climb--disconnected	Reseated pitch & CAD computer	.5
34-12	73460	"A" A/P steady red light when IAS is selected on	Swapped CADC	.5
22-12	72201	Stabilizer trim was dis-engaged motor ran ex-cessively	Swapped "A" & "C" pitch computers	.5
34-41	73402	"A" A/P warning light on steady when engaged in INS mode	Reseated INS	.5
22-13	72202	"A" A/P caused 10 deg. right bank in command	Swapped "A" & "C" roll computers	.5
22-11	73422	A/P warn light on. Both CIWS would not test	Replaced socket A/P flight director	1.0 $16.30
22-12	72201	"B" A/P had nibble in cruise	Swapped "B" & "C" pitch	.5
22-13	72202	On approach "A" A/P only 10 deg bank angle. Slow	Swapped "A" & "C" roll computers	.5

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
		to capture ILS		
22-13	72202	"A" A/P tripped off. Would not re-engage	Swapped "A" & "C" roll computers	.5
22-11	72204	"B" A/P dropped off once in cruise	Reseated MLU	.5
22-12	72201	"A" A/P engage switch locked in off position	Swapped "A" & "C" pitch computers	.5
22-11	73422	F/O A/P annunciator light bad. Must tap connection for indication	Reworked light assembly	.5
22-13	72202	"B" A/P would not capture on localiser	Swapped "A" & "B" roll computers	.5
22-12	72201	A/C pitches down through selected altitude	Swapped "A" & "C" pitch computers	.5
22-12	72201	"A" A/P disengaged during approach A/C descending	Swapped "A" & "C" pitch computers	.5
22-13	72202	"B" A/P makes very abrupt turns in heading	Swapped "B" & "C" roll computers	.5
34-41	73402	"A" A/P warning light on with radio/INS selected	Swapped INS "1" & "3"	.5
22-12	73401	"A" A/P warning light on steady no other symptom	Swapped "A" & "C" pitch computers	.5
34-12	73460	"B" A/P would not maintain airspeed or V/S in alt. sel. mode	Swapped CADC	.5

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
22-12	72201	"A" A/P caused A/C to pitch up	Swapped "A" & "C" pitch computers	.5
22-12 22-13	72201 72202	F/O "B" flight director computer inoperative. Ok later on in flight	Reseated pitch & roll computers	.5
22-12	72201	"A" A/P auto disengaged flag in view	Reseated pitch computer	.5
22-14	72224	Auto stabilizer trim light on steady at t/o and climb	Reseated ASTU	1.0
22-11	73422	Capt. annunciator light showed lock on then extinguished	Cleaned contacts on annunciator	.5
22-13 22-12	72202 72201	A/P disconnects when selecting land with either "A" or "B" channel	Reseated roll & pitch computers	1.0
34-12	73460	"A" A/P inoperative on altitude hold	Swapped CADC	.5
22-12	72201	"B" A/P trims A/C nose up	Swapped "B" & "C" pitch computers	.5
22-13	72202	"A" A/P gives steady red light when in command	Swapped "A" &"C" roll computers	.5
22-12	72201	"A" A/P selected to command alt/select remain on	Swapped "A" & "C" pitch computers	.5
22-11	72204	A/P red warning light on	Reseated MLU	.5

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
		both sides "A" A/P in command		
22-11	73422	Capt. annunciator did not operate for either "A" or "B" A/P	Reseated annunciator C/P	1.0
34-31	73458	"B" F/D did not give green nav. light after VOR intercept	Reseated No. 2 VOR receiver	.5
22-13 34-44	72202 73402	"C" F/D gives no course information in INS mode	Reseated "C" roll computer and INS	1.0
22-12	72201	A/C porpoises on "A" A/P	Reseated pitch computer	.5
22-11	73422	F/O annunciator not operating ok on test	Reseated annunciator	.5
22-13	72202	"B" A/P drifts off to left in manual mode	Swapped "B" & "C" roll computers	.5
22-12 22-13	72201 72202	Both A/P porpoise on altitude hold	Reseated "A" & "B" pitch and roll computers	1.0
22-13	72202	"B" A/P in INS capture mode wanders off course	Swapped "B" & "C" roll computers	.5
22-11	73422	No F/D lights on capt annunciator panel	Secured annunciator panel	.5
22-12	72201	On "A" A/P elevator position indicator showed over 1 deg nose up	Swapped "A" & "B" pitch computers	1.0
22-12	72201	"B" A/P in command--alt	Swapped "B" & "C" pitch	.5

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
		sel on. gradual level off then descent	computers	
22-12	72201	F/O F/D horizontal bar jumps	Swapped "A" & "B" pitch computers	.5
34-12 22-12	73460 72201	"A" A/P in command, alt sel on pitch wheel control inop	Swapped 1 and 2 CADC and "A" & "B" pitch computers	1.0
22-13	72202	"A" A/P causes aileron jitters	swapped "A" & "C" roll computers	.5
22-12	72201	"B" A/P stab light on when "B" A/P engaged	Swapped "B" & "C" pitch computers	.5
22-13	72202	F/O ADI F/D flag partially exposed	Swapped "A" & "B" roll computers	.5
22-12	72201	On "A" A/P lots of elevator without trimming	Swapped "A" & "C" pitch computers	.5
22-12 22-13	72201 72202	F/D flag in view on capt ADI on "A" or "B" A/P	Reseated pitch and roll computers	.5
22-12	72201	"A" A/P gives pitch up as selected altitude is approached	Reseated "B" pitch computer	.5
22-13	72202	"B" A/P drops from command to manual	Swapped "B" & "C" roll computers	.5
22-13	72202	"B" A/P failed to hold selected heading. No red light	Reseated "B" roll computer	.5

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
22-12	72201	"A" A/P trims A/C nose down	Swapped "A" & "C" pitch computers	.5
22-13	72202	"B" A/P in turb mode A/C goes into 1 to 3 degree left bank	Swapped "B" & "C" roll computers	.5
22-12	72201	"B" A/P in command pitches up in alt hold--alt. sel. ok	Swapped "B" & "C" pitch computers	.5
22-16	72221	Upper yaw damper light on	Swapped yaw damp computers	1.0
22-13	72202	Capt F/D computer gives erroneous indications	Reracked "A" & "C" roll computers	.5
22-12	72201	"B" A/P in command with INS selected--elevator pitches nose down	Swapped "B" & "C" pitch computers	.5
22-12	72201	A/P warning light on steady red in landing mode	Swapped "A" & "B" pitch computers	1.0 ILS tester .5
22-12	72201	"B" A/P has stab trim light on and won't hold altitude	Swapped "A" & "B" pitch computers	.5
22-12	72201	"B" A/P alt hold on A/C pitches up	Reseated pitch computer	.5
	72220	No. 2 autothrottle does not follow other throttles	Reracked auto throttle computer	.5
22-13	72202	"B" F/D computer gives	Swapped "A" & "C" roll	1.0

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
		erroneous fly left	computers	
22-12	72201	Auto stab trim "B" light on stab in trim	Swapped "A" & "B" pitch computers	1.0
22-14	72215	Auto stab trim "B" light on A/C in trim	Reseated trim interface unit	1.0
22-14	72224	"A" A/P stab trim light comes on when put in manual	Reracked auto stab computer	1.5
22-12	72201	F/D horizontal bar will not bias out of view on F/O ADI	Reseated "B" pitch computer	.5
22-13	72202	"A" A/P engaged INS mode red warning light on	Swapped "A" & "C" roll computers	.5
22-12 22-13	72201 72202	"C" F/D failed to provide proper commands for selected headings	Swapped "A" & "C" pitch and roll computers	1.0
	72216	F/O F/D annunciator green nav light is intermittent	Reseated A/P accessory box	.5
		"B" F/D inoperative on ILS ok in INS no vert bar	Reseated units in rack	1.0 ILS tester .5
22-12	72201	F/O F/D on "B" computer quit	Reseated "B" pitch computer	.5
22-11	72204	"B" A/P in manual when selected to command snaps alt hold to off	Reseated logic unit	.5

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
	P73 Panel	In level flight "B" A/P in HDG mode got A/P red warn lights	Found pin 19 in plug DR289A and pin 47 in plug DR289C bent—straightened	3.0
22-11	72204	Capt flight mode annunciator lights did not light on approach	Reseated monitor logic unit	1.0 ILS tester .5
	72216 72217	F/O A/P annunciator nav green light won't capture either A/P	Reseated both A/P accessory boxes	.5 ILS tester .5
22-12	72201	"A" A/P caused stab trim light to illuminate. "B" ok	"C" pitch computer was cocked—adjusted	1.0
22-13	72202	"B" A/P unstable due constant roll	Swapped "B" & "C" roll computers	.5
34-12	73460	"A" A/P will not level off on selected altitude	Swapped CAD computers	1.0
22-13	72202	After capture A/P failed to maintain INS course	Swapped "A" & "C" roll computers	.5
22-12	72201	"B" A/P disengages with warning flag	Swapped "A" & "B" pitch computers	.5
22-12 22-13	72201 72202	A/P "B" will not engage in flight also no engage on ground	Reseated "B" pitch and roll computers	.5
22-12	72201	With "A" A/P in command alt mode switch won't engage alt	Swapped "A" & "B" pitch computers	.5

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
22-13	72202	After capture "A" A/P failed to maintain INS course	Swapped "A" & "C" roll computers	1.0
	STA 2460	Auto stab trim "B" light on steady--no trim function	Plug DB1890 shorted--replaced plug	4.0 $21.42
22-12	72201	"A" A/P stab trim light on at all times	Swapped "A" & "C" pitch computers	1.0
22-16	72221	Lower yaw damper disengaged due excessive rudder movement	Swapped upper and lower computers	1.0
34-12	72460	"B" A/P plus-minus 200' in alt hold	Swapped "A" and "B" CAD computers	1.0
34-12	73460	"A" A/P pitches up at engagement	Swapped CAD computers	1.0
34-31	73458	Both F/D command bars showed fly right	Swapped VOR nav units	.5 ILS tester .5
22-11	73422	Capt A/P annunciator flare light no test amber	Found pin pushed back--replaced annunciator	1.0
22-12	72201	"A" A/P don't operate in pitch using man. sel.	Swapped pitch computers	.5
22-12	72201	"A" A/P trims nose up with altitude hold on	Reseated "A" pitch computer	.5
34-12	73460	"A" A/P pitched nose down when engaged to command	Swapped CADS	1.0

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
		"B" A/P won't engage in manual or command	Reseated units--engaged ok	.5
22-13	72202	After capture "B" A/P failed to maintain INS course	Swapped "A" and "B" roll computer	1.0
22-12	72201	During climb "A" A/P in command alt sel on--vert control is inop.	Swapped "A" and "C" pitch computers. OPS ok	1.5
22-13	72202	A/P "B" INS mode .1 miles left of track. B shows ADI right	Reracked "B" roll computer	1.0
22-16	72221	F/O ADI R/T flag in view	Reseated lower yaw damp computer	.5
34-41	73407	"B" F/D pitch bar and F/O ADI pitch bar inoperative	Repaired broken wire at C/P at ADI	3.0
22-12 22-13	72201 72202	"B" A/P disconnects when turn knob is moved	Reseated roll and pitch computers	.5
22-11	73422	Capt A/P annunciator panel inop	Repaired panel contacts	1.5
22-12 34-12	72201 73460	"B" A/P alt hold causes pitch up when engaged	Reseated pitch and CAD computers	1.0
22-12	72201	"A" A/P did not trim stab in cruise	Reseated pitch computer	.5
22-12	72201	"B" A/P causes A/C to pitch up. alt mode	Reracked pitch computer	.5

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
		switch off		
34-12	73460	"A" A/P in command alt selected on A/P will not capture selected HDG	Reseated CAD computer	1.0
	72222	F/O HSI course window changes 180 deg on P10	Cleaned all connections on P10 (MSP)	2.0
22-16	72221	R/T flag on capt ADI in view intermittently. Upper yaw damp light on	Reseated upper yaw damp computer	.5
22-12	72201	"A" A/P gives slight kick in elev. at times	Swapped "A" and "B" pitch computers	1.0
22-11	73422	A/P capt green light does not come on	Reseated annunciator unit	.5
22-12 22-13	72201 72202	A/P steady red light. No disengage flag	Reseated pitch and roll computers	.5
22-14	72215	Stabilizer "B" trim light on. A/C was in trim	Interface unit loose in rack--adjusted	1.0
22-11	73422	A/P annunciator light did not illuminate on approach	Cleaned, adjusted annunciator module	1.0
22-14 22-14	72224 72215	A/P auto stab trim "B" light on--stabilizer in trim	Reseated auto stab trim unit & interface unit	1.0
22-16	7221	Capt's ADI turn needle indicates 1/3 needle	Swapped yaw damper couplers	.5

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORREC. PROBLEM PLUS ATE TIME AND MATL. COS.
		width to right		
22-12	72201	A A/P causes A/C to porpoise 75-80 feet	Swapped A & C pitch computers	.5
22-12	72201	B A/P won't hold altitude in altitude select	Swapped A & B pitch computers	.5
22-11 22-12	72204 72201	B A/P dropped from command to manual on INS mode	Reseated monitor & logic unit & pitch computer	1.0
22-12	72201	On dual auto approach ok to flare then oscillates	Swapped B & C pitch computers	.5
34-41	73402	A A/P turns A/C to right in command	Swapped #1 & #3 INS navigation units	.5
22-12 22-13 22-11	72201 72202 72204	Both A/P annunciator lights intermittent	Reseated roll & pitch computers & monitor & logic unit	1.0
22-12	72201	B A/P went from command to off causing pitch down	Swapped B & C pitch computers	.5
22-11	73422	F/O's A/P annunciator navigation light intermittent	Repaired bent pin at annunciator panel connector	1.0
22-11	72204	A A/P, wailer sounds with warning lights	Reseated monitor & logic unit	.5
22-13	72202	A A/P caused erratic roll during INS capture	Swapped roll computer	.5

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
22-12	72201	F/D flag on C in view	Swapped B & C pitch computers	.5
34-41	73402	A/P coupled approach unsatisfactory--porpoises on glide slope	Swapped INS nav units	1.0
34-12	73460	B A/P in command, altitude hold, A/C deviated 200' up and down	Reseated #2 CADS computer	.5
22-11	73422	When switching from APU to ship's power B A/P wailer sounded	Adjusted F/O's B A/P disconnect light	1.0
22-11	73422	A A/P on INS mode, capt's green nav light not on	Adjusted loose dimming photo cell	.5
34-41	73402	A/C climbs/dives 150' per minute on either auto pilot	Swapped #2 & #3 navigation units	.5
22-11	72204	B A/P, disengages when INS selected	Reseated monitor & logic unit	.5
22-12	72201	A F/D failed to provide proper pitch command	Swapped A & C pitch computers	.5
22-12 22-13	72201 72202	B A/P drops from command to off	Reseated roll & pitch computers	.5
22-12	72201	No response from pedestal controller pitch wheel	Swapped A & C pitch computers	.5
22-12	72201	A A/P failed to capture selected altitude	Swapped pitch computers	.5

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
22-12	72201	B A/P causes occassional pitch up	Swapped pitch computers	.5
34-12 22-12 22-11	73460 72201 72204	A/P warn light on when A in heading mode	Reseated CADS computer, pitch computer, monitor and logic unit	1.0
22-13	72202	A/P did not couple on approach, flight director ok	Swapped roll computers	.5
22-12	72201	A A/P inop in altitude hold	Swapped A & B pitch computers, operation both normal	.5
22-13	72202	B A/P causes aileron jerk in command	Swapped B & C roll computers	.5
22-12	72201	A A/P has constant elevator jitter, B A/P is normal	Swapped A & C pitch computers	.5
34-41	73402	A A/P pitches down intermittently in command or manual	Swapped #1 & #3 INS navigation units	.5
34-12	73460	#1 CADC intermittently inop. flags in alt, mach, tas and tat	Secured computer CADC	1.0
34-12	73460	#2 alt CADC flag in view in descent	Reseated CADC	.5
22-13	72202	F/O course bar gives erratic commands on ILS	Reseated "B" computer	.5 ILS tester .5

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
22-16	72221	F/O ADI rt flag in view	Reseated lower yaw damp computer	.5
Instrument Panel		Instrument warning light test will not illuminate master light	Repaired pin on light assembly	1.5
34-41	73402	#3 INS inop in nav mode CDU warning light on malf code 42	Reracked #3 INS	1.0
34-41	73402	#2 ADI indicator, horizon pitches approximately 1° with altitude change	Swapped #2 & #3 INS nav units	1.0
34-41	73402	#2 INS warning light on code 01-33	Swapped #2 & #3 INS nav units	1.0
34-41	73402	Capt's time to go indicator blank	Swapped #1 & #3 INS nav units	1.0
34-41	73402	#1 INS 13 miles in error	Swapped #1 & #3 INS nav units	1.0
34-12	73460	Capt's computed airspeed tends to hang up	Reseated CAD computer	.5
34-41	73402	#2 INS in error	Swapped #2 & #3 INS nav units	.5
34-41	73402	#1 INS, 29 miles off in 6 hours	Swapped #1 & #3 INS nav units	.5
34-41	73402	#1 INS has 15 mile error in 5.5 hours	Swapped #1 & #3 INS nav units	.5

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
34-41	73402	#3 INS, unable to insert present position, nav function N.G.	Reseated INS nav unit	.5
34-12	73460	F/O's computed airspeed indication erratic, 15-20 knots off	Swapped CADS computers	1.0 Air Data Tester 3
34-41	73402	#2 INS, 22 mile error, 8.5 hours of flight	Swapper #2 & #3 nav units	.5
	MEC	Attitude director indicator sphere tumbled in climb	Replaced attitude transfer relay plugs	1.0 $64.80
34-31	73458	Capt's horizontal situation indicator deviation course needle oscillates	Swapped navigation receivers	.5 ILS tester .5
34-41	73402	#1 INS platform flag in view	Swapped #1 & #3 nav units	.5
34-12	73460	#1 CADS inop	Swapped #1 & #2 computers. Both normal	.5
34-12	73460	#2 CADS inop at top of climb	Repaired 2 bent pins at CADS computer	2.0 $2.00
34-21	73412	RMI mag flag & HSI HDG flag in view on #1 compass	Swapped #1 & #2 compass couplers--both normal	.5
34-41	73402	Capt's ADI tumbled (attitude sphere) in 25° right turn	Swapped #1 & #2 INS nav units	.5 .5

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
34-41	73402	F/O's heading flags in view	Swapped #2 & #3 INS nav unit	.5
34-41	73402	#2 G/S & FD pitch bar jumpy	Reseated #2 nav unit	.5 ILS tester .5
34-12	73406	#2 CAD system failed during descent	Adjusted hold down latches on equipment rack (#2 CADS computer)	1.0
	F/O's Instrument Panel	F/O ADI F/D flag always in view	Repaired broken wire at F/O's F/D selector switch	2.0
34-21	73412	Mag heading info to capt's H51 & RM1 6° in error	Swapped compass couplers	.5
34-31	73458	Capt's F/D annunciator did not show glide slope capture	Reseated nav receiver	.5 ILS tester .5
34-31	73458	B F/D--no green nav light after VOR intercept	Reseated #2 nav receiver	.5 ILS tester .5
34-31	73458	On single channel, B A/P in nav mode will not couple to ILS	Reseated #2 nav receiver	.5 ILS tester .5
34-33	73432	Capt's LRRA fluctuates up/down setting off GPWS	Reseated LRRA T/R	.5
34-41	73402	#2 INS off 11 miles in 3 hours	Swapped #2 & #3 nav units (INS)	.5
34-41	73402	#2 INS inoperative	Replaced rack connector,	8.0 $50.00

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
			INS nav unit	
34-41	73402	#2 INS red warn light on	Swapped #2 & #3 INS nav units	.5
34-12	73460	Altitude select inop	Swapped CADS computers	.5
34-12	73460	Altitude select failed to level off with A/P	Swapped CADS computers	.5
34-21	73412	Capt's compass 5° lower than F/O's	Reseated both compass couplers	.5
34-12	73460	No wind read out on #1 & #3 INS	Swapped CADS computers	.5
34-41	73402	Capt's ADI has gyro & F/D flags in view at times	Swapped #1 & #3 INS nav units	.5
34-41	73402	Capt's & F/O's compass systems differ by 10°	Swapped #1 & #2 nav units, INS	.5
34-21	73412	#2 compass drifted off heading with no annunciation	Reracked compass coupler	.5
34-21	73412	Capt's & F/O's compasses have 8° spread	Reseated both compass couplers	.5
34-41	73402	#2 INS waypoint 5 dropped out--read all zeros	Swapped #2 & #3 INS nav units	.5
34-41	73402	#3 INS inop	Repaired broken wire--P/N 46 wire TN3570, plug DB173F (nav unit)	3.0

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
34-12	73460	Capt's CADS intermittently inop	Reseated #1 CADS computer	.5
34-21	73412	Capt's & F/O compasses differ by 5°	Reseated both compass couplers	.5
34-41	73407	F/O's ADI F/D bars always biased out of view	Reseated ADI connector--bar operation now normal	.5
34-12	73460	#1 CAD system intermittent in turbulance	Reseated CADS computer	.5
34-31	73458	#1 VOR channel selection erratic	Swapped #1/#2 nav receivers	.5
34-31	73458	#1 VOR intermittently inoperative	Cleaned corroded lower plug of nav receiver rack connector	1.5 ILS tester .5
34-41	73402	#2 INS red warning light on	Swapped #2 & #3 INS nav units	1.0
34-41	73402	#2 INS will not accept present position or way-points	Swapped #2 & #3 INS nav units--both new ok	1.0
34-12	73460	#2 altitude reporting off +10,000' per LON	Reracked #2 CADs computer. No further problems	.5
34-31	73458	#1 nav receiver failed during approach	Reseated nav receiver	1.0 ILS tester .5
34-31	73458	#2 VOR fluctuates & is unreliable	Reseated nav receiver. All cks now ok	.5

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST	
34-12	73460	#2 CADS intermittent during descent. Flags on F/O's instrument	Reseated CADS computer	.5	
34-21	73462	#2 system heading flags in view	Reseated #2 compass coupler	.5	
34-31	73458	#1 VOR inoperative	Reseated nav receiver	.5	
34-33	73432	On descent both low range altimeters bouncing	Reseated LRRA transceivers	.5	
34-41	73402	#3 INS nav system inop	Replaced INS NU rack connector DB173C due burned	6.0	$50.00
34-41	73402	#1 INS battery light on intermittently during taxi	Reracked #1 INS nav unit	.5	
34-12	73460	#1 CADS drifts off calibration cause mach indication to read 1.3 low	Reracked CADS computer. Ok subsequent flts	.5	
34-31	73458	#2 G/S weak, flag in view	Reseated nav receiver	.5	
34-41	73402	#1 INS warn light on--no malfunction code	Swapped #1 & #3 INS nav units	1.0	
34-12	73460	Capt's altimeter hung up in descent	Swapped CADS computers	.5	
34-12	73460	Capt's altimeter reads 140' low	Reseated #1 CADS computer	.5	Air Data Tester 2
34-12	73460	During climb capt's alti-	Reseated #1 CADS computer	.5	Air Data

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
		meter dropped out intermittently		Tester 2
34-41	73407	Capt's pitch bar on ADI does not bias out of view when switch off	Reseated J2 connector on capt's ADI indicator	1.0
34-41	73402	Capt's ADI horizon went to 60° angle for 5 seconds on lift off	Swapped #1 & #3 INS nav units	.5
34-41	73402	#1 INS malfunction code 25--action codes 01 & 32	Reseated INS nav unit and realigned platform	.5
27-10	Cont S/O vlv #1 lat flt	#1 lat flt cont hyd sov lt on	R shorted wire in #3 lt canoe (adjusted C/P)	2.5
27-30	SW 334 + 763	T/O warn sounds w/all ctls in t/o	R wire to sw S334 & x sw S763	2.0
27-40	Stab trim mod	Stab trim amber light d/n illuminate	R brkn wire C2006-22 @ mod	2.0
27-30	CB & component	O/rotation test d/n op stick shaker	Reset CB & reracked comp NG C1	1.0
27-30		Loud knock from aural warn sys	Ck cont box adj C/P to CIXII	1.0
27-30	Tilt sw	T/O warning horn on after t/o	Cleaned tilt sw	1.5
27-40	#2 mod	Stab #2 hyd brake light on	X plug D6189C--shorted	1.5 $22.37

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
27-30		Elev indicates slight nose dn--A/C level	R wiring--ind nml	1.5
27-30	Light C/P	Stab trim pos ind light inop	R brkn conn back of plug	1.5
27-10	Ail L/O act	Ob ail lockout pops CB on grd	Repaired shorted wire on act	2.5
27-30		Elev pos ind inop on instl	R excit wire at meter case	2.0
27-30	Computer	Stick shaker on at lift off	A C/P on computer	1.0
27-10	Wire	#1 lat cont vlv CB pops occas	Spliced in wire I/B #1 s/boat	2.0
27-10	Wire	Ob ail lockout CB pops on P12	R wire RH wing conduit	1.5
27-40	Stab brake C/P	"B" stab brk rel light on	Cln and dry brake pressure switch C/P	1.0
27-40	Stab trim mod	#2 stab w/n move nose dn with pilots trim sw	Cleaned module elect connector	1.0
27-10	Wire	Ob ail lockout CB on P12 pops	Repaired shorted wire	2.5
27-60	Solenoid control stand	Auto S/B d/n ops from armed positive after lndg	Cleaned lock solenoid plug	1.0
27-30		Control column shaker	A connectors at sensor	1.0

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
		operated briefly twice in flight		
27-30		Cont/column shaker op ac norm atti. cruiz	Clnd C/P at sensor	1.0
27-20	Computer	LH rud trim req--zero with Y/damp off 22-1	Reset lower Y/damp computer	1.0
27-40	Module	Stab trim control fr yoke sw inop	A wiring short to sw 678	1.5
27-40	Module	"B" stab trim light d/n illum (#2 sys)	Cleaned C/P	1.0
27-30	shaker	Stick shaker inop--ess bus sel off	R bkn wire at shaker C/P	2.0
27-30	Cmptr	Stick shaker ops on rotation	Reseated ovr/rot cmptr	1.0
27-30	LH Blg	Shaker ops w/40 kts over V-2 on C/out	X brkn wire l/h body gear	1.5
27-40	Ind	Light out capt side stab trim pos ind	R connector	1.5
27-40	Pwr pack	Stab trim dual sw on cont whl failed	Cleaned plugs & pwr package	1.5
27-40	Pres sw	#2 hyd brk rel/lt on--no command	Clnd C/P pres sw	1.0
27-10	Act	Ob ail lockout CB on P12 trips in flight	Clnd L/H & R/H lockout act C/P's	1.5

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
27-10		OB ail lockout CB on P12 popped	R wire btw splice SP3252 and act	1.5
27-40	Stab trim module	Stab trim N/O, #3 brk re-light out, stab ok	Clnd C/P at press sw. Grd ops ok	1.0
27-30	Relay	Capt stick shaker activ on taxi	Reset relay, C/B	1.5
27-10	Lockout act	LH Ob ail--no ind on te flap ext	Clnd lockout C/P due oily	1.0
27-10	Lockout act	LH Ob ail inop	X act connex DX-452	1.5 $17.53
27-00	Valve	#1 lat control vlv pops CB	X plug DV140A & vlv	1.5 $25.56
29-10	#3 EDP	#3 EDP CP pops apt about 2 sec	Repos pin in C/P	2.0
29-30	#1 qty ind	#1 hyd qty gage motorizes	Clnd C/P--ok	1.5
29-30	#3 xmitr	#3 hyd xmitr--ck CP due pres flux	Adj loose C/P	1.0
29-10	#1 EDP	#1 EDP won't depress w sw depress	R--C/P	1.5
29-30	#1 qty ind	#1 hyd sys lo qty inop--test ng	Reconn plug at ind	.5
29-30	#4 hyd qty	#4 hyd qty dropped to 3.0 apt t/o	R wire at D2063P	3.0

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
29-30	Switch	#2 hyd qty gage d/n test	Sprayed sw--ops now ok	1.0
29-10		Apt lon #3 adp pops CB on P12 (press norm)	R bare wire W618-3M253	3.5
29-10	#1 EDP	#1 EDP lo press light illum interm	Titnd loose wiring at CP	2.0
29-30	#2 pass ind	#2 hyd press reads low	Reset ind elect connex	1.0
29-30	#4 case rtn mod	#4 hyd ovrht light on after ldng	Cleaned C/P at thermal switch	2.0
29-30	#3 press mod	#3 EDP lo press light on--EDP press norm	Cleaned contacts on press switch	2.5
29-30	#3 press mod.	#3 EDP press light flix dimly (cont.)	Jumpered press sw--C1X20	2.0
29-30	#3 pylon	#3 o/h light on intermit	Cleared chafed wire	3.5
29-30	#1 qty gage	#1 hyd gage motorized	Cleaned C/P	2.0
29-30	#3 pylon	#3 EDP lo press light inop	R bkn wire & replaced clamps	5.0
29-30		#1 hyd motorized	X wiring faulty	3.0
29-30	#2 ADP	#2 ADP run lt flkrs in auto & off	Clnd C/P & recptcl	2.0
29-30		#2 ADP run light flickers	R/bkn wire	4.0
29-20		Elec hyd pump inop	Reset CB on P-14	1.0

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
29-10	#1 & #3 ADP	#1 ADP no auto ops in flt. #3 no auto ops plt/grd	X splices on 1 & 3 ADP	2.5
29-30	Ind	#3 hyd qty ind contin motor	Ck C/P--filled to	1.5
29-30	Hyd panel	Feo pnl #4 hyd ind & pres light inop	Strtnd bent pin on ind C/P	3.0
29-30	Xmtr	T/O #4 hyd qty gage no test	Cleaned C/P on xmtr	1.5
29-30	Xmtr	#2 hyd pres low 2750 with ADP/EDP	Ckd & found xmit C/P dirty = clnd	1.5
29-30	ADP	#1 ADP & EDP lop light blink/relay chapter	R wiring abv ADP	4.0
29-30	#3 EDP	#3 EDP pres light flickers	Cleaned CP & adj (loose)	1.5
29-30	#4 ind	#4 hyd qty ind motors full circle	R bent ind pin	3.0
29-30	#4 ind	#4 hyd sys qty gage reads 0	R seated CP feo ind	1.0
29-30	#4 xmtr	#4 hyd qty 1.5 w/res full	R splice at xmtr	3.0
29-10	#4 ADP	#4 ADP intermit in auto or cont.	Ckd wires & reset CP--C/N dupl	1.5
29-30	#2 xmtr	#2 hyd xmtr causes ind motorize	X xmitr wiring rings = ok	2.0

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
29-30		#3 hyd qty ind rotates-- drift to 105	X #3 xmitr & temp r grd'd wires 72933-261	2.0
29-30	#1 ind	#1 hyd qty ind int	Adj wires to pins	1.0
29-30		#1 hyd o/h lite on at blox	Clear chaff wire	2.0
29-30	#2 P/mod	#2 ADP press on intermit in flt	Cleaned oil from C/P	1.5
29-10	#4 EDP	unable to depress #4 EDP	Cleaned & ckd C/P	1.5
29-30	#3 hyd ind	#3 hyd gage sticks on qty test	cleaned C/P	1.5
29-10	#1 sys	#1 EDP hyd supply CB pops	Repaired wire C172904F35245	3.5
29-10	#1 conduit	#1 EDP supply C/B pops	X conduit	3.0
29-10	#1 ADP	#1 ADP is erratic	Adj loose C/P on module	1.5
29-10	ADP	ADP press "0," run lite-out, sw in auto	Reset CP ADP s/o vlve act	1.5
29-10	#3 pylon	#3 EDP hyd supply line -C1	Tapped & rerouted wiring	2.0
29-10	#1 ADP	#1 ADP inop in auto or man	Clnd module C/P tapped sw ok	2.0
29-30	#4 xmitr	#4 hyd qty @ 45 gals in flight	Clnd contaminated xmtr C/P	2.0
29-30	#4 ind	#4 hyd qty slow to test	Ck wiring, clnd CP & reseated	1.5

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
29-30	#3 pr/sw	#3 EDP press lite stays on	Cln CP on press sw dirty	1.0
29-30	#2 pr/sw	#2 hyd press ind to "0," qty, lts norm	Cln CP on xmtr	1.0
29-30	#2 pr/sw	#2 hyd pres xmtr erratic	Ck & clnd C/P at xmtr	1.0
29-30	#4 pr/xtmr	#4 hyd pres ind 0--pres norm	Cleaned dirty pres xmtr CP	1.0
29-30	#3 ind	#3 qt ind rotates contin	Cleared shorted wires	2.5
29-30	#2 pylon	#2 hyd o/h lite intermit, flickers	Adj chafe wire in clamp	2.0
29-30	#3 pylon	#3 EDP pr lite inop--off no lite	R wire in #3 pylon	2.5
29-10	#3 ADP	#3 ADP inop auto-cont ok, timer?	R brkn wire	2.5
29-10	#1 EDP	#1 EDP depres inop	X CP due locks missing	2.0
29-10	#2 mod	#2 brke rel lite on--no conn stab	X plug DB189C--shorted	2.0 $22.37
29-30	#4 temp bulb	#4 hyd temp 40 dg hotter than others	Clnd temp bulb C/P	1.5
29-30	#3 pr mod	#2 ADP pr lite on with 3000 psi	Cleaned press sw and plug C18734	1.0
29-30	#1 xmtr	#1 hyd qty flux 9-10 gals	Cleaned qty xmtr C/P	1.5
29-30		2 hyd ADP pr lt on/pr = 3000 psi	Ckd and clnd CP = ops ok	1.0

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
29-30	#4 ind	4 hyd ind wn test	A ind C/P	1.5
29-30	Bk xmtr	#4 hyd pr warn lite on bk pr = "0"	Clnd connex @ brake press x	1.5
29-30	#4 qty ind	#4 hyd qty erratic--oscillates in flt	R bent pin on ind	1.5 $.80
29-30	#2 ADP	#2 ADP run lite on in cruz	X 2 burnt wires on #2 ADP	2.5
29-30	#4 pr ind	#4 hyd pres ind intr flux	Ok after gage swap & C/P unswap	1.0
29-10	Wire	#1 EDP hyd supply CB keeps popping supply vlv	Insulated chaffed wire Cks ok	3.0
29-30	4 hyd gage	#4 hyd gage intermit motorizes	R shorted shielding	2.5
29-30	4 hyd gage	#4 hyd qty reads 5 gals steady	A loose C/P on ind	1.0
29-30	4 ADP	#4 ADP run lite flickers	R wiring	3.0
29-30	Socket	#3 ADP run lt on cont--pr ok	Reset lite socket & ops ok	1.5
29-30		#2 lpl illum	Cleaned C/P & cks ok	1.5
29-30	pr module	#3 lpl illum with pres norm	Cln C/P at pres module	2.0
29-30	Pres sw	#1 ADP lpl illum with run lt on	Cleaned C/P at pres sw	1.5

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
29-10		#4 ADP inop--pops CB	Cln CP--ck ok	2.5
29-10		#3 EDP w/n depres & pops CB	Intrn short wiring C12091	3.5
29-30	Wire	#3 hyd qty rotates--x ind & tnk unit still inop	R broken wire	4.0
29-10	Wire	#3 ADP inop--CB popped	Ok since chafed wires repaired	2.0
29-30	Ind	#2 hyd qty ind stuck at 6-7 gals	S with 4 & reswap = both ok	1.0
29-30	Wire	#3 hyd pres ind on fwd pnl inop	R brkn wires (grd) in sailboat	3.0
29-10	Valve/ wire	#4 EDP C/B pops & won't reset	R shorted wire @ vlv	2.5
29-30	Resevoir	#1 hyd qty ind erratic--fluct	Removed & clnd C/P at res	1.5
29-10	S/O vlv	#3 EDP supply C/B popped & w/n reset	Clnd C/P supply s/o vlv	2.0
29-30	Wiring	#1 hyd o/h lt on preflt	R wiring behind ADP D/U	4.0
29-10	#4 EDP	#4 EDP w/n depres--ops ok	R plug at solenoid	1.5 $17.40
29-10	#2 EDP	#2 EDP w/n depres--sol x prev	R bkn wire at solenoid	1.5
29-10	#2 EDP	#2 EDP w/n depres--sw to depres	X C/P and solenoid	2.0

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
29-30	Qty ind	#4 hyd qty ind d/n test	Reseated and tested ok	1.0
29-30	Qty ind	#2 hyd qty ind intmt and no test	Reinstall ind C/P test ok	1.0
29-30	Qty ind	#2 hyd qty sticking on test	Cln pins @ ind connex	1.5
29-10	ADP D/U	#1 ADP lt d/n lt in cont	Cleared grnded wire	3.0
29-10	Qty ind	#1 hyd ind dn test	Reseated C/P on ind--now ok	1.5
29-30	Pres sw	#4 hyd qty no test in flt	R push-in pin C/P pres sw	1.5
29-30	Hyd ind	Hyd temp gage #3 & #4 inop--off scale	R 3 pulled wires back of ind	2.0
29-30	Pres xmtr	#2 hyd pres ind reads low (2200)	Cleaned pres xmtr connex	1.5
29-30	Pres ind	Hyd brk pres ind occas drops to "0"	Clnd dirty plug	1.0
29-30	Qty ind	#3 hyd qty ind motorizing	S #2 & 3 ind	.75
29-10	#3 EDP	#3 EDP d/n depres	X solenoid C/P	1.5
29-10	Wire	#3 EDP hyd supply CB on P-6 pops	R wiring in pylon area	2.0
29-10	Wire	#1 EDP w/n depres	R brkn grd wire--now ok	1.5
29-30	Qty ind	#3 hyd qty ind test to "0" but warn lite out	S #2 & 3 ind	.5

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
29-30	#1 EDP	#1 eng EDP 2300--idle = ADP cycles	Clnd C/P	1.0
29-10	#1 EDP	#1 EDP w/n depres--cut in--out	X depres C/P	1.5
29-10	#1 EDP	#1 EDP w/n depres	Reposn'd CP pin wire	1.0
29-10		#4 EDP C/B pops on occasion	X wires in pylon--brkn, chafe	2.5
29-10	#4 EDP	#4 EDP w/n depres--pops C/B	X C/P	1.5 $17.40
29-10	#4 EDP	#4 EDP w/n depres	R brkn solenoid C/P grd wire	1.5
29-30	Wire @ D48 and DB90	#2 ADP l/p lite flickers--pres @ 3100	R wire between D48 & DB90	2.0
29-30	Wires	#4 hyd sys l/p lite intermit dim	R chaffed wires in sailboat	2.0
29-30		#4 ADP pops CB in cont rod--ok auto	R chaffed wires undr clmp sailboat	2.0
29-10	#4 ADP	#4 ADP inop in auto--ok in cont	Rem & clnd ADP plugs--ops ok	2.0
29-30	Ind	#3 hyd qty motors btwn pull and zero	S 2 & 3 ind = ops ok	1.0
29-10	Wires	#3 ADP trips C/B--run lite on contin	Cleared shorted wire	3.0

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
29-10	Wire	#3 ADP CB on P12 trip--ok in flt	Sliced new wire undr ADP chaf	2.0
29-30	Ind	#2 qty ind motors to "0" in flt turb	Clnd dirty C/P	1.0
29-10	#3 EDP	#3 EDP won't depres	R brkn wire at solenoid	1.5
29-10	#1 ADP	#1 ADP w/n come on in auto	Clnd C/P--ops ck ok	1.0
29-30	Xmtr	#2 sys pres "0" with pres norm	Cleaned pres xmtr C/P	1.0
29-30	Wires	#2 hyd o/h lt on during climb--intermit	R chafed wires inside clamp	1.5
29-10	#1 EDP	#1 EDP w/n depres	CP off--secured, now ok	1.0
29-10	#4 elect pump	Elect hyd pumps pops CB in lower 41 w/n reset	X C/P--ops ok	1.5 $17.40
29-	#4 elect pump	#4 elect pump trips CB	C/P loose on pump--cln & secured	1.0
29-10	Pres sw	#1 ADP inop--no run lt, no pres	Cl C/P pres sw--ops ok	1.0
29-10	Pres sw	#3 ADP CB on P12 pops w/n reset	R chafd wiring at auto prs sw	1.5
29-30	Wire	#3 sys o/h lt on--ADP & EDP off	R wiring	2.0
29-30	Qty ind	#1 qty ind slow to run down on test	R bkn wire & pin @ ind C/P	2.5

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
29-10	ADP	#3 ADP pops control C/B on P-12	Cleaned C/P	1.0
29-10	EDP	#4 EDP w/n depres	X plug on solenoid	1.5 $17.40
29-30	O/h sw	#3 hyd sys o/h lite on	A C/P on o/h sw	1.0
29-10	#1 ADP	#1 ADP pops CB in cont	R wiring	1.5
29-10	Qty ind	#4 hyd qty drops 2.5 gals	A cannon plug	1.0
29-30	Qty ind	#1 pres flux 3000 to 400 on EDP only	S 1, 4 ind, cleaned C/P	1.0
29-10		#1 ADP runs contin in auto--EDP on	R wiring from C/P--chafed	1.5
29-10	ADP sol	#2 ADP inop in auto	A solenoid terminals	1.0
29-10	Valve	#2 EDP sw apprs failed in	Clnd & retite vlv C/P	1.0
29-10	EDP	#4 EDP d/n depres	R brkn grd term	1.5
29-30	Wire	#1 qty motorizes--gage prev x'd	R chafe on sailboat harness	1.0
29-30	Resevoir	#4 qty ind flux constant 6-9	Clnd C/P in strut	1.0
29-10	Module	#2 stab brake rel/lt on--no commd to move	Cleaned C/P pres sw	1.0
29-30	Ind	#4 qty ind--low qty lt inop	Cleaned C/P on ind	1.0
29-30	Qty ind	#2 qty inop	R wire to pin & plug at	1.5

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
			ind	
29-30	EDP	#1 EDP depres sw pops CB on P12	Clnd sw connex, iso chafe wire	1.0
29-10	Valve	#4 hyd s/o vlv inop	X plug @ s/o vlv	1.5 $23.22
29-30	Wire	#4 pres flickers intermit	A harness near xmtr	1.5
29-10	EDP	#2 EDP will not depres	R brkn wire @ solenoid	2.0
29-30	Wire	#3 EDP l/p lt flickers--pres ok	Adj R chafed wire inst	1.0
29-10	EDP	#2 EDP w/n depres	X solenoid C/P	1.5 $17.40
29-10	EDP	#2 EDP w/n depres	Repaired C/P on pump	1.0
29-30	Qty ind	#3 hyd qty rotates	Adj pin in ind plug	1.0
29-10	Wiring	#3 ADP cont pops C/B in flight	R wiring fwd of ADP C/B	1.5
29-30	Pres ind	#2 EDP output 3280	After swap 2 & 3 ind now ok	1.5
29-30	Wiring	#3 hyd qty cycles to full scale	repaired wiring--ck ok	1.5
29-10	Wires	#2 ADP run lt intermit & not run	A ADP sol brkn wires reinst	2.0
29-30	Wires	#1 qty ind erratic--btwn 1 & 5 gals	R chafed wire at hyd mod	2.0
29-30	Qty ind	#1 hyd qty gage inop	Reseated gage connex plug	1.0

ATA SYSTEM	LRU OR LOCATION	PROBLEM	ACTION TAKEN	MANHOURS TO CORRECT PROBLEM PLUS ATE TIME AND MATL. COST
29-30		#3 hyd o/h ind is erratic	Sensor C/P cleaned	1.0

APPENDIX C

FLIGHT CONTROL COMPONENT WEIGHTS

Contents

TABLES

1.0 747 FLIGHT CONTROLS

The tables provide an itemized component/installation weight listing by operational function, Mfg. P/N, Qty/Apl and Total Item Weight per Airplane for both the primary and automatic flight control systems of a baseline Model 747-200B airplane. The component weights of the leading edge flap and trailing edge flap operational systems are not included in this study.

Table C1 presents a detail weight breakdown of the primary flight control system. It includes all electronic, mechanical, hydraulic and electrical provisions associated with installation of the elevator, aileron, rudder, spoilers and stabilizer trim control subsystems. Also shown are total summations of all the component/installation weights allocated to each of these primary flight control subsystems.

Table C2 provides a tabulation of component weights associated with the automatic flight control system. It consists mainly of electronics/electrical operational components such as computers, sensors, control/display units and interconnecting wire. A summation of component weights for each of these functions is also provided.

TABLE C1

WEIGHT BREAKDOWN
OF
PRIMARY FLIGHT CONTROL SYSTEM (PFCS)

	OPERATIONAL FUNCTION	MFG. P/N	QTY/APL	WT/APL Kg
(A)	Elevator Control Subsystem			439.0
(1)	Control Column/Wheel	65B80521-4	1	21.1
(2)	Quadrant Instl. - Common Elev.	65B80482	1	10.2
(3)	Feel Centering Unit	65B81226-1	1	12.6
(4)	Feel Unit Actuator	65B81875-1	1	2.9
(5)	Feel Centering Unit/Act. Instl.	65B80596	1	3.5
(6)	Feel Computer	401-13151-01	1	5.4
(7)	Feel Computer Instl.	65B81261	1	1.6
(8)	Quadrant Instl. - O/B Elev.	65B804660	1	5.1
(9)	Quadrant and Tension Regulator	65B80310	1	3.2
(10)	Quadrant and Tension Reg. Instl.	65B82108	1	3.9
(11)	Position Transmitter - O/B Elev.	7977-05-01	2	0.3
(12)	Rods, Position XMTR Instl.	65B80468	2	0.7
(13)	Index Instl., Position XMTR	5B41209	1	0.3
(14)	Power Control Unit - I/B Elev.	93600-5007	2	176.1
(15)	Instl. Items - I/B Elev. PCU	65B80550	2	6.3
(16)	Linkage Instl. - I/B Elev. PCU	65B80474	2	12.9
(17)	Fluids - I/B Elev. PCU's	N/A	2	9.2
(18)	Power Control Unit - O/B Elev.	93700-5005	2	44.5
(19)	Instl. Items - O/B Elev. PCU	65B80549	2	2.5
(20)	Control Rod Assy - O/B Elev. PCU	65B80549	2	0.7
(21)	Fluids - O/B Elev. PCU's	N/A	2	2.5
(22)	F/C Shut-off Valve Module	AV16E1215	4	6.2
(23)	F/C S/O Valve Mod - Instl.	65B01548	4	0.5
(24)	F/C S/O Valve Mod - Fluids	N/A	4	0.3
(25)	Elev. Control Hydr. Plumbing	M/D	-	46.2
(26)	Fluids - Elev. Control Hydr. Plumbing	N/A	-	14.9
(27)	Cables, Pulley Brkts,etc.-Elev. Control	M/D	-	35.1
(28)	Wiring/Connectors - Elev. Control	M/D	-	5.4
(29)	Wiring/Connectors - Elev. Pos. Indic.	M/D	-	2.8
(30)	Computer - Stall Warning	965-0111-002	1	0.7
(31)	Computer - Over Rotation	965-0172-003	1	1.3
(B)	Aileron Control Subsystem			446.1
(1)	Quadrant, Pilot's Input, Aileron Ctrl.	65B80521	1	1.5
(2)	Quadrant, First Officer's Input, Aileron Control	65B81800	1	1.3
(3)	Supt. Struct, Aileron Quadrants	M/D	2	2.2
(4)	Lost Motion Mech, Ail. Control	65B81800	1	8.6
(5)	Control Rods and Quadrant (CCA)	65B04001	1	0.3
(6)	Quadrant Assy. Output	65B80554	1	1.4
(7)	Quadrant Instl., Inbd. Act.	65B80873	1	4.0
(8)	Lockout Actuator, O/B Aileron	DL1326M119	2	1.6
(9)	Lockout Mechanism, O/B Aileron	65B80510	2	3.4

OPERATIONAL-FUNCTION	MFG. P/N	QTY/APL	WT/APL Kg
(B) Aileron Control Subsystem (Continued)			
(10) Lockout Gearbox, O/B Aileron	65B80572	2	6.6
(11) Programmer, Aileron Control	65B80554	2	9.2
(12) Supt. Struct., Aileron Programmer	65B81524	2	0.8
(13) Control Rods, Aileron Programmer	65B81524	2	0.3
(14) Trim and Centering Mechanism	65B80521	1	1.3
(15) Actuator, Trim Control	DL1020M159	1	0.4
(16) Force Limiter, Input Bus	65B80511	1	1.3
(17) Force Limiter, Output Bus	65B82215	1	2.4
(18) Force Limiter, Back Drive	65B80872	1	0.4
(19) Position Transmitter, O/B Ail	7977-05-01	2	0.9
(20) Position Transmitter Instl, O/B Ail	65B81848	2	0.1
(21) Actuator, Central Control (CCA)	3000/300-007	2	37.6
(22) Support Structure, CCA	65B81524	2	10.6
(23) Fluid - CCA	N/A	-	4.5
(24) Power Control Unit, I/B Ail	3170120-2	2	72.0
(25) PCU Instl. Items, I/B Ail	65B81843	2	6.7
(26) Control Rods, Inbd PCU	65B80873	2	0.2
(27) Fluids, I/B Ail PCU	N/A	-	4.8
(28) Power Control Unit - O/B Aileron	3170130	2	47.1
(29) PCU Instl. Items, O/B Aileron	65B80518	2	1.4
(30) Control Link Instl., O/B Ail. PCU	65B80518	2	2.6
(31) Fluids, O/B Ail. PCU	N/A	-	1.2
(32) F/C Shut-off Valve Module	AV16E1215	4	6.3
(33) Instl. - F/C Module Valve S/O	65B80220	4	1.1
(34) Fluids - F/C Module Valve S/O	N/A	-	0.4
(35) Aileron Control Hydr. Plumbing	M/D	-	91.9
(36) Fluids - Ail Control Hydr. Plumbing	N/A	-	46.2
(37) Cables, Pully Brkts, Instl,-Ail.Control	M/D	-	55.0
(38) Indicator-Control Surface Position	9819-29	1	0.7
(39) Wiring/Connectors - Aileron Control	M/D	-	5.0
(40) Wiring/Connectors - Ail.Pos.Indic.	M/D	-	2.6
(C) Rudder Control Subsystem			218.4
(1) Quadrant and Tension Regulator, Sec. 41	65B81213	1	1.4
(2) Yoke and Jackshaft Assy, Rudder	65B81213	1	4.6
(3) Quadrant and Yoke Instl.	65B83106	1	2.7
(4) Supt Instl - Rudder Control Quad	65B81361	1	1.5
(5) Aft Quadrant/Instl.	65B81070	1	2.1
(6) Feel Centering and Trim Mech.	65B81020	1	5.2
(7) Actuator Assy, Rudder Trim	65-21831	1	1.1
(8) Instl. Items, Rudder Feel and Trim	65B81021	1	3.3
(9) Ratio Changer Servo	601300	2	1.4
(10) Ratio Changer Assy, Lwr Rudder	65B81050	2	4.7
(11) Ratio Changer Assy, Upr Rudder	65B81050	2	4.7
(12) Control Rods, Ratio Changer	65B81010	2	1.9
(13) Ratio Changer Control Unit	690500	2	2.0

OPERATIONAL FUNCTION	MFG. P/N	QTY/APL	WT/APL Kg
(C) Rudder Control Subsystem (Continued)			
(14) Ratio Changer Comparator	60B40073	1	0.3
(15) Instl. Items, Ratio Changer Unit	65B81060	2	5.0
(16) Control Surface Position XMTR	7977-05-01	2	0.3
(17) Control Rods, Position XMTR	65B81090	2	0.4
(18) Index Instl, Position XMTR	65B41209	1	0.1
(19) Power Control Unit, Upr Rudder	3822000	1	42.3
(20) Trunnion and Link Instl - Upr Rudder	65B81000	1	8.8
(21) Reaction Link Assy - Upr Rudder	65B81000	1	5.2
(22) Bolt Instl - PCU, Upr Rudder	65B81000	1	2.7
(23) Control Rod Ratio Changer, Upr PCU	65B81000	1	0.3
(24) Power Control Unit - Lwr Rudder	3822000	1	42.6
(25) Trunnion and Link Instl - Lwr Rudder	65B81000	1	8.8
(26) Reaction Link Assy - Lwr Rudder	65B81000	1	6.1
(27) Bolt Instl - PCU, Lwr Rudder	65B81000	1	2.7
(28) Control Rod Ratio Changer, Lwr Rudder	65B81000	1	0.3
(29) Fluids - Upr/Lwr PCUs	N/A	2	5.4
(30) Rudder Control Hydr Plumbing Instl	M/D	-	19.6
(31) Fluids - Rudder Control Hydr Plumbing	N/A	-	6.7
(32) Cables, Pulley Brkts, etc-Rudder Control	M/D	-	21.2
(33) Wiring/Connectors - Rudder Control	M/D	-	5.4
(34) Wiring/Connectors-Rudder Position Indic.	M/D	-	2.4
(D) Flight and Ground Spoilers Subsystem			327.2
(1) Differential Mechanism Assy	65B80836	2	22.9
(2) Quadrant Assy, Spoiler Output	65B80835	2	4.2
(3) Control Package Instl, Outbd Spoilers	65B80581	2	7.9
(4) Quadrant Instl. Items	65B80579	2	2.6
(5) Control Rods and Cranks	65B80835	-	9.1
(6) Support Items, Diff Mech	65B81524	-	5.0
(7) Position XMTR, Control Surface	7977-05-01	2	0.5
(8) Instl - Position Transmitter	65B81849	2	0.3
(9) Power Control Unit,Inbd.Flt Spoiler	29300-6	2	34.3
(10) Fluids, I/B Spoiler PCU	N/A	2	1.1
(11) Instl Items, I/B Spoiler PCU	65B80579	-	2.8
(12) Power Control Unit,O/B Flt Spoiler	29310-2	8	87.8
(13) Fluids, O/B Spoiler PCU	N/A	2	3.2
(14) Control Rods/Instl Items,O/B Spoiler PCU	M/D	-	10.0
(15) Flt Spoiler Control Hydr Plumbing	M/D	-	25.4
(16) Fluids-Flt Spoilers Cont. Hydr. Plumb.	N/A	-	9.4
(17) Cables, Pulleys, Instl,Flt Spoilers	M/D	-	39.2
(18) Controls, Auto Speed Brake	N/A	-	3.3
(19) Breakers, Switches, Relays,etc,Auto Brk	N/A	-	1.4
(20) Cables, Pulleys, Instl - Speed Brakes	M/D	-	9.2
(21) Control Lever, Speed Brake	50196-3	1	2.3
(22) Sequence Mechanism, Speed Brake	65B80859	1	6.6
(23) Actuator, Ground Spoiler	29340-3	2	17.6
(24) Fluids, Ground Spoiler Actuator	N/A	-	0.8

	OPERATIONAL FUNCTION	MFG. P/N	QTY/APL	WT/APL Kg
(D)	Flight and Ground Spoilers Subsystem (Continued)			
(25)	Instl Items, Grd Spoiler Actuator	65B80306	2	2.8
(26)	Hydr. Control Valves, Grd Spoilers	36280	1	0.8
(27)	Instl Items, Grd Spoiler Control Valve	65B81543	1	0.4
(28)	Grd Spoilers Control Hydr. Plumbing	M/D	-	13.4
(29)	Fluids, Grd Spoilers Control Hydr Plumb.	N/A	-	3.7
(30)	Wiring/Connectors,Flt/Grd Spoilers Ctrl.	M/D	-	5.0
(31)	Wiring/Connectors, Flt/Grd Spoilers Pos. Indic.	M/D	-	2.4
(E)	Stabilizer Trim Control Subsystem			279.5
(1)	Drum Assy and Supt, Travel Limiter	65B80735	1	1.7
(2)	Quadrant, Crank, Push Rods, Supts	65B80735	1	3.8
(3)	Cables, Pulleys, Instl-Stab.Trim	M/D	-	23.5
(4)	Switch Addn - Green Band	N/A	2	7.3
(5)	Switch Assy - Autopilot	65B80740	4	1.3
(6)	Switch Assy - Warning - Limit	65B80740	2	0.9
(7)	Gear Drive/Jackscrew, Actuator Instl.	65B80562	1	180.5
(8)	Fluids - Stabilizer Trim Actuator	N/A	1	2.0
(9)	Hydraulic Motor, Stab. Trim	MF1-095-6	2	8.7
(10)	Instl Items, Stab. Trim Hyd. Mtr.	65B80562	2	0.4
(11)	Fluids - Stab. Trim Hydr. Mtr.	N/A	2	0.9
(12)	Hydraulic Brakes, Stab. Trim	401-09410-01	2	6.6
(13)	Instl. Hdwe., Hydr. Brakes	65B80562	2	0.2
(14)	Fluids - Stab. Trim Hydr. Brakes	N/A	-	0.7
(15)	Control Module, Stab. Trim	401-09408-08	2	24.1
(16)	Shut-off Valve, Stab. Trim	155850	2	3.7
(17)	Instl. Items, Control Module, S/O Valve	65B80733	2	0.5
(18)	Fluids, Modular Pack, Ctrl Mod/S/O Valve	N/A	-	0.9
(19)	Stabilizer Trim Hydr Plumbing	M/D	-	4.0
(20)	Fluids - Stabilizer Trim Hydr. Plumbing	N/A	-	2.4
(21)	Switch and Time Delay, Elec, Stab. Trim	N/A	-	1.5
(22)	Wiring/Connectors - Stabilizer Trim	M/D	-	8.3
(23)	Wiring/Connectors - Stab Trim Indic.	M/D	-	2.2

ABBREVIATIONS:

M/D - Multiple Drawings

N/A - Not Available

TABLE C2
WEIGHT BREAKDOWN
OF
AUTOMATIC FLIGHT CONTROL SYSTEM (AFCS)

OPERATIONAL FUNCTION	MFG. P/N	QTY/APL	WT/APL Kg
(A) Major Computers			69.7
(1) Pitch Computers	2590622	3	21.6
(2) Pitch Calibrator	60B00013	1	0.5
(3) Roll Computers	2590623	3	20.0
(4) Roll Calibrator	60B00013	1	0.5
(5) Yaw Damper Computer	1964212-1	2	5.9
(6) Yaw Damper Calibrator	60B00069-2	1	0.4
(7) Autothrottle Computer	60B80099-102	1	10.2
(8) Autothrottle Calibrator	60B00043	1	0.2
(9) Monitor and Logic Unit	2591027-902	1	5.9
(10) Automatic Stabilizer Trim Cplr. Unit	2591415-902	1	4.4
(B) Dedicated Sensors			10.0
(1) Accessory Box No. 1, Auto Flt Ctrl	65B47520	1	3.4
(2) Accessory Box No. 2, Auto Flt Ctrl	65B47521	1	3.5
(3) Accessory Stabilizer Trim Box	65B47519	1	2.1
(4) Accelerometer Units	60B00013-601	2	0.7
(C) Servo/Control/Display Units			22.6
(1) Mode Select Panel	2590624-924	1	8.3
(2) Flight Controller, Autopilot	2590625-902	1	1.3
(3) Flight Mode Annunciator Lt. Set	75-0147-9	2	3.3
(4) Attitude Director Indicator	2590281-905	2	8.4
(5) Autothrottle Servo	1903896-1	1	1.4
(D) Shared Sensors			131.2
(1) Navigation Receiver, VOR/ILS Syst.	522-4280-108	2	16.5
(2) Low Range Transceivers, Radio Altimeter	2067631-5114	2	15.6
(3) Navigation Units, Inertial Nav. Syst.	7886580-011	3	74.1
(4) Air Data Computers, Central Air Data Sys.	60B40126	2	18.1
(5) Compass Coupler,Mag.Hdg.Ref.Syst.	60B00045	2	6.3
(6) Compass Compensators, MHRS		2	0.5
(E) Wiring and Connectors			106.1
(1) Autopilot/Flight Director, AFCS	M/D	-	71.2
(2) Autothrottle, Flight Control Syst.	M/D	-	22.4
(3) Yaw Damper, Flight Control Syst. (Less Ride Comfort Syst)	M/D	-	12.6

ABBREVIATIONS:
M/D - Multiple Drawings
N/A - Not Available

2.0 747 WING LOAD ALLEVIATION SYSTEM

This study provides itemized component/installation weight estimates of those modifications necessary to the aileron and elevator control subsystems to accommodate an electro-hydraulic wing load alleviation control system, as conceived for installation in a baseline Model 747-200B airplane. Also provided is a detail weight breakdown of the electronic control system which allows for replacement of the mechanical controls to both the outboard ailerons and outboard elevators. All data presented is categorized by major operational function, Mfg. P/N, Qty. of Items per Airplane and Total Item Weight per Airplane.

Table C3 provides weight visibility of those components that are added, replaced and modified to incorporate wing load alleviation (WLA) control into the primary aileron control subsystem (ACS). In addition, the total ACS weight with WLA and total baseline ACS weight are presented for comparison purposes.

The modifications consisted primarily of replacing the outboard aileron mechanical-hydraulic power control units (PCU's) with new dual tandem electro-hydraulic PCU's. Linear voltage differential transformers (LVDT's) are installed at the aileron programmers to provide dual lateral control command signals to the outboard aileron PCU's. This allows deletion of the outboard aileron lockout system and all control cables and control linkages between the outboard and inboard ailerons. The hydraulic distribution system is unchanged except as modified locally to accommodate the new PCU's. The new PCU's have the same output power as the existing PCU's and use the same structural attachment provisions.

Table C4 provides a detail weight breakdown of those modifications necessary to the elevator control system (ECS) for installation of the WLA control system. Also shown is the total modified ECS weight compared with the total baseline elevator control system weight.

The modifications essentially consist of replacing the existing outboard elevator mechanical-hydraulic, single actuator PCU's with new dual tandem electro-hydraulic PCU's, having the same output force and using the same structural attachments. Dual signal transducers are installed on each inboard elevator to provide command signals to the new PCU's installed on the opposite outboard elevators. This allows deletion of the existing control mechanism between the outboard elevator PCU and the opposite inboard elevator.

Table C5 provides a tabulation of component weights associated with the WLA electronic control system. It consists mainly of computers, sensors, control and display units, and interconnecting wire.

Table C6 shows a weight summary chart of aileron, elevator and electronics control subsystems, and provides a weight comparison of the overall flight control system with and without WLA.

TABLE C3

WEIGHT BREAKDOWN
OF
AILERON CONTROL SUBSYSTEM
WITH
WING LOAD ALLEVIATION PROVISIONS
(Electro-Hydraulic PCUs)

ITEM	MFG P/N	QTY/ APL	WT/APL
(A) Aileron Control Subsystem		-	(446.1) Kg
(B) Equipment Modifications to Install WLA Control System:		-	(- 8.1)
(1) Add the following:			
(a) New Dual Tandem Electro-Hydraulic Power Control Unit (PCU), O/B Aileron		2	+ 52
(b) Fluids, O/B Aileron PCU		2	+ 3
(c) PCU Instl. Items, O/B Aileron		2	+ 5
(d) Linear Voltage Differential Transformer, O/B Aileron Programmer		2	+ 1
(e) Miscellaneous/Growth Contingencies		-	+ 3
(2) Delete the following:			
(a) Power Control Unit, O/B Aileron	3170130 (60B00051)	2	- 47.1
(b) PCU Instl. Items, O/B Aileron	65B80518	2	- 4.0
(c) Fluids, O/B Aileron PCU	N/A	2	- 1.4
(d) Lockout Mechanism Instl., O/B Aileron	65B82444	2	- 11.5
(e) Wire/Connectors for O/B Ail., Lockout Mechanism	M/D	-	- 1.8
(f) Deletion of O/B Aileron Control Mechanism:			
(1) Control Cables & Fairlead Instl.	M/D	-	- 3.7
(2) Pully Instl., O/B Aileron Ctrl.	65B81845	2	- 0.5
(3) Pully Instl., O/B Aileron Ctrl.	65B81906	2	- 0.7
(4) Pully Instl., O/B Aileron Ctrl.	65B81844	2	- 1.0
(5) Pully Instl., O/B Aileron Ctrl.	65B81815	2	- 0.9
(C) Aileron Control Subsystem with Provisions for WLA			(438.0)

TABLE C4
WEIGHT BREAKDOWN
OF
ELEVATOR CONTROL SUBSYSTEM
WITH
WING LOAD ALLEVIATION PROVISIONS
(Electro-Hydraulic PCUs)

ITEM	MFG P/N	QTY/ APL	WT/APL
(A) Elevator Control Subsystem		-	(439.0) Kg
(B) Equipment Modifications to Install WLA Control System:			(+ 7.1)
(1) Add the following:			
(a) New Dual Tandem Electro-Hydraulic Power Control Unit (PCU), O/B Elevator		2	+ 54
(b) Fluids, O/B Elevator PCU		-	+ 3
(c) PCU Instl. Items, O/B Elevator		2	+ 5
(d) Dual Signal Transducers, LVDTs, I/B Elevator		2	+ 3
(e) Miscellaneous/Growth Contingencies		-	+ 3
(2) Delete the following:			
(a) Power Control Unit, O/B Elevator	93700-5005 (60B00048)	2	- 44.5
(b) PCU Instl. Items, O/B Elevator	65B80549	2	- 3.2
(c) Fluids, O/B Elevator PCU	N/A	-	- 2.5
(d) Deletion of O/B Elev. Control Mechanism:			
(1) Control Cables and Fair-lead Instl.	M/D	-	- 2.2
(2) Pully Instl., Stab. Ctr. Section	65B80469	2	- 2.4
(3) Quadrant Instl., Outbd	65B80464	2	- 1.8
(4) Quadrant Instl., Inbd. Input to O/B Elevator	65B80466	2	- 4.4
(D) Elevator Control Subsystem with Provisions for WLA			(446.1)

TABLE C5
WEIGHT BREAKDOWN
OF
WING LOAD ALLEVIATION
ELECTRONIC CONTROL SYSTEM

ITEM	MFG. P/N	QTY/ APL	WT/APL Kg
Accelerometers	Similar QA-1200	6	4
Position Sensors, Aft Inbd. Flaps		3	3
Digital Computers	Similar Collins CAP-6	2	23
Control Panel, Pilot's Station		1	1
Warning Light Instl., Pilot's Station		1	0.2
Circuit Breakers, P7 Panel		4	1
Wiring/Connectors/Wire Supports		-	153
Miscellaneous/Growth Contingencies		-	3
Total Electronic Control System			(188.2)

TABLE C6
SUBSYSTEM WEIGHT SUMMARY
WITH/WITHOUT
WING LOAD ALLEVIATION CONTROL SYSTEM

OPERATIONAL FUNCTION	WITHOUT WLA WT/APL	WITH WLA WT/APL	DELTA WT/APL
Aileron Control Subsystem	446.1	438.0	- 8.1
Elevator Control Subsystem	439.0	446.1	+ 7.1
Electronic Control Subsystem	0	188.3	+188.3
Total Weight Affect of WLA on FCS	885.1	1072.4	+187.3 Kg

Abbreviations: FCS - Flight Control System
WLA - Wing Load Alleviation
N/A - Not Available
M/D - Multiple Drawings
Est.- Estimated

APPENDIX D

PAN AM 747 FLEET DATA AND OPERATING NETWORK

This section contains descriptions of Pan Am's route network and 747 fleet composition. The information from this section and appendixes E and F comes from the data collection task performed by Pan Am.

Contents

747 FLEET AND 1978 FLIGHT HOURS

Tail No.	747 Series	1978 Flight Hrs
N530PA	SP	4,947
N531PA	SP	5,080
N532PA	SP	5,154
N533PA	SP	5,157
N534PA	SP	5,353
N535PA**	200C	3,484
N536PA	SP	5,371
N537PA*	SP	3,039
N538PA*	SP	2,589
N652PA	100	4,228
N653PA	100	4,221
N654PA	100F	3,700
N655PA	100	4,364
N656PA	100	4,304
N657PA	100	4,278
N658PA	100F	3,832
N659PA	100	4,316
N731PA	100	4,362
N732PA	100	4,189
N733PA	100	4,156
N734PA	100	4,404
N735PA	100	4,344
N737PA	100	4,501
N738PA	100	4,344
N739PA	100	4,297
N740PA	100	4,421
N741PA	100	4,172
N742PA	100	4,325
N743PA	100	4,354
N744PA	100	4,235
N747PA	100	4,155
N748PA	100	4,323
N749PA	100	4,422
N750PA	100	4,449
N751PA	100	4,192
N753PA	100	4,510
N754PA	100	4,446
N755PA	100	4,284
N770PA	100	4,301
N771PA	100F	3,803
N901PA	100F	3,834
N902PA*	100	2,257
N903PA*	100F	3,815
		182,312

* Less than 12 months operation
** Operates in the freighter configuration

THREE LETTER STATION CODE AND CITY ON 747 ROUTES

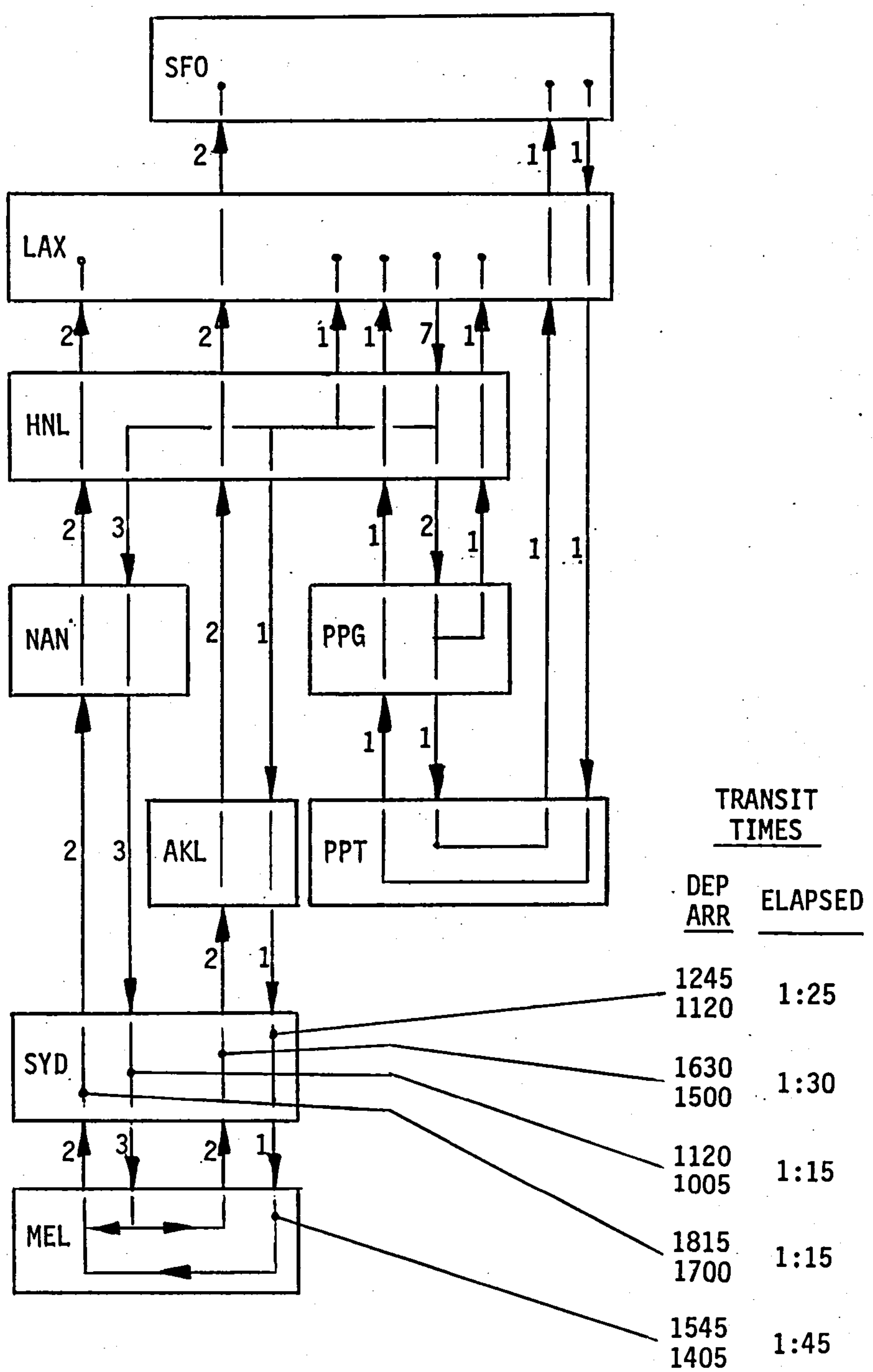
Region	Code	Line Station Class No.	City
USA GATEWAY	JFK	5	NEW YORK
	SFO	5	SAN FRANCISCO
	LAX	5	LOS ANGELES
	HNL	4	HONOLULU
	SEA	3	SEATTLE
	ORD	2	CHICAGO
	IAH	3	HOUSTON
	MIA	3	MIAMI
	DTW	3	DETROIT
	IAD	3	WASHINGTON
S. AMERICA	GUA	2	GUATEMALA CITY
	SJO	1	SAN JOSE, PUERTO RICO
	PTY	3	PANAMA CITY
	CCS	3	CARACAS
	GIG	3	RIO DE JANEIRO
	EZE	2	BUENOS AIRES
	POS	2	PORT OF SPAIN, TRINIDAD
	VCP	2	SAO PAULO, BRAZIL
	MVD	2	MONTEVIDEO, URUGUAY
S. PACIFIC	PPG	3	PAGO PAGO, AMERICAN SAMOA
	PPT	2	PAPEETE, TAHITI
	NAN	2	NADI, FIJI
	AKL	2	AUKLAND
	SYD	3	SYDNEY
	MEL	2	MELBOURNE
ORIENT	NRT	4	TOKYO
	OSA	2	OSAKA
	GUM	3	GUAM
	MNL	3	MANILA
	HKG	3	HONG KONG
	KUL	2	KUALA LUMPUR
	SIN	2	SINGAPORE
EUROPE/WORLD	MEX	3	MEXICO CITY
	LHR	5	LONDON
	PIK	2	GLASGOW
	FRA	4	FRANKFURT
	BRU	3	BRUSSELS
	FCO	3	ROME
	IST	2	ISTANBUL
	BAH	2	BAHRAIN
	THR	3	TEHRAN
	KHI	2	KARACHI
	DEL	3	DELHI
	BOM	3	BOMBAY
	BKK	2	BANGKOK

FLIGHT FREQUENCIES BY STATION AND AIRPLANE SERIES

Region	Station	747-100	747SP	747F	Total Weekly Departures
USA GATEWAY	JFK	44	12	24	80
	SFO	36	14	10	60
	LAX	37	16	5	58
	HNL	48		5	53
	SEA	15			15
	ORD			13	13
	IAH	14		2	16
	MIA	7		10	17
	DTW	7		12	19
	IAD	14			14
S. AMERICA	GUA	14		1	15
	SJO	2			2
	PTY	5			5
	CCS	22		13	35
	GIG	8		1	9
	EZE	2	2		4
	POS			1	1
	VCP			2	2
	MVD		1		1
S. PACIFIC	PPG	3		1	4
	PPT	2			2
	NAN	4		2	6
	AKL	4	8	1	13
	SYD	4	5	2	11
	MEL	4			4
ORIENT	NRT	24	14	5	43
	OSA	7			7
	GUM	14		1	15
	MNL	4			4
	HKG	14	8	2	24
	KUL			1	1
	SIN		3	1	4
EUROPE/WORLD	MEX	7			7
	LHR	44		5	49
	PIK			6	6
	FRA	28		11	39
	BRU			6	6
	FCO	14			14
	IST	14			14
	BAH		6		6
	THR	28		2	30
	KHI	3			3
	DEL	10		1	11
	BOM	4	3		7
	BKK	4	1		5

747-100 ROUTE NETWORK
USA-PACIFIC

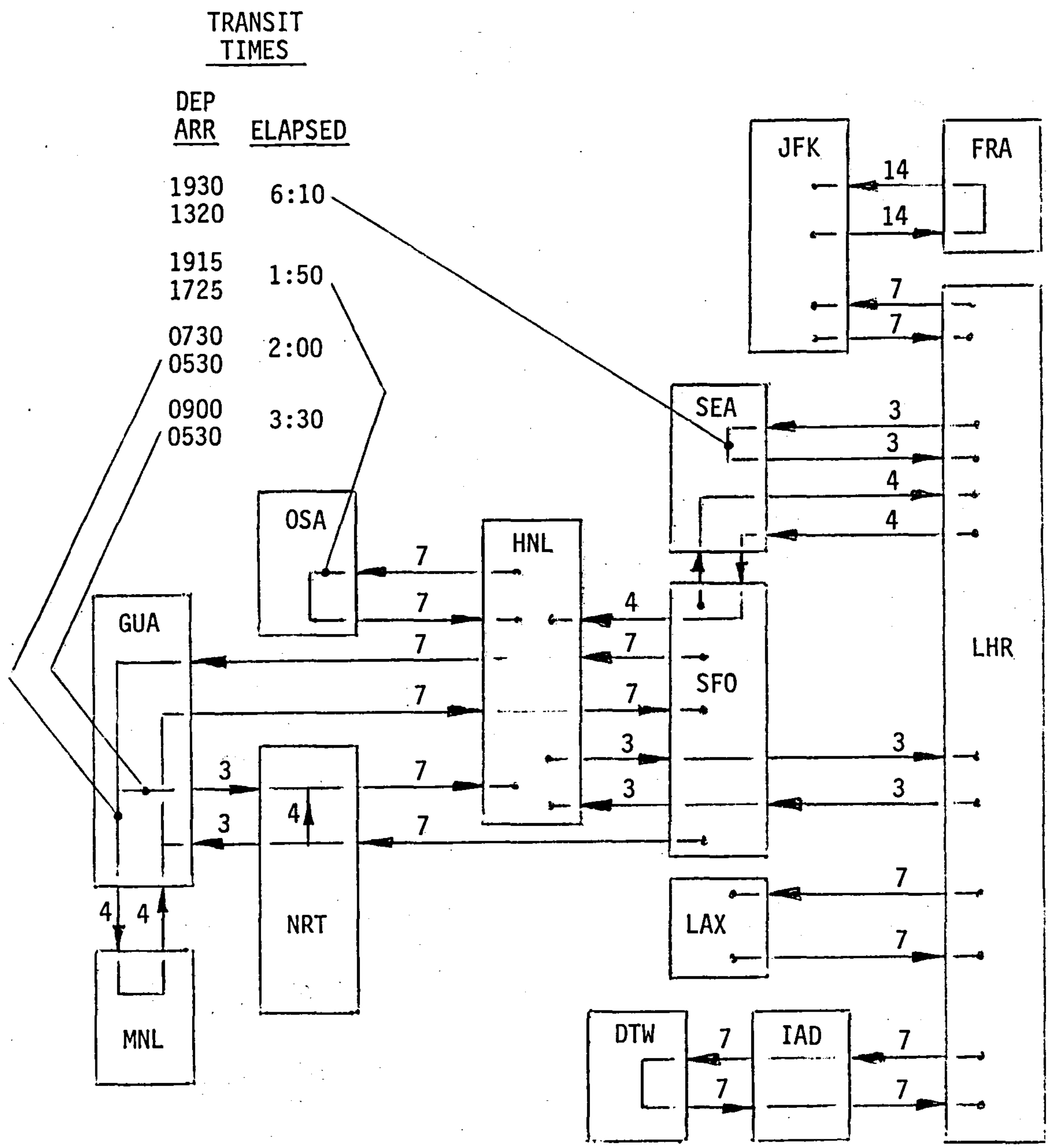
WEEKLY FLIGHT FREQUENCY AND SELECTED STATION TRANSIT TIMES



747-100 ROUTE NETWORK

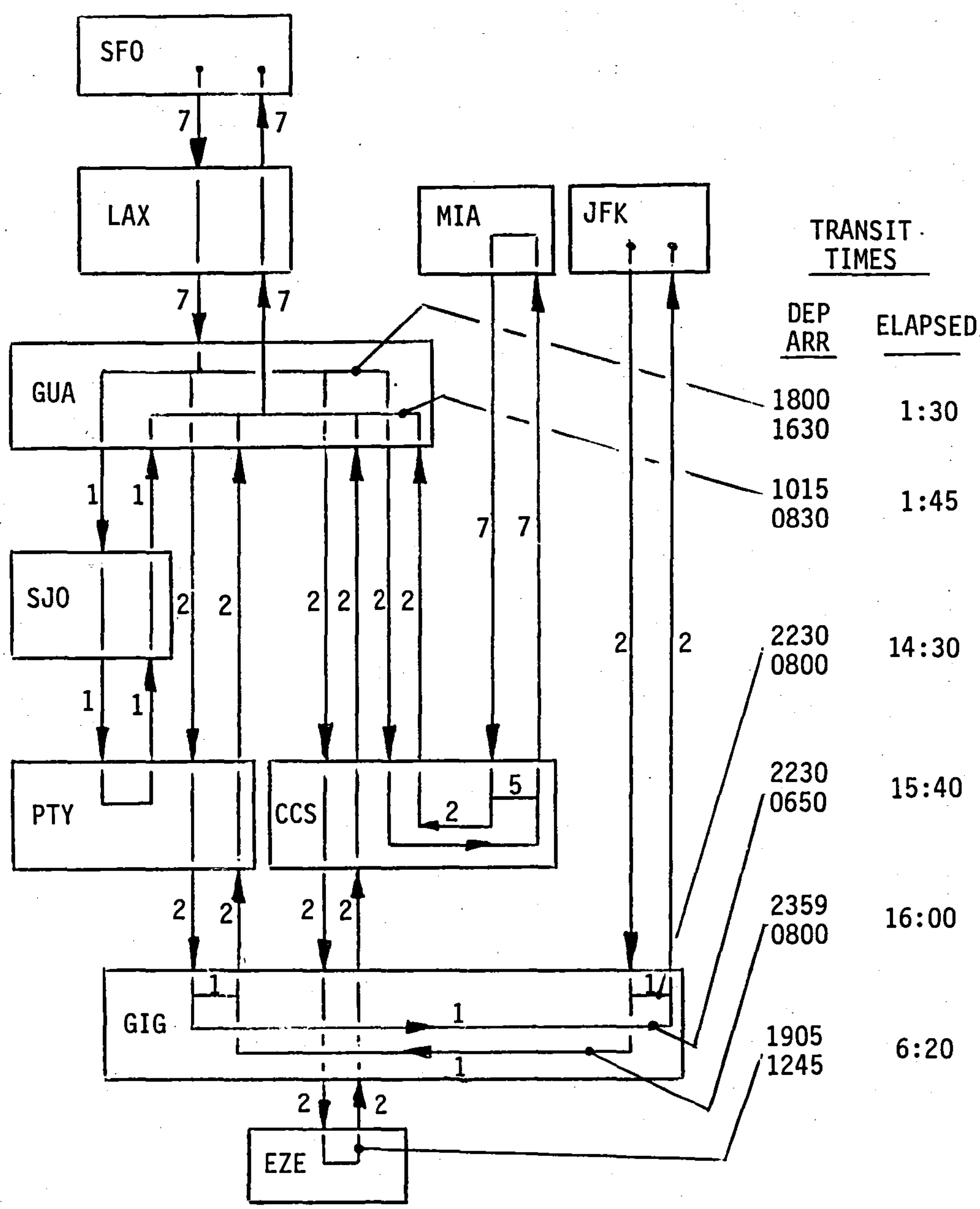
USA-ORIENT AND EUROPE

WEEKLY FLIGHT FREQUENCY AND SELECTED STATION TRANSIT TIMES



747-100 ROUTE NETWORK
USA-SOUTH AMERICA

WEEKLY FLIGHT FREQUENCY AND SELECTED STATION TRANSIT TIMES



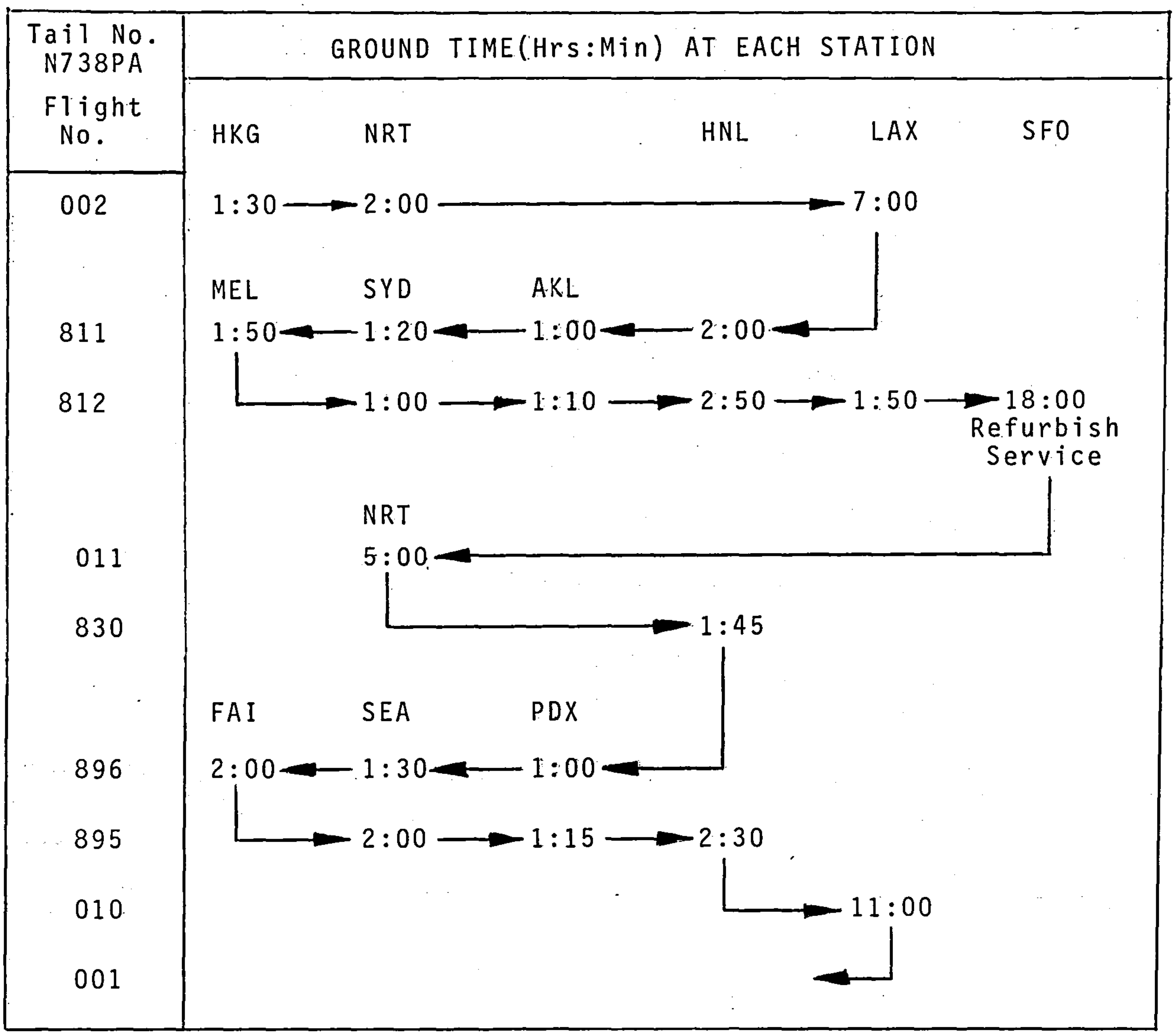
Actual Route Pattern for Four 747's from June 18 through 28, 1978

Tail No. N735PA / Flight No.	GROUND TIME(Hrs:Min) AT EACH STATION						
	SFO (Main Base)	LAX	MIA	GUA	CCS	PTY	GIG
516	15:00 Base Service	1:35		1:45		2:15	17:00
515		1:15		1:25	11:00		
442			1:30				
445					16:30		
442			1:30				
445					17:30		
442			1:30				
445					14:30		
516	8:50	1:30		1:40			
124							

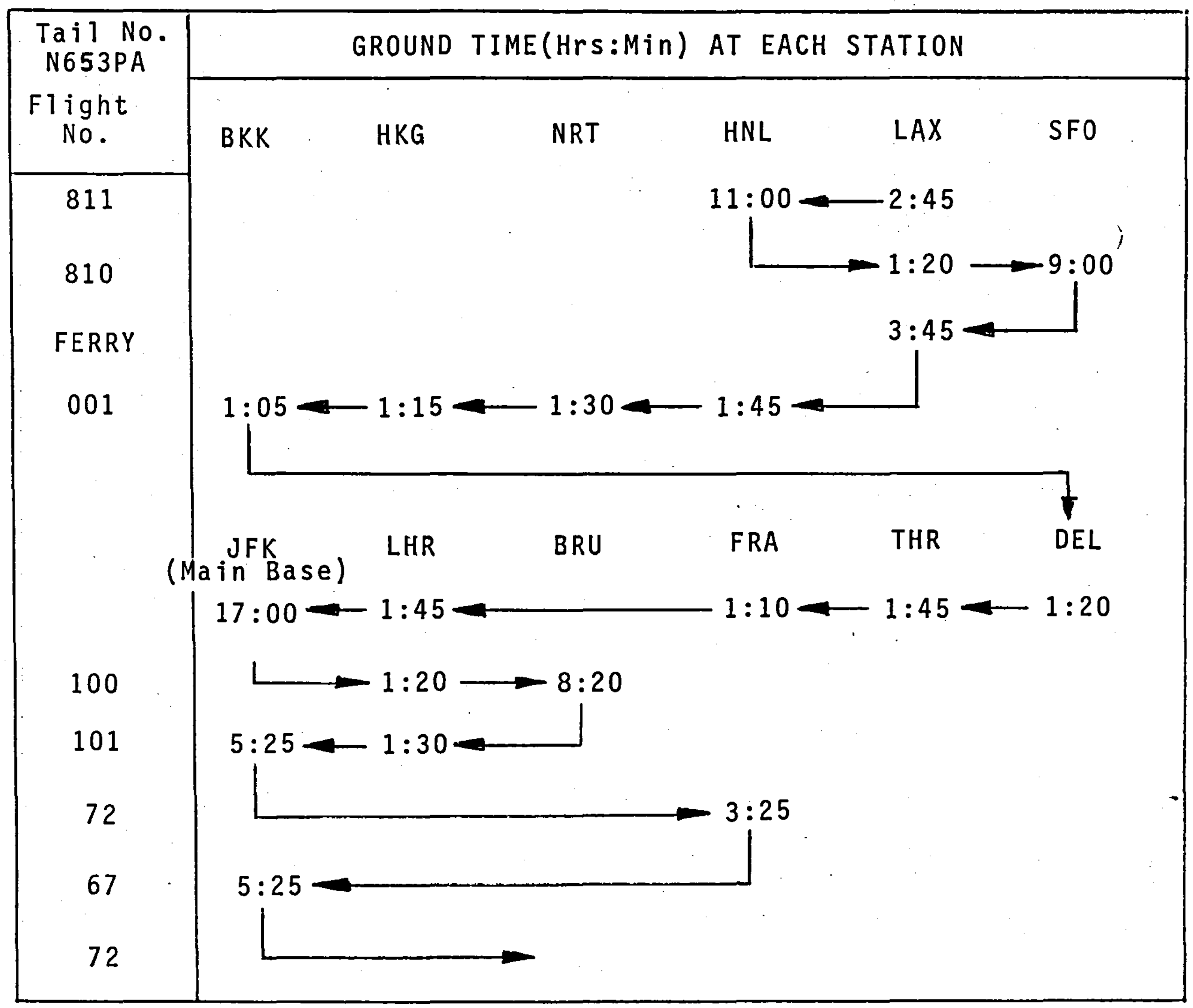
Actual Route Pattern for Four 747's from June 18 through 28, 1978

Tail No. N732PA Flight No.	JFK Main Base	LHR	BRU	FRA	FCO	THR	DEL	HKG	NRT	LAX
	GROUND TIME(Hrs:Min) AT EACH STATION									
100	4:25	2:20	7:15							
072				4:40						
067	3:30									
072				4:45						
067	4:00									
110					4:30					
111	26:00 C Service									
002		2:20		1:00		1:00	1:20	1:35	1:45	2:00
817										

Actual Route Pattern for Four 747's from June 18 through 28, 1978



Actual Route Pattern for Four 747's from June 18 through 28, 1978



APPENDIX E

RESOURCES AND COSTS FOR LINE STATION OPERATIONS

This section includes information from the Pan Am data collection, data summaries and supportive material.

Contents | Page

TABLES

TABLE E1 MAINTENANCE PERSONNEL FOR LINE STATIONS

Region	Station	Supervisors and Lead Mechanics	Licensed & Non-Lic Mechanics	Avionics Mechanics	Service Crew
USA GATEWAY	LAX*	37	56	7	25
	HNL*	24	31	15	63
	SEA	8	13	1	24
	ORD*	6	5		1
	IAH	5	10		
	MIA*	15	31	2	47
	DTW	4	7		
	IAD	5	6		
S. AMERICA	GUA*	5	13		11
	SJO		MAINTENANCE HANDLED BY LACSA		
	PTY*	6	15		6
	CCS*	7	18		12
	GIG	4	11		
	EZE	3	6		
	POS*	4	5		9
	VCP*	3	3		3
	MVD*	2	5		2
S. PACIFIC	PPG*	2	4		
	PPT	1			
	NAN		MAINTENANCE HANDLED BY QANTAS		
	AKL		MAINTENANCE HANDLED BY AIR NEW ZEALAND		
	SYD	4	MAINTENANCE HANDLED BY QANTAS		
	MEL	3			
ORIENT	NRT*	20	26	3	43
	OSA*	3	4		
	GUM*	9	12		10
	MNL	6			
	HKG	10	14	2	3
	KUL		MAINTENANCE HANDLED BY QANTAS		
	SIN	6	12		
EUROPE/WORLD	MEX	4	MECHANICS PROVIDED BY MEXICANA		
	LHR*	26	79	6	106
	PIK	3			
	FRA*	29	98	8	61
	BRU*	6	9		2
	FCO*	7	5		1
	IST*	6	6		
	BAH	1			
	THR*	5	2		7
	KHI*	3	5		1
	DEL*	3	7		

* Handles maintenance for other airlines

TABLE E2--LINE STATION SPARES
FOR PRIMARY MECHANICAL CONTROLS

Item	Part No.	Allocation JFK	Allocation SFO	Allocation Stations	Pool Item
Trim and Centering Mechanism	72749	0	0	0	--
Trim Actuator	72786	1	1	0	X
Central Control Actuator	72708/70717	6	0	0	X
Aileron Programmer	72751	0	0	0	--
Aileron Programmer	72752	0	0	0	--
Spoiler Differential (Mixer)	72753	0	0	0	--
I/B Aileron Power Control Unit	72706	2	0	0	--
O/B Aileron Power Control Unit	72707	2	0	0	--
O/B Aileron Lockout Actuator	72788	2	1	0	X
O/B Aileron Lockout Mechanism	70718/72792	1	0	0	--
O/B Aileron Lockout Mechanism	72748/72791	1	0	0	--
O/B Aileron Lockout Gearbox	72737	2	0	0	--
Flight Control S/O Valve Module	72714/72799	3	1	2	X
I/B Spoiler Power Control Unit	72709/70765	2	1	0	--
O/B Spoiler Power Control Unit	72710	4	1	0	X
Control Surface Position Ind.	72775	4	1	6	X
Control Surface Position Xmtr.	72728	4	1	2	X
Feel Trim and Centering Mechnsm	72749	0	0	0	--
Aft Quadrant	65B82246-1	0	0	0	--
Ratio Control Unit	72730/70756	2	1	15	X
Ratio Changer Actuator (Servo)	72778/70723/ 70755	4	1	36	X
Ratio Changer Comparator	70724/70731	1	1	18	X
Power Control Unit	72705	5	1	0	--
Trim Actuator	72777	2	1	0	--
Control Column Wheel	70704	0	0	0	--
Control Column Wheel	70705	0	0	0	--
Rear Quadrant	65B80482-1	0	0	0	--
Feel Unit	72773	0	0	0	--
Feel Actuator	72774	1	1	0	--
Feel Computer	72711/70772	1	1	0	X
Inbd. Power Control Unit	72703	4	0	0	--
Outbd. Power Control Unit	72704	3	0	0	--
Stall Warning Computer	72795	2	1	0	X
Over Rotation Computer	72789	4	1	5	X
Hydraulic Motor	72716/70754	1	0	0	--
Gear Drive/Jackscrew	72731	1	0	0	--
Hydraulic Brake	72785	1	1	0	--
Shut-off Valve	72779	5	1	0	--
Control Module	72723	0	0	0	--
Control Lever Brake	72715	1	0	0	--
Sequence Mechanism	72754/70771	0	0	0	--
Ground Spoiler Control Valve	72722/70768	1	1	0	--
Ground Spoiler Actuator	72713/70770	2	1	1	--

TABLE E3--LINE STATION SPARES FOR FLIGHT ELECTRONICS

Item	Part No.	Allocation JFK	Allocation SFO	Allocation Stations	Pool Item
Pitch Computer	72201	20	4	15	X
Roll Computer	72202	15	4	14	X
Yaw Damp Computer	72221	5	1	4	X
Monitor & Logic Unit	72204	11	2	14	X
Auto Stabilizer Trim Unit	72224	6	0	0	X
Auto Throttle Computer	72220	3	0	0	--
Normal Accelerometer	57381	1	1	0	X
Accessory Stabilizer Trim Box	72215	7	1	5	X
Accessory #1 Box	72217/72223	1	1	4	X
Accessory #2 Box	72216	4	1	1	X
Mode Select Panel	72222	10	2	3	--
A/P Flight Control	72203	1	1	8	X
Flight Mode Annunciator Light Set	73422	1	1	5	X
Attitude Director Indicator	73407	10	2	55	X
Navigation Receiver	73458	14	5	45	X
Low Range Radio Alt. Xcvr	73432	12	8	38	X
Inertial Navigation Unit	73402	30	2	16	X
Central Air Data Computer	73460	22	4	23	X
Central Air Data Computer	73404	0	0	0	--
MHR Compass Coupler	73412/73462	11	2	15	X
Auto Throttle Servo	72207	1	1	0	--
<u>SP COMPONENTS</u>					
Flight Mode Annunciator Light Set	42206	2	0	0	--
Yaw Damp Computer	42207	2	1	1	--
Accessory Stabilizer Trim Box	42208	1	1	1	--
Accessory #3 Box	42210	1	0	1	--
Central Air Data Computer	42211	3	1	1	--
Pitch Computer	42212	4	1	3	--
Monitor & Logic Unit	42213	1	1	1	--
Mode Select Panel	42214	1	1	1	--
Auto Throttle Computer	42217	1	0	0	--

Pan American World Airways, Inc.

* ATA CHAPTER INDEX REPAIRABLE COMPCNENT *

LINE STATION 747 A/C PART KIT

DATE: 05/22/78

ATA CHAPTER-27- FLT CONTROLS

	MANUFACTURER'S PART NUMBER	PAA CODE NUMBER	DESCRIPTION	UNIT OF ISSUE	UNIT COST	TYPE AIRCRAFT			SFO	5	4	3	2	1	POOL ITEM NUMBER
[illegible]	964-CC76-CC4	C7C724	CCMPARATGR RUD RATIO	EA	560.00	25			1	1	1				220
									DEL 001	ROM C01	SAO C01	BKK 001	BRU 001	CCS 001	
									THR 001	GUM C01	SYD C01	SEA 001	KHI 1		
									MIA 001	HKG C01	~~JNB 001~~				
[illegible]62	4C1-09408-11	07C732	MODULAR STAB TRIM	EA	14780.00	25			1	1					215
									FRA 001	SYD C01	TYO C01	LAX 000			
[illegible]	96C1-C9-03	C7C733	IND WING FLAP POSITICN	EA	631.00	25			2	1	1				221
									DEL 001	ROM CC1	NAN C01	SYD 001	THR 001	HNL C00	
									~~SAO 001~~	SEA 001	HKG 001				
[illegible]	18-1585-9	07C734	XMTR INBO TE FLAP POSITION	EA	550.00	25			1	1					204
[illegible]	18-1586-6	C7C735	XMTR ASSY POS OUTBD TE FLAP	EA	400.00	25			1	1					205
[illegible]	26E0220M6	07C739	MODULAR TE FLAP INBO	EA	3984.51	25			1						223
[illegible]	26EC219M6	C7C740	MOCULAR TE FLAP OUTBD	EA	2224.CC	25			1						227
[illegible]	5C13CC-C5	C7C755	ACTUATOR RUDDER RATIO CHANGER	EA	3953.00	25			1	1	1	1			272A
									BKK 001	NAN C01	~~OKA 001~~	~~HUC 001~~	SIN 001	DFW 001	
									~~JNB 001~~	MVD 1	KHI 1	BRU 0	OSA 1		

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Pan American World Airways, Inc.

* ATA CHAPTER INDEX REPAIRABLE COMPCNENT *

LINE STATION 747 A/C PART KIT

DATE: 05/22/78

ATA CHAPTER-27- FLT CONTROLS

E7

CLASS	MANUFACTURER'S PART NUMBER	PAA CODE NUMBER	DESCRIPTION	UNIT OF ISSUE	UNIT COST	TYPE AIRCRAFT	STATION ALLOCATION		SFO	5	4	3	2	1	POOL ITEM NUMBER
536	69C5CC-06	07C756	CONTROL UNIT RUDDER RATIO	EA	179C.CC	25			1	1	1				264A
									THR 001	DEL CC1	SEA OC1	SYD 001	SAO 001	GUM C01	
									ROM 001	MIA 001	HKG C01		MVD 1		
557	DL2033M2	070762	ACTUATOR AUTO SPEED BRAKE	EA	2250.00	25			1	1					202
									LAX 000						
~~648~~ 650	293CC-10	C7C765	POWER PACK SPOILER NBR 8	EA	62.12	25			1						207A
314	1C1263-3	C7C768	VALVE GRD SPOILER CONTROL	EA	160C.CC	25			1						
~~648~~ 650	34620-4	07C770	ACTR ASSY GRCUND SPOILER	EA	8440.80	25			1						
									DFW 001						
562	4C1-13151-04	07C772	POWER PKG FEEL COMPUTER ELEV	EA	18111.30	25			1						216
678	126344-4-1	C7C773	DRV ASSY L/E FLAPS INBD KRUEG	EA	8242.00	25 -24-21			2	1	1		RIO 1		225B
									GUM 001	SYD 001		BKK 001	DEL 001	DTW 001	
									MIA 001	THR CC1	HKG 001	CCS 001	FAI 001	NBO C01	
									BOG 001	BRU C01	CFW 001	MNL 001	ROB 001	JNB 001	
411	2591415-902MOD	C72224	UNIT TRIM AUTOMATIC STAB	EA	474C.00	25			1	2	1				90
									THR 001	DEL C01	ROM C01	SYD C01		GUM 001	
									HKG 001						
643	29310-3	C72710	PWR PKG SPCILER OUTBD	EA	4056.CC	25			1						208

Pan American World Airways, Inc.

* ATA CHAPTER INDEX REPAIRABLE COMPONENT * LINE STATION 747 A/C PART KIT DATE: 05/22/78 PAGE: 26

ATA CHAPTER-27- FLT CONTROLS

CLASS	MANUFACTURER'S PART NUMBER	PAA CODE NUMBER	DESCRIPTION	UNIT OF ISSUE	UNIT COST	TYPE AIRCRAFT	STATION ALLOCATION		SFO	5	4	3	2	1	POOL ITEM NUMBER
586	1176T100-3	072724	ALT ELEC MOTOR INBD TE FLAP	EA	1038.00	25			1						217
530	1769C0-201	072726	ACTUATOR ROTARY LEADING EDGE	EA	943.00	25			1						203
434	7977-18-01	072728	XMTR FLT CONTROL POSITION	EA	203.50	25			1	1					255
678	126344-3-1	072743	DRV ASSY L/E FLAPS OUTBD V/C	EA	8242.00	25-24-23			2	1	1				225A
									GUM 001	SYD C01	~~SAC C01~~	BKK 001	HKG 001	DTW 001	
									DEL 001	MIA C01	THR C01	CCS 001	FAI 001	JNB 001	
									BOG 001	DFW C01	MNL C01	ROM 001	AMS 001	ROB 001	
									NBO 001	RIO 1		AKL 1			
363	26E0222M3	072744	MODULAR ASSY INBD TE FLAP	EA	1605.00	25			1						
363	26EC221M3	072745	MODULAR ASSY OUTBD TE FLAP	EA	1605.00	25			1						
423	9819-29	072775	IND CENTRAL SURFACE POSITION	EA	1122.00	25			1	1	1				258
									SYD 001						
121	65-21831-12	072777	ACTUATOR AY RUD TRIM CONTROL	EA	513.00	25			1						248
682	155850-1	072779	ACTUATOR AY MOTOR HYD FLT CON	EA	243.00	25			1						
121	65BE1129-105	072783	TRANSMISSION FLAP	EA	16669.00	25			1						
562	4C1-C9410-01	072785	BRAKE AY STAB CONTL SECOND	EA	1785.00	25			1						260
567	LL1C2CM159	072786	ACTUATOR AIL LATERAL TRIM	EA	694.00	25			1						268
356	PCC1-1B12	072787	SW SPEED 9 TO FLAP BLOW BACK	EA	180.00	25			1						575
678	544646-1	072725	ACTUATOR ROTARY LEADING EDGE	EA	945.00	25			1						218

Pan American World Airways, Inc.

* ATA CHAPTER INDEX REPAIRABLE COMPONENT * LINE STATION 747 A/C PART KIT DATE: 05/22/78 PAGE: 27

ATA CHAPTER-27- FLT CONTROLS

CLASS	MANUFACTURER'S PART NUMBER	PAA CODE NUMBER	DESCRIPTION	UNIT OF ISSUE	UNIT COST	TYPE AIRCRAFT	STATION ALLOCATION		SFO	5	4	3	2	1	POOL ITEM NUMBER
567	JL1326M119	C72788	ACTUATOR OUTBD AIL LOCKOUT	EA	1027.00	25			1						270
625	965-0172-003	072789	COMPUTER OVER ROTATION	EA	2995.00	25			1	1	1				465
121	65B81133-3	072790	POWER UNIT OUTBD TE FLAP	EA	3268.00	25			1						
625	965-0111-002	072795	COMPUTER STALL WARNING	EA	1434.00	25			1						568
632	AV16E1215-3	C72799	MODULAR HYD SHUT OFF	EA	734.08	25			1	1					213
									HNL 001						
121	65B15169-13	R37208	PANEL L/E FLAP LH NBR 6	EA	6336.00	25			1						
									LON 001						
121	65B15169-14	R37209	PANEL L/E FLAP R/H NBR 21	EA	4718.00	25			1						
									LON 001						
121	65B15170-6	R37193	PANEL L/E FLAP LH7-10 RH17-20	EA	4816.40	25			1						
									LON 001						

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Pan American World Airways, Inc.

* ATA CHAPTER INDEX REPAIRABLE COMPONENT *

LINE STATION 747 A/C PART KIT

DATE: 05/22/78 PAGE: 7

ATA CHAPTER-22- AUTO PILOT

E10

CLASS	MANUFACTURER'S PART NUMBER	PAA CODE NUMBER	DESCRIPTION	UNIT OF ISSUE	UNIT COST	TYPE AIRCRAFT	STATION ALLOCATION		SFO	5	4	3	2	1	POOL ITEM NUMBER
411	2590622-908	072201	COMPUTER PITCH AUTO PILOT	EA	11647.00	25			4	1	1				78
									SAO 001 [crossed out]	GUM C01	LAX +1	HNL +1	ROM 001	HKG C01	
									SYD C01	SEA C01	TYO +1	DFB 001	RIO 1		
411	2593545-905	072202	COMPUTER ROLL AUTO PILOT	EA	12099.00	25			4	1	1				79
									HKG 001	ROM C01	GUM 001	SYD 001	SAO 001 [crossed out]	LAX +1	
									HNL +1	SEA 001	DFW 001	RIO 1			
411	2590625-902	072203	CONTROLLER AUTO PILOT	EA	2489.00	25			1	1	1				81
									HKG 001	SAO C01 [crossed out]	SEA 001	RIO 1			
411	2591027-902	072204	UNIT MONITOR LOGIC	EA	9892.00	25			2	1	1				82
									SYD 001	GUM 001	ROM 001	HNL +1	SAO 001 [crossed out]		
									HKG 001	SEA C01	TYO +1	RIO 1	BRU 1		
405	19C3896-1	072207	SERVO AUTO THROTTLE	EA	958.00	25			1						77
121	65847519-9	072215	UNIT ASSY ACCY STAB TRIM	EA	2384.00	25			1	1					87
									FRA 001	HNL 001	LAX CC0				
121	65847521-18	072216	ACCY UNIT 2 AUTO PILOT	EA	5909.00	25			1						88
									LAX 001						
405	1964212-1	072221	COMPUTER YAW DAMPER	EA	4510.00	25			1	1					75
									HNL 001	ROM C01					

Pan American World Airways, Inc.

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LINE STATION 747 A/C PART KIT

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ATA CHAPTER-22- AUTO PILOT

CLASS	MANUFACTURER'S PART NUMBER	PAA CODE NUMBER	DESCRIPTION	UNIT OF ISSUE	UNIT COST'	TYPE AIRCRAFT	STATION ALLOCATION								POOL ITEM NUMBER
									SFO	5	4	3	2	1	
411	2590624-924	C72222	PANEL AUTO PILOT SELECTOR	EA	15120.00	25			2	1					
									HNL 001						
121	65847520-14	072223	ACCY UNIT 1 AUTO PILOT	EA	3386.00	25			1	1					89A
									HNL 001	LAX C00					

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Pan American World Airways, Inc.

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LINE STATION 747 A/C PART KIT

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ATA CHAPTER-34- NAVIGATION

CLASS	MANUFACTURER'S PART NUMBER	PAA CODE NUMBER	DESCRIPTION	UNIT OF ISSUE	UNIT COST	TYPE AIRCRAFT	STATION ALLOCATION		SFO	5	4	3	2	1	POOL ITEM NUMBER
~~C66~~ 484	7883460-031 KCR/842	073401	UNIT DISPLAY INS CDU	EA	5021.00	25			3	2	1				G782
									HKG 001	HNL +1	RIO 001	ROB 1			
~~C66~~ 484	7883450-041 KCR 853	073402	UNIT NAVIGATION INS	EA	73856.00	25			2	2	1				G783
									HNL +2	LAX +2	TYO +1	RIO 001	HKG 002	ROB 1	
484	7883480-011	073403	BATTERY INS A10786-9	EA	638.00	25			4	1	1				G780
									~~FRA -1~~	HKG C01	FRA 0	ROB 1			
666	771-1083-001	073405	IND HORIZONTAL SITUATION	EA	6816.00	25			3	2	2	1			
									MIA 001	BKK C01					
~~C00~~ 666	772-5018-003	073406	COMPUT CENTRAL INST WARNING	EA	2826.00	25			1	1	1				569A
									HKG 001						
~~C00~~ 411	2590281-905	073407	IND ATTITUDE DIRECTOR	EA	7200.00	25			2	2	1	1	1		5788
									~~GLA 000~~	ORD CCC	~~NUC C00~~	~~BOS 000~~	~~PDX 000~~		
									HNL +1	~~BCC C00~~	CLO C00	KUL C00			
409	SLZ9392A	073410	IND RATE OF CLIMB	EA	693.00	25			1	1	1				557
									RIO 001	SYC C01	SEA C01	HKG 001			
402	A42927-10-001	073411	IND AIRSPEED	EA	5725.00	25			2	1	1				553
									ROM 001	SAO C01	GUM 001	SYD 001	SEA 001		
411	2591200-901	073413	COMPENSATOR REMOTE MAGNETIC	EA	333.00	25			1						560

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Pan American World Airways, Inc.

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ATA CHAPTER-34- NAVIGATION

CLASS	MANUFACTURER'S PART NUMBER	PAA CODE NUMBER	DESCRIPTION	UNIT OF ISSUE	UNIT COST	TYPE AIRCRAFT	STATION ALLOCATION		SFO	5	4	3	2	1	POOL ITEM NUMBER
405	36154-1AF25B1	073414	IND RADIO MAGNETIC	EA	2357.00	25			1	1	1				
									HKG C01						
605	75-C147-9	073422	ANNUNCIATOR FLT MODE	EA	646.00	25			1	1	1				91
565	40-300-1	073425	IND STATIC AIR TEMP	EA	1099.00	25			1	1	1				563
565	40-301-1	073426	IND MACH DIGITAL AIRSPEED	EA	1008.00	25			1	1	1				
									ROM 001	SAO C01	GUM 001	SYD 001			
565	40-302-3	C73427	IND TOTAL AIR TEMP	EA	1745.00	25			1						564
									DFB 001						
565	40-309-1	073428	IND TRUE AIRSPEED	EA	1097.00	25			1	1	1				565
550	G1684C	C73437	PANEL CONTROL ATC-MKR	EA	297.00	25			2						
402	A42899-10-016	073439	ALTIMETER	EA	7950.00	25			2	2	1	1	1	X	580
									HNL +1	GLA C00	MNL C00	PTY 000	DTW 000	CCS C00	
									SAO 000	WAS CC0	PPT C00	FAI 000	AMS 00C	[illegible]	
									BOG 000	BAH C00	POX C00	LON -1	CLO 000	CKA C00	
408	26C910	073441	IND COMPASS SYNC	EA	154.00	25			1						552
600	594CCCCC-1C1	C73443	IND TIME TO GO	EA	2400.00	25-21			1	1					
									HNL 001						

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Pan American World Airways, Inc.

* ATA CHAPTER INCEX REPAIRABLE COMPONENT * LINE STATION 747 A/C PART KIT DATE: 05/22/78

ATA CHAPTER-34- NAVIGATION

CLASS	MANUFACTURER'S PART NUMBER	PAA CODE NUMBER	DESCRIPTION	UNIT OF ISSUE	UNIT COST	TYPE AIRCRAFT	STATION ALLOCATION		SFO	5	4	3	2	1	POOL ITEM NUMBER
410	8C7C7-10018	073445	SW MACH AIRSPEED WARNING	EA	487.CC	25			1	1	1				555
									SEA 001						
121	65C47577-28	073451	BCX ASSY INSTRUMENT SW UNIT	EA	1453.CC	25			1						
199	A1C981-1	073452	SENSOR MAGNETIC FIELD	EA	510.C0	25			1	1					562
									HNL 001	SYD C01					
625	965-0184-001	073453	COMPUTER ALTITUDE ALERT	EA	1980.00	25			1	1					567
410	B07C4-10043	C73456	SENSOR CVERSPEED	EA	832.00	25									
									HKG 001						
C00	A12158-1	073460	COMPUTER CENTRAL AIR DATA	EA	14926.0C	25			4	2	1				576
									ROM 001	SYD CC3	GUM C01	~~SAO 001~~	THR 001	DEL 001	
									SEA 002	HNL +1	HKG 002	TYO +1	DFW 001	~~JNB 001~~	
									NBO 001	BOG C01	RIO 1				
199	A12345-1	073462	CCUPLER MAGNETIC COMPASS	EA	4232.00	25-24-23 21			2	2	1				561
									SEA 001	RIO C01	GUM 001	SYD 001	HNL +1	ROM C01	
									BRU 001	~~AMS C01~~	HKG 001	NBO 001			
121	658C6732-7	R32066	PANEL LH ADF SENSE ANTENNA	EA	3400.00	25			1						
499	1C2CP2AG	R36063	SENSOR TCTAL TEMPERATURE	EA	1635.50	25			1	1	1				559
665	2070057-0701	R36069	ANTENNA ALT ANA 51D	EA	204.00	25			1						

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* ATA CHAPTER INDEX REPAIRABLE COMPONENT *

747 LINE STATION A/C PART KIT

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ATA CHAPTER-22- AUTO PILOT

CLASS	MANUFACTURER'S PART NUMBER	PAA CODE NUMBER	DESCRIPTION	UNIT OF ISSUE	UNIT COST	TYPE AIRCRAFT	STATION ALLOCATION								POOL ITEM NUMBER
									SFO	5	4	3	2	1	
405	3757198-1	042207	COMPUTER YAW DAMP	EA	8231.00	21									
									SFO 001	LAX C01					
121	65E47571-4	042208	BOX ASSY STAB TRIM	EA	5220.00	21			1						
									LAX 001						
121	65E47573-25	042210	BOX AUTO FLITE ACCESSY NBR 3	EA	7074.00	21									
									LAX 001						
121	65B47572-19	042211	BOX AUTO FLITE ASSY NBR 1-2	EA	7749.00	21			1						
									LAX 001						
411	2590622-926	042212	COMPUTER PITCH	EA	17790.00	21			1						
									LAX 001	TYO 001	AKL 001				
411	259336C-911	042213	UNIT LOGIC LANDING CONTROL	EA	38000.00	21			1						
									LAX 001						
411	2593362-924	042214	PANEL AUTO PILOT SELECTOR	EA	40965.00	21			1						
									LAX 001						
121	65-42163-1	055466	BOX ASSY GEAR AUTO THROTTLE	EA	1049.00	25 27			1						
411	25EE656-9C4MCD	C57381	ACCELERCMETER AUTO PILCT	EA	660.00	25 27 28			1						83

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LINE STATION AVIONIC KIT

CLASS	PART NUMBER	CODE	DESCRIPTION	UNIT COST	POOL ITEM NUMBER
000	522-4280-108 -109		Receiver, VHF NAV 51RV -2B	4152.00	G-310 G-308

TYPE AIRCRAFT				CONTAINER NUMBER	KCR NUMBER					
720-023B -10		707-321B-19		7A	293	395	481	637	704	723
707-139 -11		727-21 -27			302	450	494	663	708	729
707-321C -14		727-21C -28			304	441	528	670	709	731
707-321 -16		747 -25	x		310	447	551	680	711	732
720-030B -17		747SP -21	x		325	470	593	686	716	733
707-121 -15		747F -24	x		363	479	623	700	717	

REMARKS:

	TOTAL	POOL TO	POOL FROM		TOTAL	POOL TO	POOL FROM		TOTAL	POOL TO	POOL FROM		TOTAL	POOL TO	POOL FROM		TOTAL	POOL TO	POOL FROM		TOTAL	POOL TO	POOL FROM
ABJ	1							GUA	1			MAR											
ACC	1							GUM	1							PAP				SFO	5		
AKL	1			CCS	1			HAJ				MEL	1 ✓		1								
AMS								HAM				MEX	1 ✓		1					SIN	1 ✓		1
AMM																							
ANC	1			COO								MGA				PDX				SJO			
ANK				CPH				HKG	2			MIA	1			PHL				SJU			
				DAM				HNL	2			MID				POS	1						
				DAR				HOU	1			MNL	1 ✓		1	PPG	1			SNN			
				DAC																			
BAH	1		1	DEL	1			IST	1 ✓		1	MOW				PPT	1						
BAQ				DKR	1			JFK								PRG				STR			
				DHA	1			JKT															
				DPS				JNB				MUC	1		1	PTY	1						
				DFW				KBL															
BEG				DTW	1			KUL				MVD				RIO	1			SYD	2 ✓		1
BER				DUS								NAN	1			ROB				THR	1		
BEY								KHI	1 ✓		1					ROM	1 ✓		1	TPA			
BOM	1		1 ✓	FAI				LAX	2											TYO	2 ✓		1
BOG												NBO								TPE			
BKK	1							LBV								SAL							
BOS				FIH				LIS				NUE				SAO	1			WAS	1		
BRU	1		1					LON	6			OKO								WAW			
BSB				FRA	2			LOS				ORD	1			SDQ				WRI			
												OKA											
BUE	1		1	GEO				MAD				OSA	1			SEA	1						
				GLA								OSL											

DATE: 1/11/79

LINE STATION AVIONIC KIT

CLASS	PART NUMBER	CODE	DESCRIPTION	UNIT COST	POOL ITEM NUMBER
000	2067631-5114	-	Altimeter Unit. ALA-51A	5157.00	G-451

TYPE AIRCRAFT				CONTAINER NUMBER	KCR NUMBER					
720-023B -10		707-321B-19	x		304	450	585			
707-139 -11		727-21 -27	x		330	443	600			
707-321C -14	x	727-21C -28	x		377	511	637			
707-321 -16		747-121 -25	x		379	531	646			
720-030B -17		747SP -21			416	556	706			
707-121 -15					431	579	715			

REMARKS:

	TOTAL	POOL TO	POOL FROM		TOTAL	POOL TO	POOL FROM		TOTAL	POOL TO	POOL FROM		TOTAL	POOL TO	POOL FROM		TOTAL	POOL TO	POOL FROM		TOTAL	POOL TO	POOL FROM
ABJ								GUA				MAR											
ACC								GUM	1							PAP				SFO	8 ✓		
AKL	1 ✓			CCS								MEL											
AMS								HAM				MEX								SIN			
AMM																							
ANC				COO								MGA				PDX				SJO			
ANK				CPH				HKG	1 ✓			MIA	2 ✓			PHL				SJU			
				DAM				HNL	2 ✓			MID				POS							
ASU	1			DAR				HOU				MNL				PPG				SNN			
BAH				DAC								MLH	1										
				DEL				IST	1			MOW				PPT							
BAQ				DKR				JFK								PRG				STR			
				DLA				JKT															
				DPS				JNB				MUC				PTY							
				DFW				KBL															
BEG				DTW				KUL				MVD				RIO	1 ✓			SYD	1 ✓		
BER	3 ✓			DUS								NAN				ROB				THR			
BEY								KHI								ROM				TPA			
BGO				FAI				LAX	2 ✓											TYO	2 ✓		
BOG												NBO								TFE			
BKK								LBV								SAL							
BOS				FHI				LIS				NUE				SAO				WAS			
BRU				FPO				LON	6 ✓	1		OKO								WAW			
BSB				FRA	3 ✓			LOS				ORD				SDQ				WRI			
BUD												OKA											
BUE				GEO				MAD				OSA				SEA	1 ✓						
BUH				GLA								OSL											

DATE: 6/10/77

SPARES POOLING

INTERNATIONAL AIRLINES TECHNICAL POOL

Introduction

With the introduction of the large jet passenger aircraft, the Boeing 707 and Douglas DC8, a small number of the international major airlines held a series of exploratory meetings in 1959 in connection with the sharing or pooling of spares, both for aircraft and ground equipment. From the discussions that took place, the airlines quickly realized that benefits, both from actual financial savings, and from increased line station coverage, could be readily negotiated. From this beginning, the first effective International Airlines Technical Pool (I.A.T.P.) meeting was held at Lucerne in March 1960. At the meeting only nine airlines were represented. This number has now increased to over 60.

Pool Meetings

The calendar year is divided into two Pooling seasons, the Winter Season, lasting 5 months from November 1 to March 31; and the Summer Season, lasting 7 months from April 1 to October 31. This is to take into account the seasonal variations in traffic as experienced by most airlines and as such, variations on spares requirements.

Business Conducted at a Pre-season Pool Meeting

The main purpose of the business conducted at a pre-season Pool Meeting is for the established providers at stations to agree on what items they will provide for the participants concerned.

The meetings are split up according to the Pool Groups (which are explained in the Rules of the I.A.T.P.). For each Pool Group at each station in turn, the concerned participants (knowing their provisioning requirements and knowing what stations they will be using with each aircraft type) will ask the provider to make available all those items requested for pooling. When items are of a standardized nature and common to most aircraft of the Pool Group, then the requests for providing them are usually acceptable. With customized items that are common to only one airline's fleet, the provider can refuse to make available these items for pooling.

At the end of the meeting, those items that an airline did not have accepted for pooling will have to be provisioned privately.

Rules of the I.A.T.P.

The Rules of the I.A.T.P. are published in a book containing I.A.T.P. Agreements and Annexes. Airlines which are members of the I.A.T.P. operate according to these rules as members of a particular Pool Group. The definition of a Pool Group is "Any pooling activity between parties to the agreement which is concerned with a specific aircraft, or engine type, equipment, facilities or avionic equipment, will be known as a Pool Group."

The various Pool Groups are given identifying letters which are as follows:

Pool Letter	Pool Group Description
C	Power Plants and Fifth Pod Kits
D	Ground Handling Equipment
E	Ground Maintenance Equipment
F	Technical Facilities
G	Avionic Equipment
	Aircraft
J	Boeing 707/720
K	Boeing 727
L	Boeing 737
M	Boeing 747
N	Douglas DC8
P	Douglas DC9
Q	Douglas DC-10
T	BAC VC 10
U	Sud Caravelle
V	BAC 1-11
W	Concorde
Y	Lockheed 1011

All Pool Groups function in much the same way, and basically to the same kind of rules. Each airline member of the Group in turn acts as chairman of the Group for one season.

There are three types of membership. Participation in the activities of any Pool Group is restricted to these categories:

1. "Member" Airline is a full member of a particular Pool Group and can participate both as a provider and a user (explained in Providers and Users).
2. "Observer" Airline, which is not a member of the I.A.T.P. and desires to participate in a group, may attend one meeting of that Group as an "Observer" in order to familiarize itself with the procedures and extent of pooling.
3. "Paying Guest" Airline, which may or may not be a member of the International Air Transport Association (I.A.T.A.), can enjoy the benefits of Pooling through the Sponsorship of a Member

Airline.

The documentation used in all of the Pool Groups is referred to as Annexes, which are numbered one to six. The annex number, coupled with a Pool Group letter, refers the particular documentation to an aircraft or equipment type. Thus J1 refers Annex 1 to the Boeing 707 aircraft.

Annex 1:
This annex lists all stations where pooling for the particular group has been confirmed, and against each station is listed the airline which provides and the airlines which share.

Annex 2:
This annex is, in effect, a catalog of all the items available for pooling purposes in that group. The items are listed in ATA chapter order and each carries its pool item number, item description, cost, and applicability to aircraft type.

Annex 3:
This annex is regarded as the most important one of the system and the 747 flight control components (Annex M3 and G3) are included in this section. It is a complete schedule of all the pooling agreed for the Group for the season, and is the only document which is pertinent for the Pool costing for the season. The items are listed in pool item number, and the heading gives pool item number, description and cost. The pooling is shown in station three letter code sequence, and against each station is shown the quantity in pool at that station and the period of pooling. This has to be a complete season for items costing under $300, but may only be part of a season for items in excess of $300.

Also shown is the airline providing the item and all the users. If a user is sponsoring a non-pool group member for that item, a figure 3 appears after the airline two letter code. If, however, a group member not using a particular item at a station sponsors a non-pool group member for an item, a figure 2 appears after the sponsoring airline two letter code, indicating that the airline is paying two shares for that item at the particular station.

Annex 4:
This annex shows a station by station presentation of all the items pooled at each station.

Annex 5:
This annex contains all the operating rules which are particular to that group.

Annex 6:

This annex is a schedule giving a complete breakdown of the season's charges for pooling for each group. It shows the revenue for payment to the pool providers and it gives a very good picture of the benefits of pooling. Comparisons can be made between airlines as to the extent of borrowing; which was a consistent user of certain items or at certain stations.

All these costs are cleared through the I.A.T.A. Clearing House, which is the same body that deals with payments for airline tickets.

The information supplied in the various annexes is published by R. Dixon Speas Associates, data processing unit. Annexes 1, 2, 3, and 4 provide a very useful guide in preparation for a pre-season Pool Meeting as the business to be discussed really amounts to amending these annexes of the previous season's pooling commitments.

POOLING SCHEME

Providers and Users

The basis on which the scheme works is for an airline at a particular station to make available spare parts, ground equipment, and technical services to other airlines which are members of a pool group and serve that station. That airline concerned is known as a provider and the participating airlines are known as users.

Normally one airline is the main provider at each station, and this airline is referred to as the logical provider. Where the station is the main base of the airline, e.g. Paris and Air France, Tokyo and Japan Airlines, the logic is sound, but where the station does not have a major airline base there, or the major airline does not participate in the particular pool, the logic gets somewhat strained. Examples of this are DC8 and B727 pool groups at London.

All pool groups now work on an optional geographical basis. All airlines can participate in the items of their choice at the stations of their choice. Where there is no logical provider at a station, then a request is made for a volunteer provider.

COST SHARING DETAILS FOR THE 747 POOL GROUP

The availability charges for the 747 are as follows:

1. The average service life for a pool item is determined at 10 years. Accordingly 10% of the agreed Manufacturer's current list price is considered the basic annual availability charge.

2. To this charge is added the "Cost of Ownership" to compensate for:
   - capital interest
   - pipeline investments
   - modifications
   - obsolescence risk
   - procurement, storage, insurance, packing, shipping, customs clearance and administration

The "Cost of Ownership," together with the basic availability charge, is calculated according to the item price as shown in the table.

Item Pool Value	Charges as % of Item Price (M)
Item less than $300	30% per year
$300 to less than $1000	28% per year
$1000 to less than $2000	26% per year
$2000 to less than $3000	24% per year
$3000 to less than $5000	22% per year
$5000 to less than $10,000	20% per year
$10,000 to less than $20,000	19% per year
$20,000 and over	18% per year

These total availability charges (cost of ownership and basic availability) are distributed among the participants as follows:

1. For items having a Pool value of less than $1000, the charges are equally shared by all pool participants.
2. For items having a pool value of $1000 or more, each uplift will be considered as one share in addition to the participation shares. (An uplift occurs each time an airline member borrows a part from the pool provider.) Thus, the total availability charges will be divided between the total number of shares (participation plus uplifts).

These charges can be expressed in the form of equations as follows:

1. Item price less than $1000

Participation charge, $C = \frac{\text{total availability charges}}{\text{number of Pool participants}}$

$C = \frac{M}{N}$ where M = % of item price according to pool value obtained from table

N = number of Pool participants

2. Item price over $1000

Participation charge, $C = \frac{M}{N + U}$

where U = total number of uplifts

(a) For a Pool User

User's Annual Charge = Participation Charge + Uplift Charge

$= C + CV$

where V is number of user's uplifts

$$= \frac{M(1 + V)}{(N + U)}$$

(b) For a Pool Provider

Provider's Annual Revenue = total availability charges - Users Annual Charge

$= M - C(1 + V)$

$$= M - \frac{M(1 + V)}{(N + U)}$$

If the provider at his main base does not uplift from the pool, but his own store, then,

Provider's Annual Revenue $= M - \frac{M}{N + U}$

The annex rules permit members to participate in items of over $300 each for periods of less than the duration of a season. The actual costing is calculated on a day to day basis by dividing the annual availability charge by 365. The reason to allow pool participation for only part of a season enables the airline to suit its spares backing to the full duration of its services which may be introduced or curtailed midway through a season.

For items under $1000 the participant charges and provider revenues can be calculated at the beginning of a pool season.

For items of over $1000 in value no predetermination of the individual charges can be made. The true costing has to be carried out after the season has ended and when all reported uplifts have been recorded.

EXAMPLE OF THE COST SHARING SCHEME FOR THE B747

An example of the cost sharing scheme for B747 pool items is given to illustrate the various benefits to providers and users.

> Consider the pitch computer, pool item number M078, the agreed manufacturer's price being $11,647. The total availability charges per year will be 19% of $11,647 or $2215.

Because the item is more than $1000 in price, the distribution of availability charges is divided equally among the participating airlines (one share for each member airline), plus one share for each uplift that occurs.

An uplift occurs each time a pool participant borrows that pool item.

Consider five airlines A, B, C, D and E which participate in this item at London.

Assume there were three uplifts of this item during the year. This makes eight shares total.

The participation charge is $2215/8 = $227.

Airline	Participation Charge	Uplifts Recorded	Uplift Charge	User's Annual Charge
A	$ 277	0		$ 277
B	277	3	$831	1107
C	277	0		277
D	277	0		277
E	277	0		277
	$1385			$2215

The five airlines would pay a total charge of $2215 for that year.

Benefits to Providers

- If airline A was the pool provider at that station, then it would receive at the end of the year the total charges of $2215, less $277 for being a participant. With an investment of $11,647 and revenue of $1938 paid in at the end of one year, there is a return on capital invested which could very well pay off the initial capital outlay over the life of the component.

The pooling scheme allows the provider to have its uplifts not included in the charges if the provider maintains two or more of the same items for pooling. In the above example this would increase the revenue by less than $100 (as the total number of shares drops to seven). This does not encourage the provider to maintain an extra spare item available due to the small return on the extra $11,647 capital investment.

However, if the station happens to be the provider's main base, then there is probably an extra item available for pool use from the main stores. Alternatively the provider may elect to provide only one item for pool use and uplift from the main store, thereby keeping the pool charges low. In this case, using the equation on provider's revenue

$$\text{Provider's annual revenue} = M - \frac{M}{N + U}$$

where M = % of item price
N = number of participants
U = total number of uplifts

It can be seen from this equation that the larger the number of participants and/or the larger the number of uplifts then the revenue paid to the provider approaches M. The annual income ranging from 18% to 30% of the item price clearly shows the advantages of pooling for the provider.

Benefits to Users

As the pooling charges are affected by the amount of borrowing of pool items, the effect of this is best seen from the equations established on user charges.

$$\text{User's annual charge} = \frac{M(1 + V)}{(N + U)}$$

where V = number of user's uplifts

It can be seen that the first time a pool user borrows that item, its annual charge doubles and each further uplift increases its charge by the same amount. This is true if the ratio of the user's uplifts (V) to the total number of uplifts (U) remains constant (i.e., an average borrowing rate as compared with the other participating airlines). However, excessive usage of a pool item by one airline will load the majority of the charges on it; a clear incentive to improve its technical reliability.

Referring to the cost sharing example, airline B which made the uplifts is charged $1107, while airline C is charged only $277. It can be argued that, as airline B did not need to borrow that item during the year, then it need not have participated in the pooling of that item in the first place. Airline B, however, has depended on that item being available as it borrowed it three times during that year. With charges of $1107 though, there is a strong case for the airline to leave the pool and provide its own item.

INTERNATIONAL AIRLINES TECHNICAL POOL

ANNEX M3 B-747 GROUP--1978/1979 SEASON

Participants are noted by the standard 2-letter airline code

Yaw Damper Computer
Pool Item M075, PA No. 72221

Station	Qty	Period	Provider	Participants
HNL	1		PA	CI-JL-KE-PA
LHR	1		PA	PA-TW-KU

Auto Throttle Computer
Pool Item M076, PA No. 72220
Not Pooled

Auto Throttle Servo
Pool Item M077, PA No. 72207
Not Pooled

Pitch Computer
Pool Item M078, PA No. 72201

Station	Qty	Period	Provider	Participants
BRU	1		SN	PA-SN
HNL	1		UA	CI-JL-KE-NW-PA-QF-UA
JFK	1	1	PA	AF-AZ-EI-FT-IB-LH-LY-NW-PA-SN-TP
JFK	1	2	PA	AF-AZ-EI-FT-IB-LY-NW-PA-SN-TP
LHR	1		PA	JL-PA-SQ.2-KU
NRT	1		JL	AF-JL-NW-PA
SEA	1		NW	FT-NW-PA

Roll Computer
Pool Item M079, PA No. 72202

Station	Qty	Period	Provider	Participants
BRU	1		SN	PA-SN
HNL	1		UA	CI-JL-KE-NW-PA-QF-UA
JFK	1		PA	AF-AT-AZ-EI-IB-LH-LY-NW-PA-RJ-SA-SN-TP
LHR	1		BA	AC-BA-1A.2-JL-PA-QF-RJ-SA
NRT	1		JL	AF-FT-JL-NW-PA-QF
SEA	1		NW	NW-PA

Mode Select Panel
Pool Item M081, PA No. 72203

Station	Qty	Period	Provider	Participants
BRU	1		SN	PA-SN
HKG	1		PA	CI-PA-SQ.2
HNL	1		UA	BN-CI-KE-PA-UA
JFK	1		PA	AF-AI-AT-AZ-IB-PA-SA-SK-SN-SR
SEA	1		NW	NW-PA
SYD	1		QF	AZ-PA-QF

Monitor and Logic Unit
Pool Item M082, PA No. 72204

Station	Qty	Period	Provider	Participants
BRU	1		SN	PA-SN
FCO	1		AZ	AI-AZ-PA-QF-TW
FRA	1	1	LH	AC-AI-AV.2-LH-OA-PA-QF
HNL	1		UA	BN-CI-KE-NW-PA-QF-UA
JFK	1		PA	AF-AI-AZ-EI-IB-LY-NW-PA-SN-SR
NRT	1		JL	AF-CP-FT-JL-PA-QF
SEA	1		NW	NW-PA

Accelerometer
Pool Item M083, PA No. 57381

Station	Qty	Period	Provider	Participants
JFK	1		PA	AZ-IB-PA-SR

Stabilizer Trim Interface Unit
Pool Item M087, PA No. 72215

Station	Qty	Period	Provider	Participants
FRA	1	1	LH	AV.2-IA.2-LH-OA-PA
JFK	1		PA	EI-FT-LY-PA-SR
LHR	1		PA	IA.2-LY-PA-TW
HNL	1		PA	PA-BN

Accessory Box No. 2
Pool Item M088, PA No. 72216

Station	Qty	Period	Provider	Participants
JFK	1		PA	PA-SN

Accessory Box No. 1
Pool Item M089A, PA No. 72223

Station	Qty	Period	Provider	Participants
JFK	1		PA	AF-EI-FT-PA-SR-TP

Auto Stabilizer Trim Unit
Pool Item M090, PA No. 72224

Station	Qty	Period	Provider	Participants
BRU	1		SN	PA-SA-SN
DEL	1		AI	AI-IA.2-KL-PA
FCO	1		AZ	AI-AR-AZ-PA-QF-SA-TW
FRA	1		LH	AI-AV.2-IA.2-IR-LH-OA-PA-PK-QF-SA
HKG	1		NW	BA-CI-CP-KL-NW-PA-QF-SA-SQ.2
HNL	1		UA	CI-CP-JL-NW-PA-QF-UA
JFK	1		PA	AF-AI-AT-AZ-BA-EI-IB-IR-KL-LH-LY-NW-PA-RJ-SA-SK-SN-SR
LHR	1		BA	AC-AI-BA-IA.2-IR-LY-PA-QF-RJ-SA-SQ.2-TW
NRT	1		JL	AF-BA-CP-JL-KL-PA-QF
THR	1		IR	BA-IR-PA-PK

Flight Mode Annunciator
Pool Item M091, PA No. 73422

Station	Qty	Period	Provider	Participants
FRA	1	1	LH	LH-OA-PA-PK
FRA	1	2	PA	PA-PK
LHR	1		PA	PA-PK-SQ.2-KU

Central Air Data Computer
Pool Item M576, PA No. 73460

Station	Qty	Period	Provider	Participants
BRU	1		SN	PA-SN
DEL	1		AI	AI-BA-JL-KL-PA
FCO	1		AZ	AI-AR-AZ-JL-PA-QF-SA-SQ.2-TW
FRA	2		LH	AR-AI-AR-BA-IR-JL-KL-LH-OA-PA-PK-QF-SA-SQ.2
HKG	1		NW	AF-BA-CI-CP-FT-JL-KL-NW-PA-QF-SA-SQ.2
HNL	1		PA	BN-CI-JL-KE-NW-PA-QF-UA
HNL	1		UA	BN-CI-CP-JL-KE-NW-PA-QF-UA

JFK	1		PA	AF-AI-AT-BA-EI-FT-IB-IR-JL-KL-LH-LY-NW-PA-SA-SK-SN-SR-TP
LHR	1		BA	AC-AI-BA-IR-JL-PA-QF-SA-SQ.2-TW-AR
LHR	1		PA	AC-AI-BA-JL-LY-PA-QF-SA-SQ.2
NRT	2		JL	AF-BA-CP-FT-JL-KL-NW-PA-QF
SEA	1		NW	NW-PA
SYD	1		BA	AI-AZ-BA-KL-LH-PA-QF-SA-SQ.2
THR	1		IR	BA-IR-JL-PA-PK

Compass Coupler
Pool Item M561, PA No. 73462

Station	Qty	Period	Provider	Participants
BRU	1		SN	PA-SN
GIG	1		PA	AR-AT-PA
GUM	1		PA	JL-PA
HNL	1		PA	BN-CI-JL-KE-NW-PA-QF-UA
HNL	1		UA	BN-CI-JL-KE-NW-PA-QF-UA
JFK	1		PA	AF-AI-AT-AZ-IB-JL-KL-LH-LY-NW-PA-RJ-SA-SN-SR
SEA	1		NW	NW-PA

Attitude Director Indicator
Pool Item M578B, PA No. 73407

Station	Qty	Period	Provider	Participants
GUM	1		PA	JL-PA
HNL	1		PA	CI-JL-PA
JFK	1		PA	JL-PA
LAX	1		PA	CI-JL-PA

Navigation Receiver
Pool Item G308, PA No. 73458

Station	Qty	Period	Provider	Participants
BAH	1		QF	IA.2-MS-PA-QF-RJ-SQ.2
BOM	1		SR	AZ-ET-IA.2-MS-PA-QF-SR
BRU	1		IB	AZ-IA.2-IB-JU-OA-PA-SA-SR-TP
EZE	1		AR	AR-IB-PA-SK
IST	1		SR	AZ-IA.2-JU-PA-SN-SR-SV
KHI	1		PK	IA.2-MS-PA-PK-TG
MEL	1		QF	AZ-PA-QF
MEX	1		SN	AR-IB-PA-SN
MNL	1		SK	MS-PA-QF-SK-TG

NRT	1		JL	AZ-CP-FT-JL-MS-PA-QF-RG-SK-SQ.2
SIN	1		QF	AZ-FT-JL-JU-PA-QF
SYD	1		QF	AZ-CP-JL-JU-PA-QF-SQ.2
FCO	1		AZ	AZ-PA
IAH	1		EA	EA-FT-PA
MIA	1		EA	BW-EA-PA
ORD	1		EA	EA-PA

Low Range Radio Altimeter
Pool Item G-451, PA No. 73432

Station	Qty	Period	Provider	Participants
LHR	1		PA	KM-KU-MS-PA

Inertial Navigation Unit
Pool Item G-783, PA No. 73402

Station	Qty	Period	Provider	Participants
HNL	1		PA	CP-PA-QF-SQ.2
LAX	1		PA	CI-JL-PA

Outboard Spoiler Power Control Unit
Pool Item M208, PA No. 72710

Station	Qty	Period	Provider	Participants
JFK	1		PA	AZ-FT-PA-TP

Central Lateral Control Actuator
Pool Item M210, PA No. 70717
Not Pooled

Flight Control Shut-off Valve
Pool Item M213, PA No. 72799

Station	Qty	Period	Provider	Participants
HNL	1		UA	BN-CI-PA-UA
JFK	1		PA	AI-IB-IR-PA-SA-TP
LAX	1		AA	AA-CI-PA-TP

Stabilizer Trim Control Module
Pool Item M215, PA No. 72723

Station	Qty	Period	Provider	Participants
FRA	1		LH	IA.2-LH-PA-PK

LHR	1		BA	BA-IA.2-PA-SQ.2
NRT	1		JL	JL-PA
SYD	1		QF	PA-QF

Elevator Feel Computer
Pool Item M216, PA No. 70772

Station	Qty	Period	Provider	Participants
JFK	1		PA	AZ-FT-PA-SR-TP

Rudder Ratio Changer Comparator
Pool Item M220, PA No. 70724

Station	Qty	Period	Provider	Participants
BRU	1		SN	PA-SN
FRA	1		LH	AC-AR-AV.2-IA.2-IR-LH-LY-PA-PK-QF-SA
HKG	1		NW	BA-CI-FT-NW-PA-QF-SA
HNL	1		UA	BN-CI-KE-PA-QF-UA
JFK	1		PA	AZ-BA-EI-IB-IR-LY-NW-PA-SA-SN-SR-TP
LHR	1		PA	AC-IA.2-IR-LY-PA-QF-SA
NRT	1		JL	BA-CI-FT-JL-NW-PA-QF
SEA	1		NW	FT-NW-PA
SPL	1		KL	KL-PA
SYD	1		QF	BA-PA-QF-SA
THR	1		IR	BA-IR-PA-PK

Control Surface Position Transmitter
Pool Item M255, PA No. 72728

Station	Qty	Period	Provider	Participants
JFK	1		PA	AF-AI-AZ-IB-IR-PA-SA-SK-SN-SR
LHR	1		BA	AI-BA-IA.2-IR-PA-SA-SQ.2

Control Surface Position Indicator
Pool Item M258, PA No. 72775

Station	Qty	Period	Provider	Participants
FRA	1		LH	AV.2-IA.2-LH-PA-PK
HNL	1		UA	BN-CI-PA-QF-UA
JFK	1		PA	AF-AZ-IB-KL-PA-SK-SR
SYD	1		QF	AZ-PA-QF

Stabilizer Trim Hydraulic Brake
Pool Item M260, PA No. 72785

Station	Qty	Period	Provider	Participants
JFK	1		PA	AZ-PA

Rudder Ratio Control Unit
Pool Item M264A, PA No. 70756

Station	Qty	Period	Provider	Participants
BRU	1		SN	PA-SN
DEL	1		AI	AI-IA.2-KL-PA
FCO	1		AZ	AI-AR-AZ-JL-PA-QF
FRA	1		LH	AI-AR-AV.2-IA.2-IR-LH-LY-PA-PK-QF
HKG	1		BA	BA-JL-NW-PA-QF-SA
HNL	1		UA	CI-JL-NW-PA-QF-UA
JFK	1		PA	AF-AI-AZ-BA-IB-IR-JL-KL-LH-LY-NW-PA-SA-SK-SN
LHR	1		BA	AI-BA-IA.2-IR-JL-LY-PA-QF-SA-SQ.2
MIA	1		BA	AV.2-BA-PA
NRT	1		JL	AF-BA-CI-FT-JL-KL-NW-PA-QF
SEA	1		NW	FT-NW-PA
SPL	1		KL	JL-KL-LY-PA-QF
SYD	1		QF	AI-BA-KL-PA-QF-SA
THR	1		BA	BA-JL-PA-PK
MVD	1		AF	AF-PA

Aileron Trim Actuator
Pool Item M268, PA No. 72786

Station	Qty	Period	Provider	Participants
JFK	1		PA	AZ-FT-IB-PA-SR

Outboard Aileron Lockout Actuator
Pool Item M270, PA No. 72788

Station	Qty	Period	Provider	Participants
JFK	1		PA	AZ-PA-AI

Rudder Ratio Changer Actuator
Pool Item M272A, PA No. 70755

Station	Qty	Period	Provider	Participants
BAH	1		BA	BA-QF-SQ.2-PA
BKK	1		KL	BA-JL-KL-PA-QF-SQ.2
BOM	1		AI	AI-LH-QF-SQ.2-PA

BRU	1		SN	PA-SN
DEL	1		AI	AF-AI-KL-PA
FCO	1		AZ	AI-AR-AZ-CP-JL-PA-QF-SQ.2-TW
FRA	1		LH	AC-AI-AR-AV.2-IR-LH-LY-PA-PK-QF-SQ.2
GIG	1		PA	AR-PA
HKG	1		BA	BA-JL-PA-QF-SA-SQ.2
IAH	1		KL	AF-KL-PA
JFK	1		PA	AF-AI-AZ-BA-IB-IR-JL-LH-LY-PA-SA-SN-SR
LHR	1		BA	AC-AI-BA-BN-JL-LY-PA-QF-SA-SQ.2-TW
MEX	1		KL	IB-JL-KL-PA
MIA	1		BA	AV.2-BA-PA
NRT	1		JL	AF-BA-CP-FT-JL-KL-NW-PA-QF
SEA	1		NW	FT-NW-PA
SIN	1		QF	AI-BA-KL-LH-PA-QF
SPL	1		KL	CP-JL-KL-LH-LY-PA-QF-SQ.2
SYD	1		QF	AI-BA-KL-LH-PA-QF-SA
THR	1		IR	BA-IR-PA-PK
MVD	1		AF	AF-PA

Over Rotation Warning Computer
Pool Item M465, PA No. 72789

Station	Qty	Period	Provider	Participants
HNL	1		UA	CI-PA-UA
JFK	1		PA	LY-PA-SR
LHR	1		BA	BA-IA.2-PA-QF

Stall Warning Computer
Pool Item M568, PA No. 72795

Station	Qty	Period	Provider	Participants
JFK	1		PA	EI-LY-PA

TABLE E4 B-747 POOLING CHARGES FOR PANAM
SUMMER SEASON 1978

	Pooling Charges Income	Expense
PRIMARY CONTROLS		
Aileron Trim Actuator	98	---
Aileron L/O Actuator	93	---
F/C Shut Off Valve	75	46
O/B Spoiler PCU	441	---
Surface Position Indicator	177	128
Surface Position Transmitter	207	3
Ratio Control Unit	282	741
Ratio Servo	455	1,113
Ratio Comparator	---	164
Elevator Feel Computer	1,114	---
Stall Warning Comp.	155	---
O/Rotation Computer	356	285
Subtotal	$ 3,453	$ 2,480
FLIGHT ELECTRONICS		
Pitch Computer	2,515	1,731
Roll Computer	1,467	2,593
Yaw Computer	1,018	---
MLU	1,153	1,913
ASTU	620	847
Accelerometer	94	---
STIU	667	---
Accessory Box 1	634	---
Accessory Box 2	419	---
A/P Controller	739	593
Annunciator	191	---
ADI	1,760	---
VOR/NAV Receiver	---	843
LRRA	428	---
INU	15,650	---
CADC	6,057	4,634
Compass Coupler	1,645	733
Subtotal	$35,057	$13,887
TOTAL POOLING CHARGES	$38,510	$16,367

TABLE E5--LINE MAINTENANCE MANHOURS AND 1978 ACTIONS FOR PRIMARY MECHANICAL CONTROLS

Item	Part No.	(Line) Aircraft Activity Manhours Remove-Replace Time Per Unit	12 Month Maint. Actions
Trim and Centering Mechanism	72749	16	0
Trim Actuator	72786	1	2
Central Control Actuator	72708/70717	16	5
Aileron Programmer	72751	6	0
Aileron Programmer	72752	6	0
Spoiler Differential (Mixer)	72753	6	0
I/B Aileron Power Control Unit	72706	20	1
O/B Aileron Power Control Unit	72707	16	1
O/B Aileron Lockout Actuator	72788	2	4
O/B Aileron Lockout Mechanism	70718/72792	8	0
O/B Aileron Lockout Mechanism	72748/72791	8	0
O/B Aileron Lockout Gearbox	72737	8	0
Flight Control S/O Valve Module	72714/72799	2	8
I/B Spoiler Power Control Unit	72709/70765	6	1
O/B Spoiler Power Control Unit	72710	4	7
Control Surface Position Ind.	72775	1	51
Control Surface Position Xmtr.	72728	2	2
Feel Trim and Centering Mechnsm	72749	16	0
Aft Quadrant	65B82246-1	24	0
Ratio Control Unit	72730/70756	2	24
Ratio Changer Actuator (Servo)	72778/70723/ 70755	8	19
Ratio Changer Comparator	70724/70731	2	17
Power Control Unit	72705	21	1
Trim Actuator	72777	16	1
Control Column Wheel	70704	6	0
Control Column Wheel	70705	6	0
Rear Quadrant	65B80482-1	48	0
Feel Unit	72773	3	0
Feel Actuator	72774	2	0
Feel Computer	72711/70772	3	5
Inbd. Power Control Unit	72703	36	7
Outbd. Power Control Unit	72704	16	1
Stall Warning Computer	72795	1	4
Over Rotation Computer	72789	1	6
Hydraulic Motor	72716/70754	2	0
Gear Drive/Jackscrew	72731	50	0
Hydraulic Brake	72785	2	0
Shut-off Valve	72779	1	1
Control Module	72723	3	0
Control Lever Brake	72715	16	0
Sequence Mechanism	72754/70771	6	0
Ground Spoiler Control Valve	72722/70768	4	0
Ground Spoiler Actuator	72713/70770	4	1

TABLE E6--LINE MAINTENANCE MANHOURS AND 1978 ACTIONS FOR FLIGHT ELECTRONICS

Item	Part No.	(Line) Aircraft Activity Manhours Remove-Replace Time Per Unit	12 Month Maint. Actions
Pitch Computer	72201	1	368
Roll Computer	72202	1	336
Yaw Damp Computer	72221	1	78
Monitor & Logic Unit	72204	1	67
Auto Stabilizer Trim Unit	72224	1.5	118
Auto Throttle Computer	72220	1	25
Normal Accelerometer	57381	2	1
Accessory Stabilizer Trim Box	72215	1.5	24
Accessory #1 Box	72217/72223	1	9
Accessory #2 Box	72216	1	5
Mode Select Panel	72222	2	111
A/P Flight Control	72203	1	17
Flight Mode Annunciator Light Set	73422	1	20
Attitude Director Indicator	73407	1	74
Navigation Receiver	73458	1	303
Low Range Radio Alt. Xcvr	73432	1	241
Inertial Navigation Unit	73402	1	756
Central Air Data Computer	73460	1	448
Central Air Data Computer	73404	1	5
MHR Compass Coupler	73412/73462	1	92
Auto Throttle Servo	72207	6	0
SP COMPONENTS			
Flight Mode Annunciator Light Set	42206	1	2
Yaw Damp Computer	42207	1	7
Accessory Stabilizer Trim Box	42208	1.5	2
Accessory #3 Box	42210	1	0
Central Air Data Computer	42211	1	1
Pitch Computer	42212	1	15
Monitor & Logic Unit	42213	1	6
Mode Select Panel	42214	2	14
Auto Throttle Computer	42217	1	3

TABLE E7 DELAYS BY STATION FOR PRIMARY MECHANICAL CONTROLS

Region	Station	Number of Delays				Avg. Delay Time
		-100	SP	F	Total	Per Delay (Hrs)
USA GATEWAY	JFK	6	0	5	11	4.25
	SFO	1	0	3	4	1.01
	LAX	6	2	0	8	1.43
	HNL	3	-	1	4	3.28
	SEA	1	-	-	1	0.63
	ORD	-	-	2	2	1.48
	IAH	0	-	0	0	
	MIA	1	-	1	2	1.61
	DTW	0	-	2	2	4.32
	IAD	1	-	0	1	1.58
S. AMERICA	GUA	1	-	0	1	0.30
	SJO	0	-	-	0	
	PTY	1	-	-	1	0.78
	CCS	0	-	1	1	2.52
	GIG	0	-	0	0	
	EZE	0	0	-	0	
	POS	-	-	0	0	
	VCP	-	-	0	0	
	MVD	-	0	-	0	
S. PACIFIC	PPG	0	-	0	0	
	PPT	0	-	-	0	
	NAN	1	-	1	2	0.42
	AKL	0	3	0	3	2.19
	SYD	3	0	0	3	6.08
	MEL	1	-	-	1	0.15
ORIENT	NRT	1	0	1	2	3.60
	OSA	0	-	-	0	
	GUM	2	-	0	2	4.80
	MNL	1	-	-	1	15.00
	HKG	1	0	0	1	6.52
	KUL	0	-	0	0	
	SIN	0	1	0	1	0.33
EUROPE/WORLD	MEX	0	-	-	0	
	LHR	8	-	0	8	3.71
	PIK	-	-	-	0	
	FRA	3	-	0	3	3.20
	BRU	1	-	0	1	1.83
	FCO	1	-	-	0	1.17
	IST	0	-	-	0	
	BAH	-	0	-	0	
	THR	2	-	0	2	2.49
	KHI	0	-	-	0	
	DEL	0	-	0	0	
	BOM	0	0	-	0	
	BKK	0	0	-	0	

TABLE E8 DELAYS BY STATION FOR FLIGHT ELECTRONICS

Region	Station	Number of Delays -100	SP	F	Total	Avg Delay Time Per Delay (Hrs)
USA GATEWAY	JFK	12	0	1	13	1.02
	SFO	2	1	0	3	0.19
	LAX	2	2	0	4	0.78
	HNL	6	-	1	7	1.07
	SEA	0	-	-	0	
	ORD	-	-	0	0	
	IAH	0	-	0	0	
	MIA	2	-	2	4	1.81
	DTW	0	-	0	0	
	IAD	3	-	0	3	0.66
S. AMERICA	GUA	1	-	0	1	0.16
	SJO	0	-	-	0	
	PTY	0	-	-	0	
	CCS	1	-	0	1	0.42
	GIG	4	-	0	4	0.68
	EZE	0	0	-	0	
	POS	-	-	0	0	
	VCP	-	-	0	0	
	MVD	-	0	-	0	
S. PACIFIC	PPG	0	-	0	0	
	PPT	1	-	-	1	0.33
	NAN	0	-	0	0	
	AKL	0	1	0	1	1.68
	SYD	1	2	0	3	0.35
	MEL	0	-	-	0	
ORIENT	NRT	2	0	0	2	0.62
	OSA	2	-	-	2	0.76
	GUM	1	-	0	1	0.30
	MNL	0	-	-	0	
	HKG	0	1	0	1	1.00
	KUL	0	-	0	0	
	SIN	0	0	1	1	0.51
EUROPE/WORLD	MEX	0	-	-	0	
	LHR	4	1	2	7	0.93
	PIK	-	-	-	0	
	FRA	7	-	1	8	0.36
	BRU	0	-	0	0	
	FCO	0	-	-	0	
	IST	1	-	-	1	1.58
	BAH	-	1	-	1	0.42
	THR	1	-	0	1	1.25
	KHI	0	-	-	0	
	DEL	0	-	1	1	8.32
	BOM	0	0	-	0	
	BKK	1	0	-	1	0.08

TABLE E9 DELAY AND CANCELLATION RATE SUMMARY

	747 Series	Cancellations Per 100 Dep.	Delays Per 100 Dep.	Average Delay Time (Hr)	Average Flight Length (Hr)
PRIMARY MECHANICAL CONTROLS	-100	.0036	.17	3.2	4.2
	SP	0	.30	2.8	3.6
	F	0	.10	1.6	9.5
	Combined	.0026	.18	3.0	5.1
FLIGHT ELECTRONICS	-100	.0071	.20	0.9	4.2
	SP	0	.18	1.4	3.6
	F	0	.20	0.8	9.5
	Combined	.0052	.20	0.9	5.1

FLIGHT CONTROL DELAY AND CANCELLATION DETAILS

FOR PAN AM 747 FLEET DURING 1978

PRIMARY MECHANICAL CONTROLS (PART OF ATA 27)

FLIGHT ELECTRONICS (ATA 22 AND PART OF ATA 34)

DETAILS SORTED BY ATA SYSTEM (ASN)

APPLICABLE CODES USED:

REG = AIRPLANE REGISTRATION NUMBER

MS = AIRPLANE MODEL AND SERIES

- EC = 747-100 PASSENGER
- EP = 747SP PASSENGER
- ED = 747-100F FREIGHTER
- EK = 747-200C FREIGHTER

EOF = EFFECT ON FLIGHT

- IF = DELAY
- IE = CANCELLATION
- IG = GROUND TURNBACK
- IS = AIRPLANE SUBSTITUTION

FN = FLIGHT NUMBER

07/22/80

FLIGHT DELAYS FOR PANAM B-747 FLEET DURING 1978
FLIGHT CONTROL DELAY AND CANCELLATION EVENTS

ASN	NOMENCLATURE		A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
22-00-136-181	CONNR, APILT ACC/U	PAA-243	PA	N750PA	EC	THR	780831	01	IF	111	1.25
	AT DEPT CREW REPORTED BOTH A/P WARNING LIGHTS ON STEADY, NO WARNING HORN OR FLASHING LIGHTS. INTERMITTENT "A" AUTO STAB TRIM LIGHT AND G/S ANNUC LITE. TRIED A/P PWR NO HELP. SEATED A/P MONITOR AND LOGIC UNIT NO HELP, SEATED A/P ACC BOXES AND ALL INDICATIONS CLEARED EXCEPT B A/P ENGAGE SW LOCKED IN OFF POSITION WHICH WAS AN INB ITEM. TO C.I.										
22-12-368-011	PANEL, APILT CONT	PAA-068	PA	N536PA	EP	JFK	780309	01	IF	815	1.72
	CO-PILOT'S HORIZON PITCH DISPLAY INOP, P10 PNL NIS C/N 42214. DELAY DUE NECY TO ROB FIRST AVAIL INBD SP ACFT.										
22-12-368-171	PANEL, APILT CONT ....(GENRL)	PAA-363	PA	N744PA	EC	FRA	781229	01	IF		.57
	ALT HOLD AND ALT SELECT WOULD NOT ENGAGE ON EITHER AUTO-PILOT ....ROBBED N749 AND INSTALLED BAD PANEL IN N749 RETURNING TO NYC.										
22-12-567-011	TRIM UNIT, AUTO STBLR	PAA-273	PA	N749PA	EC	HNL	780930	02	IF		1.55
	AUTO STAB TRIM B LITE ILLUMINATED. STABILIZER WAS NOT IN TRIM. ELEVATOR POSITION INDICATOR WENT FULL TRIM NOSE UP. AFTER MANUALLY RESETTING TO TRIM CONDITION, AUTO STAB B OPERATIONAL AGAIN. CAPTS ELECT CONTROL OF STAB IS EXTREMELY SLOW. MANUAL CONTROL OK...REPLACED STAB TRIM ACCY BOX C/N 72215 AND ASTU C/N 72224, BITE TEST OK.										
22-13-130-051	COMPUTER, APILT ROLL	PAA-089	PA	N658PA	ED	JFK	780330	01	IF	875	1.07
	DURING CKOUT, AFTER LEFT CCA REPLACEMENT, A AND B A/P GIVE HARDOVER AILERON, RPLD A ROLL COMPUTER. RELEASED WITH B A/P INOP.										
22-14-576-241	VALVE, RUDDR PCU ELHYD ELCNT SERVO	PAA-347	PA	N538PA	EP	AKL	781213	01	IF		5.95
	ON ARRIVAL, ADDED 2 1/4 GALS HYDRAULIC FLUID TO NBR 2 SYSTEM. FOUND RUNNING LEAK FROM LOWER RUDDER POWER										

FLIGHT DELAYS FOR PANAM B-747 FLEET DURING 1978
FLIGHT CONTROL DELAY AND CANCELLATION EVENTS

ASN	NOMENCLATURE		A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
22-14-576-241	VALVE,RUDDR PCU ELHYD ELCNT SERVO	PAA-347	PA	N538PA	EP	AKL	781213	01	IF		5.95
	PACK, ELECTRO-HYD SERVO VALVE. REPLACED VALVE ASSY AND LEAK CHECK OK.										
27-02-576-811	VALVE, AIL/SPLR/CLCP HYD S/O ...	PAA-215	PA	N771PA	ED	LHR	780803	01	IF	703	4.15
	AFTER PUSHBACK, FLT CREW REPORTED LOSS HYD QTY NBR 3 SYSTEM, ON PULL BACK TO BLOCKS, NOTICED HYD FLUID COMING FROM RH WING GEAR WHEEL WELL, FOUND LEAK AT INB MODULE FLT CONTROL S/O C/N 72799. NO FURTHER LEAKS - REPLACED.										
27-02-576-811	VALVE, AIL/SPLR/CLCP HYD S/O ...	PAA-321	PA	N755PA	EC	LHR	781116	01	IFIC		1.40
	NBR 1 HYD LATERAL CONTROL VALVE C/B ON P-12 POPS, UNABLE TO RESET. DEACTIVATED VALVE PER 27-13-01 AND ENTERED C.I.										
27-02-576-821	VALVE, RUDDR/ELEV HYD S/O	PAA-127	PA	N535PA	EK	HNL	780507	01	IF	871	3.78
	MRS 29.40C; SLOW LEAK NR 1 HYD SYS. ISOLATED LK WITH ADP AND EDP OFF. QTY STAB AT 3.0 GALS. IN CRUZ. ADDED 12 GALS OF FLUID, FND LK IN THE TIAL FROM THE RUDDER/ELEV SHUTOFF VLV, BOLTS HOLDING THE MOTOR TO VLV BODY WERE BRKN AND A SEAL WAS EXTRUDING FROM A PARTING SURFACE. RPLD THE VLV CN72799 WITH UAL POOL PART. DU SN 22430 RTND FOR ENGRG EVAL ON S/O B1319382.										
27-02-576-821	VALVE, RUDDR/ELEV HYD S/O	PAA-179	PA	N770PA	EC	LHR	780628	01	IF	125	2.15
	ON W/A FOUND HYDRAULIC LEAK FROM TAIL COMPARTMENT, TRACED TO NBR 1 HYD SYSTEM RUDDER S/O VASLVE WHICH WAS LEAKING FROM CASE - REPLACED ON 72799, ADDED 4 GALS HYD.										
27-02-675-131	CON/U, CNTRL LTRL HYD (CLCP/CCA)	PAA-100	PA	N655PA	EC	MEL	780411	01	IF	812	.15
	AILERONS STIFF BOTH DIRECTIONS, MORE PERNOUNCED IN R/T TURNS. CKD CCA FILTERS DUE MUCH BETTER WITH NR 2 HYD SYS OFF. FILTER CLEAN. FLT CREW CONCURS CONTINUE TO SYD.										
27-02-675-131	CON/U, CNTRL LTRL HYD (CLCP/CCA)	PAA-101	PA	N655PA	EC	SYD	780411	01	IF	812	14.90
	REPEAT: AILERONS STIFF BOTH DIRECTIONS. INSPECTED CCA AILERON PROGRAMMER RIGGING, CABLE RUNS,										

FLIGHT DELAYS FOR PANAM B-747 FLEET DURING 1978
FLIGHT CONTROL DELAY AND CANCELLATION EVENTS

ASN	NOMENCLATURE		A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
27-02-675-131	CON/U, CNTRL LTRL HYD (CLCP/CCA)	PAA-101	PA	N655PA	EC	SYD	780411	01	IF	812	14.90
	BACK DRIVE ROD, INOPUT/OUTPUT LIMITER RODS, ALL APPEAR OK. AFTER EXTENSIVE T/S. RPLD LH CCA DUE EXCESSIVE FORCES REQ TO MOVE AILERONS IN ALL REGIMES OF FLT YET OK ON GRND. PERFORMED RIGGING CK, ALL OK. AFTER T/O, CREW REPORTS CONTROLS FUNCTIONING NORMALLY.										
27-02-675-131	CON/U, CNTRL LTRL HYD (CLCP/CCA)	PAA-337	PA	N653PA	EC	LAX	781203	01	IFIS		5.67
	HYD LEAK FROM LEFT WING GEAR WELL. TRACED TO CCA UNIT. UNABLE TO PINPOINT. TRIED REPLACING SEALS ON IN AND OUT PORTS, NO HELP. SUSPECT PORUS BODY. SWITCHED A/C TO FIRST INBD A/C.										
27-11-000-001	FLGHT CONT AIL AND TAB CONT-GENRL	PAA-100	PA	N658PA	ED	MIA	780410	01	IF	317	1.82
	INCOMING FLT CREW VERBALLY REPORTED TO OUT GOING CREW, AILERON STIFFNESS IN A/C. DEPARTING CREW REFUSED A/C. CKD CABLE IN FUSELAGE AND PROTECTIVE BAR, OK CKD CABLE IN WHEEL WELLS, OK. TORQUE CKD AIL WHEEL BREAKAWAY 66 IN/LBS, RIGHT, 60 IN/LBS, LEFT. CKD LOST MOTION DEVICE AND FND SLIGHT CONTACT TO RIGHT. ITEM CONTINUED FOR RIGGING AT NYC.										
27-11-000-001	FLGHT CONT AIL AND TAB CONT-GENRL	PAA-166	PA	N537PA	EP	SIN	780615	01	IF	006	.33
	BTB NO AILERON TRIM CONTROL REL'D WITH AIL TRIM INDR PER MEL.										
27-11-000-001	FLGHT CONT AIL AND TAB CONT-GENRL	PAA-218	PA	N901PA	ED	NAN	780806	01	IF	106	.17
	C.I. F/O CONTROL COLUMNE HAS APPROX 15 DEG PLAY IN ROLL MODE. INSP'D BUSS CABLE BETWEEN COLUMNS AND OK. A/C REL'D AFTER DISCUSSION WITH NYC.										
27-11-000-001	FLGHT CONT AIL AND TAB CONT-GENRL	PAA-315	PA	N733PA	EC	ROM	781111	01	IF		1.17
	NO MRS, WITH AND W/O A/P, EXPERIENCED ERRATIC AILERON CONTROL INPUTS OR SPOILER INPUTS. VERBAL REPORT STATES ALL OK IN INS MODE, PROB APPEARED WHEN SWITCHED FROM INS TO RADIO MODE. PERFORMED FLT CONTROL CHECK, OK. CHKED CABLE RUNS, OK. CHECKED AILS FOR PLAY, OK. CREW REPORTS AFTER T/O, APPEARS NORMAL.										

FLIGHT DELAYS FOR PANAM B-747 FLEET DURING 1978
FLIGHT CONTROL DELAY AND CANCELLATION EVENTS

ASN	NOMENCLATURE		A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
27-11-008-361	ACTUATOR, AIL LKOUT	PAA-236	PA	N654PA	ED	JFK	780824	01	IF	216	7.95
	ON DELIVERY TO CGO, LH OUTBD AILERON LOCK ACTUATOR AND NBR 1 HYD FLT CONTROL S/O VAL POPPING C/B. PARTS NIS, NECESSARY TO ROB N741 REPLACED LOCKOUT ACTUATOR C/N 72788 AND FLT CONTROL S/O VAL C/N 72799.										
27-11-136-021	CONNR, AIL AND TAB CONT .(GENRL)	PAA-228	PA	N749PA	EC	FAI	780816	01	IFIC	895	2.03
	BTB, "LH AILERON POSN INDICATOR INDICATED LESS THAN NORMAL TRAVEL, SHOWED ZERO MOVEMENT ON CONTROL SURFACE POSN INDICATOR"... GRND VISUAL CHK ON RETURN TO BLOCKS NO MOVEMENT. PULLED C/B ON LH OUTBD AILERON LOCKOUT ACTUATOR, CHKD VOLTAGE AND CLEANED C/P AND RESTORED OPS.										
27-11-136-641	CONNR, AIL TRIM CONT ACTR MOTOR	PAA-309	PA	N652PA	EC	HNL	781105	01	IFIC		3.30
	LEFT AILERON POSITION IND FAILED TO INDICATE MOVEMENT. CLEANED ACT C/P AND OPER OK.										
27-11-136-651	CONNECTOR, AIL LKOUT ACTR ELECT	PAA-327	PA	N754PA	EC	LHR	781123	01	IF		3.10
	CREW REPORTED NO MOVEMENT FROM LEFT OUTBD AILERON. AFTER T/S FOUND LOCK-OUT ACTUATOR INOP DUE C/P SOAKED WITH OIL. CLEANED AND OPERATIONAL CHECK NORMAL.										
27-11-312-091	LINE, AIL HYD ....(GENRL)	PAA-124	PA	N742PA	EC	LHR	780504	01	IF		4.17
	ON W/A, FND SKYDROL LKNG AREA LT WING AILERON INBD. REMOVED PWR PACKAGE ACCESS PNL. FND CHAFED LINE. EFFECTED INTERIM RPR.										
27-11-312-091	LINE, AIL HYD ....(GENRL)	PAA-150	PA	N739PA	EC	BRU	780530	01	IF	101	1.83
	ON W/A FND HYD LK LT WING. TRACED TO PRESS LINE FOR OTBD AIL. LOCATED BWTN WING GEAR AND NR 2 PYLON ADJACENT TO INBD SPOILER ACT. CUT OUT SECTION OF LINE WITH PIN HOLE IN IT, INST FITTING AND TEMP FLEX LINE.										

E45

FLIGHT CONTROL DELAY AND CANCELLATION EVENTS

ASN	NOMENCLATURE	A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
27-11-312-091	LINE, AIL HYD ....(GENRL) PAA-296	PA	N747PA	EC	LHR	781023	01	IF		.45
	INB OCI CHECK SOURCE OF HYD SEEP AT WING PNL AFT AND INB OF NBR 2 PYLON. OPENED PNL AND FOUND SLIGHT LEAK FROM LH INB AIL PWR UNIT RETURN LINE. RETORQUED B NUT AND LEAK CHECK OK.									
27-11-436-061	ROD, AIL AND TAB CONT ...(GENRL) PAA-153	PA	N654PA	ED	JFK	780602	01	IF	160	2.25
	A/C DEPARTED BLOCKS IN CGO, FLT CREW REPORTED AILERON CONTROL WHEEL BINDING IN LEFT TURN, ADJUSTED BACK DRIVE ROD AT RH CCA.									
27-11-602-021	WIRING, AIL AND TAB CONT (GENRL) PAA-183	PA	N654PA	ED	SFO	780702	01	IF	876	.37
	AILERON LOCKOUT C/B POPS WITH FLAPS UP, ACTUATOR CP REMOVAL NO HELP. FOUND CHAFED WIRING IN REAR SPAR AREA AFT OF NBR 1 PYLON.									
27-11-602-021	WIRING, AIL AND TAB CONT (GENRL) PAA-244	PA	N747PA	EC	JFK	780901	01	IF		3.73
	ON DELIVERY TO GATE AILERON LOCKOUT C/B POPS WHEN T/E FLAPS ARE EXT'D. REMOVED C/P FROM BOTH LEFT AND RIGHT AIL LOCKOUT ACT'S, C/B STILL POPS. ISOLATED PROBLEM TO RH WING. FOUND GROUNDED WIRE IN AREA OF NBR 3 SAILBOAT. SPLICED IN NEW WIRE FROM INB SAILBOAT AREA TO MIDWAY BETWEEN NBR 3 AND 4 ENG'S. SYSTEM NOW OK.									
27-11-602-021	WIRING, AIL AND TAB CONT (GENRL) PAA-361	PA	N732PA	EC	GUM	781227	01	IF		8.42
	OUTBD AILERON C/B ON P-12 POPS WITH T/E FLAPS IN UP POSITION. DISCONNECTED BOTH AILERON C/P'S FROM LOCKOUT ACTUATOR AND C/B STILL POPS. ISOLATED AT SPLICE SP7396, PROB IN RIGHT WING. UNABLE TO FIND BAD WIRE, SPLICED IN NEW WIRE FROM SPLICE TO ACTUATOR.									
27-21-000-001	FC RUDDR AND TAB CONT - GENRL .. PAA-012	PA	N534PA	EP	SFO	780112	01	IFIC	815	.58
	RUDDER TRIM STIFF. REMOVED PEDESTAL TRIM KNOB AND INSPECTED, UNABLE TO DUP BINDING. REINSTALLED KNOB. THEN HAD TBT DUE RUDDER 3 DEG OFF ZERO WITH KNOW ON ZERO. REINSTALLED KNOB CORRECTLY.									

FLIGHT CONTROL DELAY AND CANCELLATION EVENTS

ASN	NOMENCLATURE		A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
27-21-000-001	FC RUDDR AND TAB CONT - GENRL ..	PAA-012	PA	N534PA	EP	SFO	780112	01	IFIC	815	.58
27-21-000-001	FC RUDDR AND TAB CONT - GENRL ..	PAA-105	PA	N741PA	EC	IAD	780415	01	IFIC	066	1.58
	BTB. DURING TAXI OUT, RUDDER RATIO LITE CAME ON. FLT CONTROL CK SHOWED UPPER RUDDER TRAVEL 6 DEGS. CONFIRMING LACK OF RUDDER TRAVEL. AT BLOX LITE WAS OUT. DRAINED STATIC LINES. SWAPPED UPPER AND LOWER RATIO CONTROL UNITS. CKD SYS WITH GRD SENSING C/B PULLED AND RUDDER AND LITE OPS NRML BOTH RUDDERS. A/C RELEASED.										
27-21-000-001	FC RUDDR AND TAB CONT - GENRL ..	PAA-119	PA	N903PA	ED	ORD	780429	01	IF	166	2.28
	DURING ENG START, RUDDER RATIO LITE CAME ON. OBSERVED UPR RUDDER TO HAVE REDUCED TRAVEL. OPENED GRD SENSING C/B FOR FEW MINS, RESET AND RUDDERS OK.										
27-21-000-001	FC RUDDR AND TAB CONT - GENRL ..	PAA-170	PA	N903PA	ED	MIA	780619	01	IF	305	1.40
	NO MRS CALLED IN; RUDDER RATIO LIGHT BLINKS IN FLIGHT, RUDDER RATIO CHECK NOT ACCOMPLISHED. RATIO LITE CAME ON ON LANDING WHEN CPI SHOWED 4 DEGREES GROUND OPERATIONAL CHECK OK VISUAL CHECK OF PITOT STATIC DRAINS OK. FEO REQUESTED TO CHECK NEX LEG PER MRS.										
27-21-000-001	FC RUDDR AND TAB CONT - GENRL ..	PAA-190	PA	N903PA	ED	SFO	780709	02	IF	877	2.65
	DURING PREFLIGHT HAD STREAMLINING HYDRAULIC LEAK IN NOSE WHEEL WELL. REPLACED NLG GEAR OPERATED SEQUENCE VALVE CN 71276, DUE TO A PINHOLE IN THE CASTING. DI SN 122 RETURNED JFK B/B ON CER 7418. FURTHER DELAY DUE RETURNED TO BLOX WITH RUDDER RATIO LIGHT ON. CREW CYCLED RUDDER ON RETURN TAXI AND THE LIGHT WAS OUT AT THE BLOX. RUDDER RATIO CHECKS OK, UNABLE TO DUPLICATEPROBLEM. ADDITIONAL FUEL ADDED.										
27-21-000-001	FC RUDDR AND TAB CONT - GENRL ..	PAA-261	PA	N652PA	EC	PTY	780918	01	IF		.78
	BTB RUDDER RATIO LIGHT ON AT BLOX...RESET C/B ON P12 NO HELP. RESET C/B ON P6 AND OPER OK.										
27-21-008-341	ACTUATOR, RUDDR RATIO CHGR(SERVO)	PAA-012	PA	N743PA	EC	LAX	780112	01	IF	811	.23

ASN	NOMENCLATURE		A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
27-21-008-341	ACTUATOR, RUDDR RATIO CHGR(SERVO)	PAA-012	PA	N743PA	EC	LAX	780112	01	IF	811	.23
	RUDDER RATIO LITE ON STEADY IN FLT, CK NOT ACCOMPLISHED. ON PITOT CK FND LWR RUDDER STUCK IN HI SPEED MODE, RPLD ACT.										
27-21-008-341	ACTUATOR, RUDDR RATIO CHGR(SERVO)	PAA-009	PA	N743PA	EC	LAX	780109	02	IF	515	1.73
	RUDDER RATIO LITE CAME ON IN CLIMB. AT BLOX LWR RUDDER IN HI SPEED MODE AND LITE ON. CKD SYS WITH TEST UNIT AND BOTH NRML AND SMOOTH. SYS OPS AND LEAK CK OK. RPLD CONTROL UNIT WITH NON POOL LOAN. R/R ACT.										
27-21-008-341	ACTUATOR, RUDDR RATIO CHGR(SERVO)	PAA-110	PA	N741PA	EC	HKG	780420	01	IF	002	6.52
	RUDDER RATIO PROB. RPLD UPR RATIO ACT.										
27-21-008-341	ACTUATOR, RUDDR RATIO CHGR(SERVO)	PAA-161	PA	N755PA	EC	JFK	780810	01	IF	001	1.33
	EXCESSIVE RUDDER FORCE REQUIRED - FOUND UPPER RUDDER RATIO ACTUAGOR AT FAULT REPLACED ACTUATOR AND OPS OK. DELAY EXTENDED DUE FROZEN SCREWS ON ACCESS PLATE.										
27-21-008-341	ACTUATOR, RUDDR RATIO CHGR(SERVO)	PAA-143	PA	N653PA	EC	JFK	780523	01	IF	125	1.47
	RUDDER RATIO LITE ON, NO OTHER INDS. C.I. FOR LWR RUDDER POPS. FND LWR RUDDER STUCK IN MID POSN, SWAPPED CONTROLLER NO HELP. RPLD LWR RUDDER RATIO ACT. OPS CK OK.										
27-21-008-341	ACTUATOR, RUDDR RATIO CHGR(SERVO)	PAA-147	PA	N901PA	ED	JFK	780527	01	IF	877	1.65
	INBD ITEM, RUDDER RATIO LITE ON STEADY IN FLT; RUDDER TIRM CK 7 UNITS LT, UPR RUDDER IND 5 UNITS LT AND LWR RUDDER READ 3 UNITS LT, IAS 260 KTS. RPLD UPR RUDDER RATIO ACT, OPERATIONAL CK NG. REMOVED AND RPLD A SECOND ACT AND OPERATION OK.										
27-21-098-021	CHANGER, RUDDR RATIO	PAA-191	PA	N903PA	ED	TYO	780710	01	IF	387	3.77
	BTB "RUDDER RATIO LIGHT ON, TOP RUDDER VERY LITTLE MOVMENT ON INDICATOR, LOWER FULL TRAVEL" FOUND LIGHT ON STEADY, EVEN WITH RUDDER IN NEUTRAL. REPLACED UPPER CTL UNIT, NO HELP. REPLCD RATIO CHANGER AND OPERATION OK.										

FLIGHT CONTROL DELAY AND CANCELLATION EVENTS

ASN	NOMENCLATURE	A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
27-21-576-112	VALVE, RUDDR AND TAB CONT (GENRL) PAA-336	PA	N538PA	EP	AKL	781202	01	IF		.20
	HYD LEAK ON UNDER SIDE OF FUSELAGE BELOW TAIL. TRACED TO LWR RUDDER PWR PACKAGE SOLENOID VAL. LEAK NIL WHEN PRESSURIZED, ENTERED C.I. DELAY INCURRED DUE RAIN MADE IT DIFFICULT TO TRACE LEAK SOURCE.									
27-21-675-021	CONTROL UNIT, RUDDR POWER (PCU) PAA-346	PA	N538PA	EP	AKL	781212	01	IF		.42
	NBR 2 HYDRAULIC QUANTITY DOWN TO 2 GALS. ON W/A NOTED EVIDENCE OF LEAKAGE IN THE AREA OF THE POWER RUDDER UPPER ACTUATOR. REMOVED PANEL AND FOUND ONLY A STATIC LEAK OF 5 DROPS PER MINUTE, NO LEAKAGE OF THE ACTUATOR WITH PRESSURE ON. ADDED 4.5 GALS OF FLUID, NO OTHER LEAKS FOUND.									
27-21-675-191	CONTROL UNIT, RUDDR RATIO CHGR . PAA-187	PA	N903PA	ED	ORD	780706	01	IF	881	.67
	RUDDER RATIO LITE CAME ON IN CLIMB, REMAINED ON TILL FLAPS LOWERED, THEN OUT. WITH 5 DEG. OF TRIM INPUT, RUDDER ANGEL INDICATED UPPER 5 DEG. LLOWER 3 DEG. REPLACED UPPER CONTROL UNIT.									
27-21-675-191	CONTROL UNIT, RUDDR RATIO CHGR . PAA-204	PA	N738PA	EC	LAX	780723	01	IF	515	.27
	ON TAXI EX SFO, RUDDER RATIO LITE CAMEE ON. CYCLD C/BS & LITE WENT OUT. ON GND CK FND UPR RUDDER RATIO ERRATIC. REPLD CONTL UNIT & OPS OK.									
27-28-602-051	WIRING, RUDDR INDG/WARNG (GENRL) PAA-065	PA	N655PA	EC	SFO	780306	01	IF	124	.37
	ON FEO PREFLT FND RUDDRER RATIO LITE WUD NOT TEST. DURING T/S FND LOOSE WIRE AT LITE ASSY. ENTERED C.I. WITH CAPTS CONCURRENCE.									
27-31-000-000	FC ELEVATOR AND TAB CONTROL PAA-185	PA	N530PA	EP	LAX	780704	01	IF	120	1.98
	ITEM, LGIHT THUMP FELT IN ELEVATOR CONTROL 10 TO 15 RANGE. INSPECTED RIGHT AND LEFT INBD STABILIZER HINGE BUSHINGS AND CONTROL									

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FLIGHT CONTROL DELAY AND CANCELLATION EVENTS

ASN	NOMENCLATURE	A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
27-31-000-000	FC ELEVATOR AND TAB CONTROL PAA-185	PA	N530PA	EP	LAX	780704	01	IF	120	1.98

UNIT BUSHINGS. OK. DRAINED PITOT SYSTEM AND CHECKED FEEL COMPUTER PER
MM. OK.

ASN	NOMENCLATURE	A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
27-31-000-001	FC ELEV AND TAB CONT - GENRL ... PAA-121	PA	N742PA	EC	FRA	780501	01	IF		7.25

BTB DUE ELEV FELL LITE STAYED ON AFTER SYS 2 AND 3 WERE PRESSURIZED. WHEN CONTROL COLUMN IS MOVED FWD OR AFT LITE GOES OUT MOMENTARILY. UNABLE TO PERFORM FEEL COMP TEST PER MM 27-32-14 DUE LACK OF TEST EQUIP. ALT TEST COL. FORCE DID NOT DECREASE WITH STAB TO FULL NOSE UP. COMP NON-KIT FRA. DLH HAD UNIT IN POOL WITH SABENA, NECY TO GET OK FROM BRU TO USE, OK DLYD DUE HOLIDAY. RPLD UNIT AND OPS CK OK.

ASN	NOMENCLATURE	A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
27-31-000-001	FC ELEV AND TAB CONT - GENRL ... PAA-270	PA	N903PA	ED	CCS	780927	01	IFIC		2.52

BTB. ON CONTROL CK DURING TAXI OUT, A THUMP IS HEARD WHEN ELEVATOR REACHES EITHER FULL UP OR FULL DOWN. WITH HYD PWR OFF NO THUMP HEARD. MADE VISUAL CONTROL CK, CKD CABLE RUNS AND PULLEYS, ALL FOUND OK. DISCUSSED WITH MJ NYC, A/C RELEASED.

ASN	NOMENCLATURE	A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
27-31-130-021	COMPUTER, ELEV FEEL PAA-179	PA	N653PA	EC	LHR	780628	01	IE	100	.00

ITEM, ELEVATOR FEEL LIGHT CAME ON IN CLIMB AND REMAINED ON. ALL HYD PRESSURES NORMAL. CLEANED C/P AND DRAINED PS/TOT/STATIC LINES. NO HELP. PERFORMED PITOT/ STATIC CHECKS PER MM AND TEST OK. UNABLE BORROW FEEL COMPUTER CN 70772.

ASN	NOMENCLATURE	A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
27-31-312-101	LINE,ELEV AND TAB CONT HYD(GENRL) PAA-129	PA	N742PA	EC	FRA	780509	01	IF	002	.38

NR 3 HYD QTY DROPPED FROM 4.5 TO 2.5 IN 1 HR. FND RUNNING LEAK FROM NR 3 HYD SUPPLY LINE TO ELEV FEEL COMPUTER, REF 27-31-14 PG 202 FIG 201, RETORQUED B NUT AT FEEL COMPTR AND LEAK CK OK.

ASN	NOMENCLATURE	A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
27-31-675-051	CONTROL UNIT, ELEV POWER PAA-209	PA	N654PA	ED	JFK	780728	01	IF	166	6.23

A/C LATE IN CGO DUE HEAVY MAINT ITEMS. LIMITING ITEM, REPLACEMENT OF LT. INBD ELEV PWR PKG DUE INTERNAL LEAKAGE. DLY EXTENDED DUE NEC REMOVE NEW PKG AND REPLACE LOWER MOUNT BOLTS DUE DAMAGED.

E51

FLIGHT CONTROL DELAY AND CANCELLATION EVENTS

ASN	NOMENCLATURE		A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
27-31-675-051	CONTROL UNIT, ELEV POWER	PAA-203	PA	N902PA	EC	JFK	780722	01	IF	201	12.72
	BTB DRNG FLT CONTL CK, ELEV POSN DOES NOT RETURN TO NEUTRAL. SWD EQUIP REPLCD RT IB ELEV PWR PK.										
27-32-420-081	RELAY, ATUDE/STALL WARNG (GENRL)	PAA-294	PA	N655PA	EC	LAX	781021	01	IF		.73
	ATT WARNING STICK SHAKER CAME ON DURING TAXI PULLED C/B TO SILENCE. RESEATED COMPUTER, REPOSITIONED VANE, NO HELP. RESEATED R853 RELAY AND OPS OK.										
27-38-000-001	ELEV INDG AND WARNG - GENRL	PAA-053	PA	N747PA	EC	LAX	780222	01	IF	811	.95
	IMM 27/10TC. ELEV FEEL LITE ON COMPLETE TRIP. AUX SYS IS NRML. REMOVED C/P FROM ELEV FEEL COMPUTER AND LITE STAYED ON. SWAPPED CARDS IN MASTER DIM/TEST BOX NO HELP. CKD SYS PER MM 27/31/14 PG 801 AND SYS CHKS OK. AFTER LITE REPOSND MANY TIMES AND BULB RPLD, LITE COMMENCED TO FUNCTION NRMLLY. AFTER T/O, CREW REPORTED SYS OPERATION IS NRML.										
27-41-000-001	HORZL STBLR CONT - GENRL	PAA-186	PA	N770PA	EC	PDX	780705	01	IF	896	1.58
	ITEM WHEN STAB TRIM SWITCH OR MANUAL LEVERS MOVED BRAKE RELEASE LITES ON BUT CAPT REPORTS DELAYED TRIM RESPONSE. STAB TRIM MOTION INDICATOR ALSO DELAYED AND ABNORMALLY LOUD. VISUAL INSP OF STAB TRIM MECHNSM ALL OK. STAB CK PER 27-41-06 PAGE 401/403 ALL NORMAL. RLEASED PER ATCC TELX, CI ENTERED REF NOISE LEVEL.										
27-41-280-211	HOSE,STBTR MOD/U-TO-HYD MOTOR HYD	PAA-059	PA	N654PA	ED	GUA	780228	01	IF	315	.30
	ON W/A FND HYD LEAK FROM TAIL, TRACED TO RT STAB MOTOR, UPPER HOSE PN BACH30BF1E050T. INSTALLED INTERIM HOSE ASSY.										
27-41-280-211	HOSE,STBTR MOD/U-TO-HYD MOTOR HYD	PAA-208	PA	N771PA	ED	SFO	780727	01	IF	874	2.02
	ON PUSHOUT, HYD LEAK FROM TAIL AREA. FOUND LINE FROM STAB MODULE TO R/H JACKSCREW MOTOR LEAKING. REPLACED TWO FLEX LINES DUE UNABLE TO TELL WHICH DUE HEAVY SPRAY AND MIST WHICH ALSO EXTENDED DLY.										
27-41-312-081	LINE, HORZL STBTR CONT HYD(GENRL)	PAA-014	PA	N733PA	EC	THR	780114	01	IF	002	.77

ASN	NOMENCLATURE		A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
27-41-312-081	LINE, HORZL STBTR CONT HYD(GENRL)	PAA-014	PA	N733PA	EC	THR	780114	01	IF	002	.77
	NR 3 HYD SYSQTY LOSS, STOPPED WITH EDP AND ADP OFF. ON W/A FND FUMES COMMING FROM TAIL COMPT. CLEARED AREA AND ON LEAK CK FND LEAK AT B NUT OF LT STAB TRIM MODULE, TIGHTENED AND LEAK CK OK.										
27-41-312-081	LINE, HORZL STBTR CONT HYD(GENRL)	PAA-174	PA	N754PA	EC	SEA	780623	01	IF	123	.63
	ITEM CK FOR HYD LEAK NBR 3 SYSTEM. ADDED 5 GALS HYD FLUID LEAK TRACED TO INBD END LEFT STABILIZER. PRESS LINE B NUT LOOSE ONE FULL TURN. LK OK AFTER NUT TIGHTENED.										
27-41-312-081	LINE, HORZL STBTR CONT HYD(GENRL)	PAA-257	PA	N732PA	EC	SYD	780914	01	IF		1.67
	NO MRS, NBR 3 HYDRAULIC SYSTEM HAS SLOW LEAK. FOUND EVIDENCE OF FLUID IN RUDDER AREA BUT LEAK CHECK OK. FOUND FLUID LEAKING AT RH ELEVATOR OUTBOARD END. DE-ACTIVATED NBR 3 SYSTEM LINE TO THE OUTBOARD PACKAGE WAS LOOSE AND HAD TWO PINHOLES IN IT, CAPPED LINE OFF AT THE STABILIZER SWIVEL FITTING, CI COVERS.										
27-41-312-081	LINE, HORZL STBTR CONT HYD(GENRL)	PAA-273	PA	N902PA	EC	GUM	780930	01	IF		1.17
	NBR 2 HYD SYSTEM LEAK. STOPPED WITH EDP SUPPLY OFF... FOUND NBR 2 SYSTEM LINE TO STAB BRAKE RELEASE LEAKING IN SECT 48. REPAIRED LINE WITH UNION AND LEAK CHECK OK. DELAY EXTENDED DUE EXCESSIVE FLUID MIST IN COMPT AND NECESSARY TO SHUT DOWN APU AND EVACUATE WITH AIR COND.										
27-41-402-021	PUMP, HORZL STBTR STBY HYD	PAA-074	PA	N742PA	EC	SYD	780315	01	IF	812	1.67
	HYD LEAK IN TAIL AREA. FND LEAK AT STAB MOROT/PUMP SHAFT SEAL. RPLD MOTOR/PUMP USING NONPOOL LOAN.										
27-41-452-171	SEAL, HORZL STBTR CONT HYD(GENRL)	PAA-214	PA	N538PA	EP	LAX	780802	01	IF	002	.75
	INBOUND ITEM REQUESTING LEAK CHECK OF NBR 2 HYDRAULIC SYSTEM. FOUND STABILIZER TRIM MODULE LEAKING FROM A SOLENOID, REPLACED O RING. POSITION WAS RH.										

E53

FLIGHT DELAYS FOR PANAM B-747 FLEET DURING 1978
FLIGHT CONTROL DELAY AND CANCELLATION EVENTS

ASN	NOMENCLATURE		A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
27-41-522-042	SWITCH,ELEV OPRD HOSTB CONT LIMIT	PAA-274	PA	N734PA	EC	LHR	781001	01	IF		16.00
	TOTAL TIME 22.75. STAB WOULD NOT MOVE NOSE DOWN WITH CAPT'S OR F/O'S TRIM SWITCH. BRAKE REL LITES WERE OUT. GRD OPS CHECKS OK. FOUND LARGE DIFFERANCE IN ELEV OPERATED CUTOUT SWITCH OPERATION. FOUND SWITCH ROLLERS BADLY WORN. REPLACED SWITCHES WITH SWITCH FROM BA.										
27-41-522-042	SWITCH,ELEV OPRD HOSTB CONT LIMIT	PAA-275	PA	N732PA	EC	MNL	781002	01	IFIC		15.00
	STAB TRIM CONTROL INOP NOSE UP AT BOTH PILOTS POSN. CHKD SW CONTACTS S457 FOUND OK. CHKD PWR AT DB 188A AND 189A PIN 19 BOTH HAVE 28V PWR WITH PICKLE SW IN NOSE UP POSN. FURTHER T/S FOUND NO PWR TO PIN 15 ON TRIM CONTROL MODULES A&B. TRACED PROBLEM TO DOWN ELEVATOR OPERATED SW. REWIRED CIRCUIT TO USE A A/P SWITCH AND RELEASED WITH A A/P INOP.										
27-41-576-781	VALVE,HORZL STBTR MOD/U MONTD S/O	PAA-005	PA	N536PA	EK	JFK	780105	01	IF	875	1.07
	ON W/A FND HYD LEAK FROM TAIL COMPT. TRACED TO RT STAB TRIM CONT MODULE UPPER SOLENOID VLV. RPLD SEAL PLATE AND FINAL LEAK CK OK.										
27-41-602-091	WIRING, HORZL STBTR CONT (GENRL)	PAA-277	PA	N732PA	EC	HNL	781004	01	IF		5.02
	ELEC TRIM TOWARD NOSE UP IS INOP FROM BOTH YOKE POSITIONS UNLESS FWD YOKE PRESSURE IS EXERTED. IN FLT, NO NOSE UP EVEN WITH FWD PRESS EXERTED..... AFTER EXTENSIVE ATTEMPTS AT SWITCH RIGGING FOR ELEV OPERATED SWITCHES, FOUND WIRES TO SW 678 HOOKED UP WRONG. REWIRED SW AND STAB TRIM OPS NORMAL.										
27-41-687-101	MOD/U,. HORZL STBLR TRIM CONT ...	PAA-291	PA	N749PA	EC	LHR	781018	01	IFIS		2.22
	BTB BRAKE RELEASE LITE OUT WHEN TRYING TO TRIM STAB NOSE DOWN FROM EITHER PICKLE SWITCH FOR NBR 2 SYS. MANUAL OPER AND NBR 3 SYSTEM OPER OK. TRACED PROB TO LH STAB TRIM CONTROL MODULE. SW'D EQUIP DUE CREW DIDNT WANT TO OPER PER MEL 27-26. REPLACED MODULE AND OPER OK										

ASN	NOMENCLATURE		A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
27-41-687-101	MOD/U, HORZL STBLR TRIM CONT ...	PAA-291	PA	N749PA	EC	LHR	781018	01	IFIS		2.22
	AFTER EQUIP SWITCH.										
27-41-687-101	MOD/U, HORZL STBLR TRIM CONT ...	PAA-313	PA	N901PA	ED	LHR	781109	01	IF		4.48
	CLOSEOUT PREV REPORTED HYD LEAK MDR 312 ITEM 18 REPLACING STAB HYD MODULE.										
27-60-312-071	LINE, FC SPLR HYD PRES ..(GENRL)	PAA-158	PA	N740PA	EC	NAN	780607	01	IF	811	.67
	AFTER PRESSURIZING NBR 4 HYD SYSTEM ELECT PUMP, FOUND HYD LEAK ON SPOILER DOWN LINE. LEAK TRACED TO LINE IN R/H WHEEL WELL. LINE FOUND CRACKED AND REPLACED WITH INTERIM HOSE. DAMAGED LINE LEFT INSTALLED, LEAK CHECK OK.										
27-61-224-621	FTG, FLGHT SPLR HYD LINE (GENRL)	PAA-288	PA	N748PA	EC	THR	781015	01	IF		4.20
	NBR 2 HYD SYSTEM 3 GALS LOW AND A HYD LEAK FROM RH WING OUTBD CANOE...FOUND NBR 10 SPOILER ACTUATOR PRESS LINE TEE FITTING CRACKED. IN-STALLED PART SVCD HYD SYSTEM AND LEAK CHK OK.										
27-61-675-161	CON/U, F/SPL POWER (PCU) (ACTR)	PAA-046	PA	N653PA	EC	TYO	780215	01	IF	002	3.42
	NR 3 HYD QTY DROPPED TO 6 GALS DURING APPROACH. FND VLV HOUSING CRACKED ON NR 1 SPOILER PWR PACKAGE C/N 72710 NON KIT TYO. BORROWED SAME FROM JAL. RPLD PWR PACKAGE. OPS AND LEAK CK OK.										
27-61-675-161	CON/U, F/SPL POWER (PCU) (ACTR)	PAA-248	PA	N732PA	EC	FRA	780905	01	IF		1.97
	HYDRAULIC LEAK FROM NBR 2 SPOILER ACTUATOR CAP ITEM 35, 27-61-08-01. REPLACED O-RING AND STILL HAD SLIGHT LEAKAGE. INSTALLED SLIGHTLY THICKER PACKING.										
27-62-008-111	ACTUATOR, GRD SPLR	PAA-033	PA	N656PA	EC	HNL	780202	01	IF	812	1.03
	HISTORY NBR 2 HYD SYSTEM FLUID LOSS. FOUND A PLUG LEAKING ON THE NBR 3 SPOILER ACTUATOR, REPLACED SEALS AND LEAK CHECK OK.										

FLIGHT CONTROL DELAY AND CANCELLATION EVENTS

ASN	NOMENCLATURE		A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
27-62-008-111	ACTUATOR, GRD SPLR	PAA-033	PA	N656PA	EC	HNL	780202	01	IF	812	1.03
27-62-008-111	ACTUATOR, GRD SPLR	PAA-084	PA	N901PA	ED	JFK	780325	01	IF	331	6.88
	NR 4 HYD SYST LOW. FND NBR 7 SPOILER ACT LEAKING FROM PISTON HOUSING CAP. REPLD SPOILER ACT.										
27-62-008-111	ACTUATOR, GRD SPLR	PAA-086	PA	N732PA	EC	LHR	780327	01	IF	125	.25
	PURSER REPORTS LEFT INBD SPOILER LIFTING UP APPROX 1 INCH. FND ACT PISTON JAM-NUT BAKCED OFF 1/4 INCH. RETORQUED AND WIRE-LOCKED.										
34-12-130-011	COMPUTER, AIR DATA (CADC)	PAA-159	PA	N750PA	EC	HNL	780608	02	IZ	841	.00
	INBOUND ITEMS, B AUTOPILOT INOP IN COMMAND MODE AND PITCHES DOWN IN ALTITUDE HOLD MODE; A AUTO PILOT INOP IN INS MODE, A/P RED WARNING LIGHT ON STEADILY; ALSO CADS 2 INOP. REPLACED INS NAV UNIT NBR 1 AND NBR 2 CADC CN 73460. DELAY DUE OBTAINING POOL CADC FROM UAL POOL NOTE NO MRS CODES APPLY.										
34-12-130-011	COMPUTER, AIR DATA (CADC)	PAA-225	PA	N743PA	EC	IST	780813	01	IF	012	1.58
	NO MRS, ABORTED TAKEOFF DUE TAKEOFF WARNING HORN. CHECKED BRAKE ENERGY CHART AND COOLING TIME 0055 MINUTES. PROBLEM ISOLATED TO F/OS CADS COMPUTER ALTITUDE WARNING INOP, SWAPPED BOTH COMPUTERS AND BOTH UNITS GROUND OPERATION OK. DELAY EXTENDED DUE BRAKE COOLING TIME. AFTER T/O CREW RADIO'D ALL OK.										
34-21-152-011	COUPLER, REMOT MAG COMPS	PAA-035	PA	N656PA	EC	SYD	780204	01	IF	812	.10
	DUE NBR 1 MHRS C/BPOPPING...ISOLATED PROBLEM TO COMPAS COUPLER, REPLACED SAME AND LIFTED DXT.										
34-21-152-011	COUPLER, REMOT MAG COMPS	PAA-057	PA	N750PA	EC	SFO	780226	01	IF	124	.08
	30 MINS PRIOR TO DEPT, NR 1 COMPASS WUD NOT SLAVE TO PROPER HEADING. RPLD COMPASS COUPLER.										

ASN	NOMENCLATURE		A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
34-21-152-011	COUPLER, REMOT MAG COMPS	PAA-061	PA	N531PA	EP	SYD	780302	01	IF	816	.12
	AT DEPT, NR 2 COMPASS SPLIT 100 DEGS AND NO SYNCH. RPLD COMPASS COUPLER.										
34-21-152-011	COUPLER, REMOT MAG COMPS	PAA-101	PA	N735PA	EC	AMS	780411	01	IFIC	101	.95
	ON DEPT HDG FLAG ON F/O HSI, UNABLE TO TRANSFER OR GET RID OF FLAG. RESET C/B NO HELP. RPLD COMPASS COUPLER NR 2, OPS NRML. BTB DUE F/O COMPASS HDG FLAG DROPPING INTO VIEW AT TIMES. SWAPPED COMPASS COUPLERS NR 1 ADN 2. FLAGS BOTH OUT OF VIEW. COUPLER C/N 73462.										
34-21-152-011	COUPLER, REMOT MAG COMPS	PAA-126	PA	N901PA	ED	DEL	780507	01	IF	161	8.32
	ITEM, NR1 HSI HEADING FLAG AND NR 2 RMI OFF-FLAG IN VIEW. FND NR 1 COMPASS COUPLER FAULTY, CN 73412 NON-KIT. CREW REST CALLED. RPLD WITH AIR INDIA 24 HRS NON-POOL LOAD PART AND OPERATION NRML.										
34-21-152-011	COUPLER, REMOT MAG COMPS	PAA-198	PA	N748PA	EC	GUA	780717	02	IF	516	.32
	CLWS LIGHTS WERE FLASHING, HEADING LIGHTS ON, NO HEADG FLAG IN VIEW, RMI'S 120 DEG SPLIT. SWAPPED COMPASS COUPLRS & NR 1 & 3 INS NAV UNITS & PROB CLEARD.										
34-26-000-001	FLGHT DIRTR - GENRL	PAA-156	PA	N749PA	EC	HNL	780605	01	IF	841	.27
	GLIDE SLOPE FLAG IN VIEW ON CAPT'S HSI. SWAPPED VOR REC'S NO HELP CYCLED C/B'S AND PROBLEM CORRECTED.										
34-26-000-001	FLGHT DIRTR - GENRL	PAA-126	PA	N732PA	EC	LHR	780506	01	IF	123	.30
	AT DEPT TIME, CAPT REPORTED THAT NR 1 HSI G/S BAR WUD NOT MOVE ON TEST OR FROM CO-PILOTS XFER SW. CHKD CAPTS HSI, FND OK. CYCLED RADIO/INS SW SEV TIMES AND G/S SYS CKS OK.										
34-26-000-001	FLGHT DIRTR - GENRL	PAA-226	PA	N536PA	EP	BAH	780814	01	IF	114	.92
	PRIOR DEPT. CAPTS ADI HAD G AND FD FLAGS. SWAPPED 1 AND 3 NAV UNITS, NO HELP. SWAPPED 2 AND 1 NAV UNITS, NO HELP. INST NEW ADI INDICATOR, NO HELP. INST AL UNITS IN THEIR ORIG POSITIONS AND FLAGS DISAPPEARED.										

FLIGHT CONTROL DELAY AND CANCELLATION EVENTS

ASN	NOMENCLATURE		A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
34-26-000-001	FLGHT DIRTR - GENRL	PAA-229	PA	N658PA	ED	MIA	780817	01	IF	305	1.33
	PRIOR TO DEPARTURE, CREW ADVISED THE F/O'S HSI FLAG WAS IN VIEW, INDICATOR SWAP NO HELP. RELEASED FLAG INOP PER ATCC, COORDINATED WITH OPERATIONS ENGINEERING.										
34-26-000-001	FLGHT DIRTR - GENRL	PAA-276	PA	N656PA	EC	LHR	781003	01	IF		1.08
	CAPTS RMI AND HSI COMPASS READS 40 DEG OFF, CIWS LITE ON. NO FLAGS SHOWING. SWAPPED NAV UNITS, RMI IND, COMP COUPLER, NO HELP. REPLACED NBR 1 MAG FIELD SENSOR, STILL NG. RELEASED WITH NBR 1 COMPASS INOP.										
34-26-136-511	CONNR, FLGHT DIRTR ADI	PAA-001	PA	N733PA	EC	RIO	780101	01	IF	516	.42
	DURING ENG START CAPT REPORTED HIS ADI TUMBLED WITH FLAG. SWAPPED ADI'S AND BOTH CKD OK.										
34-26-284-481	INDR, ATUDE DIRTR (HDI,FPDI,FDI)	PAA-353	PA	N658PA	ED	MIA	781219	01	IF		.38
	CO-PILOTS ATT SPHERE IS ERRATIC IN PITCH AND ROLL PLUS/MINUS 4 DEGS. ROLL, PLUS/MINUS 1 DEG PITCH. B A/P ALSO EFFECTED. REPLACED NBR 2 ADI.										
34-43-602-461	WIRING, GRD PXMTY WARNG .(GENRL)	PAA-077	PA	N735PA	EC	JFK	780318	01	IF	201	4.13
	FEO PICK-UP GRD PROX INOP. SWITCHED EQUIP DUE WIRING PROB BEHIND NR 1 LRRA R/T RECPT.										
34-48-000-001	LOW RANGE RADIO ALTM - GENRL ...	PAA-356	PA	N743PA	EC	HNL	781222	01	IF		.12
	CREW REPORTS NBR 2 LRRA INDICATOR ROTATING CONTINUOUSLY. REPLACED T/R AND STILL SAME. REINSTALLED ORIGINAL UNIT AND OKI'D.										
34-48-136-221	CONNR, LOW RANGE RALTM ..(GENRL)	PAA-091	PA	N744PA	EC	JFK	780401	01	IF	110	2.50
	ON ROUTINE AVIONICS CK, NR 1 LRRA POPPING C/B. FND SHORTED PLUG IN LRRA RACK. ROBBED N742 ON ARR TO RPLC SAME. PLUG WAS NIS, PN DPXB MA 336 0022.										

ASN	NOMENCLATURE	A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
34-48-136-221	CONNR, LOW RANGE RALTM ..(GENRL) PAA-091	PA	N744PA	EC	JFK	780401	01	IF	110	2.50
34-48-550-091	TRANSCEIVER, LOW RANGE RADIO ALTM PAA-023	PA	N748PA	EC	JFK	780123	01	IF	002	.12
	AT DEPT, CAPTS LRRA FAILED. SWAPPED TRANSCEIVERS. RELEASED A/C WITH F/O'S INOP.									
34-48-550-091	TRANSCEIVER, LOW RANGE RADIO ALTM PAA-087	PA	N749PA	EC	SFO	780328	01	IF	124	.12
	PRIOR TO DEPT. GRD PROXIMITY WARNING SYST BEGAN GIVING FALS AURAL AND VISUAL WARNINGS AND NR 1LRRA CYCLED RAPIDLY. RPLD LRRA R/T AND WAS OK.									
34-48-550-091	TRANSCEIVER, LOW RANGE RADIO ALTM PAA-161	PA	N744PA	EC	JFK	780610	01	IF	002	.22
	NBR 1 LRRA INOP - REPLACED T/R									
34-48-550-091	TRANSCEIVER, LOW RANGE RADIO ALTM PAA-254	PA	N734PA	EC	TYO	780911	01	IFIC		1.07
	BTB CAPTS GPWS ACTIVATED ON T/O ABORTED, RADIO ALT CAPT FLUCTUATING. REPLACED NBR 1 LOW RANGE RADIO ALT TEST'S OK. GPWS BITE CHECK OK ALSO.									
34-48-550-091	TRANSCEIVER, LOW RANGE RADIO ALTM PAA-333	PA	N744PA	EC	FRA	781129	02	IF		.27
	INORDINATE AVIONICS WORK LOAD ON SEVERAL A/C SIMULTANEOUSLY. LIMITING ITEMS NBR 1 ADF NOT POINTING CORRECTLY, REPLACED REC. NBR 2 LRRA INOP. REPLACED T/R.									
34-49-000-001	INRTL NAV SYS (INS) - GENRL PAA-118	PA	N530PA	EP	SYD	780428	01	IF	816	.82
	PRIOR DEPT. ALL 3 INS SYSTS WAYPOINTS SHIFTED. AT CREW REQ RERACKED ALL 3 NAV UNITS AND REALIGNED. NRS 1 AND 2 CKD OK, BUT NR 3 REPEATED A WAY POINT SHIFT, RELEASED NR 3 OPERATIVEIN ATTITUDE MODE ONLY.									
34-49-000-001	INRTL NAV SYS (INS) - GENRL PAA-205	PA	N739PA	EC	SNN	780724	01	IF	020	5.05

FLIGHT CONTROL DELAY AND CANCELLATION EVENTS

ASN	NOMENCLATURE	A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
34-49-000-001	INRTL NAV SYS (INS) - GENRL PAA-205	PA	N739PA	EC	SNN	780724	01	IF	020	5.05
	NO. 1 AND 3 INS SYSTEMS HAVE RED LITE ON. SWAPPING UNITS NO HELP. A/C RELEASED BLUE SPRUCE ROUTE.									
34-49-000-001	INRTL NAV SYS (INS) - GENRL PAA-213	PA	N657PA	EC	CCS	780801	01	IF	201	.42
	AT DEPT TIME, CAPT REPORTED NBR 2 INS INOP. SWAPPED WITH NBR 3.									
34-49-000-001	INRTL NAV SYS (INS) - GENRL PAA-265	PA	N538PA	EP	LAX	780922	01	IF		.60
	AT DEPT INS 2 WARNING LIGHT CAME ON AND DISPLAY WENT BLANK....SWAPPED NAV UNIT AND CDU AND NO HELP. CYCLED SYSTEM OFF AND ON AND GOT COUNT DOWN AND INSERT OK. ON GOING TO SHIP'S POWER, THE DISPLAY AGAIN WENT BLANK AND LITE ON, RECYCLED AND OPERATION OK.									
34-49-000-001	INRTL NAV SYS (INS) - GENRL PAA-291	PA	N903PA	ED	JFK	781018	01	IF		.32
	CREW REPORTED NBR 1 INS INOP. RECYCLED UNIT INS DISPLAY NORMAL.									
34-49-000-001	INRTL NAV SYS (INS) - GENRL PAA-296	PA	N533PA	EP	AKL	781023	01	IF		1.68
	NBR 1 INS HDG FLAG IN VIEW IN NAV MODE. NBR 3 INS PREV INOP DUE ATT PROBLEM. TOOK NBR 1 NU AND INST IN NBR 3 POSITION. TOOK NBR 3 NU AND PUT IN NBR 2 POS- ITION. NBR 2 NU INST'D IN NBR 1. NBR 1 SYSTEM NOW OPS NORMAL IN NAV AND ATT, NBR 2 INOP IN ATT MODE, NBR 3 INOP IN NAV MODE.									
34-49-000-001	INRTL NAV SYS (INS) - GENRL PAA-341	PA	N749PA	EC	LAX	781207	01	IE		.00
	A A/P WOULD NOT ENGAGE, RED A/P LITE ON, THIS IN COMMAND MODE. WAS OK IN RADIO. PROB WAS INTERMITTANT AND WOULD COME AND GO. B A/P WOULD ONLY FOLLOW NBR 2 HDG BUG IN INS MODE. ON GROUND CHK, NBR 1 HSI HEADING FLAG IN VIEW PLUS NAV FLAG. REPLACING NAV UNIT NO HELP. SWAPPED NAV UNITS AND NOW HAD HDG FLAGS IN BOTH INS SYSTEMS. ROBBED NAV UNITS FROM INBD A/C, THEN NBR 2									

FLIGHT DELAYS FOR PANAM B-747 FLEET DURING 1978
FLIGHT CONTROL DELAY AND CANCELLATION EVENTS

ASN	NOMENCLATURE		A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
34-49-000-001	INRTL NAV SYS (INS) - GENRL	PAA-341	PA	N749PA	EC	LAX	781207	01	IE		.00
	FLAG OK BUT NBR 1 STILL NG. AFTER SWITCHING INS XFR SW FROM CAPT TO F/O, FLAG APPEARED IN NBR 2 AND COULD THEN NOT EXTING-UISH SAME. SUSPECT NAV UNITS BURNING OUT DUE WIRING PROBS.										
34-49-000-001	INRTL NAV SYS (INS) - GENRL	PAA-361	PA	N902PA	EC	GKK	781227	01	IF		.08
	NBR 3 INS RED LITE ON CODE 63, AND NBR 1 INS INSERT LITE STAYED ON. RECYCLED NBR 1 AND OPS OK.										
34-49-136-901	CONNR, INS NAV/U	PAA-004	PA	N749PA	EC	HNL	780104	01	IF	826	5.37
	NR 2 INS INIP, CDU BLANK EXCEPT FOR INTERNAL LITES. FND OPEN IN WIRE NR TN2077. PIN NBR 48 AT CONNECTOR NR B110F OF CONTROL SELECTOR. DIA 34/41/22 PG 2. RPLD CONNECTOR AND OPS OK A/C SWAP TO MINIMIZE DLY.										
34-49-136-901	CONNR, INS NAV/U	PAA-110	PA	N744PA	EC	RIO	780420	02	IF	515	2.68
	AT DEPT, INS 1 WARNING LITE CAME ON AND P7 5 A CB POPPED. FND NAV UNIT CP J1B PIN 3 BURNT OFF, N/U CN 73402 NIS. INS 3 INOP/C.I. INBD, N/U FAILED.										
34-49-368-291	PANEL, INS CONT/DSPLY (CDU)	PAA-078	PA	N741PA	EC	JFK	780319	02	IF	100	.72
	FLT CREW P/U, NR 3 INS INOP TO PREVENT DELAY ENTERED C.I. AND PLACED NR 3 INS TO ATTITUDE, THEN CREW REPORTED NR 1 INS INOP. RPLD CDU AND NAV UNIT.										
34-49-368-291	PANEL, INS CONT/DSPLY (CDU)	PAA-162	PA	N750PA	EC	HNL	780611	02	IF	896	.92
	NBR 2 INS WENT BLANK AND NBR 5 INS ALREADY INOP DUE WARNING LIGHT NAV UNIT NIS, ROBBED UNIT AND INSTALLED NBR 3 POSITION. AFTER REL THE NBR 2 INS WENT BLANK AGAIN; SWAPPED NAV UNIT DISPLAY UNIT WITH NBR 3 AND NOW NBR 2 INS OK.										
34-49-368-291	PANEL, INS CONT/DSPLY (CDU)	PAA-228	PA	N536PA	EP	BAH	780816	01	IF	021	.42
	NBR 1 INS CDU LITES FAILED JUST PRIOR TO DEPT, NO ADI FLAGS SHOWN...SWAPPED NBR 1 CDU WITH NBR 3, OPS OK. DELAYED										

HONEYWELL PAGE PRINTING SYSTEM- P1185-02

FLIGHT DELAYS FOR PANAM B-747 FLEET DURING 1978
FLIGHT CONTROL DELAY AND CANCELLATION EVENTS

ASN	NOMENCLATURE		A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
34-49-368-291	PANEL, INS CONT/DSPLY (CDU)	PAA-228	PA	N536PA	EP	BAH	780816	01	IF	021	.42
	EXTENDED FOR ALIGNMENT.										
34-49-368-291	PANEL, INS CONT/DSPLY (CDU)	PAA-275	PA	N751PA	EC	OSA	781002	02	IF		2.13
	NBRS 1 AND 3 INS RED WARNING LITES ON. NAV UNIT CN 73402 AND CDU CN 73401. REPLACED NBR 1 NAV AND CDU UNIT, CKS OK. NBR 3 INS CONTINUED INOP.										
34-49-368-291	PANEL, INS CONT/DSPLY (CDU)	PAA-279	PA	N652PA	EC	TYO	781006	02	IB		1.88
	AFTER T/O F/O'S GYRO AND INS WENT OUT, WARNING ON INS. CAPT TOOK A/C, CHKD OUT INS AND DETERMINED UNSUITABLE FOR NAVIGATION...REPLACED NAV UNIT AND CDU.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-041	PA	N739PA	EC	FRA	780210	01	IF	002	.57
	ON PRE FLIGHT, #1 INS FAILED CODE 003-022. SWAPPED NAV. UNIT WITH #3 POSOTION.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-045	PA	N740PA	EC	JFK	780214	01	IF	110	.67
	ON TAXI OUT CREW REPORTED #2 INS FAILED. REPLCD NAV UNIT, ALIGNMENT CHECK OK.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-025	PA	N770PA	EC	FRA	780125	01	IF	073	.25
	AT DEPT, CREW REPORTS NR 1 INS WARN LITE ON. SWAPPED NAV UNIT WITH NR 3 POSN.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-066	PA	N656PA	EC	RIO	780307	01	IF	516	.12
	AT DEPT, CREW REPORTED NR 2 INS GYRO TUMBLED WHEN CREW BOARDED A/C. RPLD NR 2 NAV UNIT, OK ON GRND CHKS.										
34-49-692-021	NAVIGATION UNIT, INS	PA-067	PA	N534PA	EP	SFO	780308	01	IF	005	.37
	NR 1 INS RED WARNG LITE CAME ON WHEN INSERTING RAMPPOSN. ACTION CODE WAS 41. SWAPPED NR 1 AND										

FLIGHT DELAYS FOR PANAM B-747 FLEET DURING 1978
FLIGHT CONTROL DELAY AND CANCELLATION EVENTS

ASN	NOMENCLATURE		A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
34-49-692-021	NAVIGATION UNIT, INS	PA-067	PA	N534PA	EP	SFO	780308	01	IF	005	.37
	3 NAV UNITS. C.I. ENTERED.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-086	PA	N751PA	EC	FRA	780327	01	IF	073	.33
	NR 1 INS WARN LITE CAME ON, DRIFT ANGLE AND G/S OFF. RPLD NAV UNIT WITH PART RECEIVED FROM LON.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-094	PA	N659PA	EC	GUM	780404	01	IF	842	.30
	ON PREFLT, NR 2 INS WUD NOT ACCEPT WAYPOINTS. SWAPPED 2 AND 3 NAV UNITS AND BOTH SYSTS CKD OK.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-097	PA	N731PA	EC	JFK	780407	01	IF	201	.23
	PRIOR TO DEPT. FLT CREW REPORTED NR 2 GYRO TUMBLED. RPLD INS 2 NAV UNIT.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-099	PA	N657PA	EC	IAD	780409	01	IF	106	.08
	AT DEPT, NR 2 INS RED WARNING LITE ON AND F/O ADI TUMBLED. SWAPPED 2 AND 3 NAV UNITS AND NBR 2 THEN OK. CONTINUED NR 3 INOP.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-109	PA	N741PA	EC	FRA	780419	01	IFTC	002	.58
	BTB. ON STARTUP, NR 1 INS WARNING LITE ON AND CODES. SWAPPED 1 AND 3 NAV UNITS, ALIGNMENT ON NR 1 OK. ENTERED CI NR 3 INOP.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-111	PA	N733PA	EC	LAX	780421	01	IF	811	1.93
	AT DEPT TIME, CREW REPORTED NR 1 INS DISPLAYED UNUSABLE DATA DURING PREFLT. NU C/N 73402 NIS LAX. INSTALLED BORROWED UNIT FROM TWA, HAD A RED WARNING LITE AT TURN ON, UNABLE TO EXTINGUISH. ROBBED NU AND CDU FROM N754, INSTALLED SAME AND SYS NOW OK. D/U'S REMOVED FROM N733 INSTALLED ON N754 AND C.I. ENTERED. DLY EXTENDED DUE CORROW DROM TWA AND AWAITING ARRVL N754.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-157	PA	N655PA	EC	JFK	780606	01	IF	100	.35
	DELAY DUE NBR 1 INS RED WARNING LIGHT ON, FLIGHT CREW PICK UP. REPLACED NAV UNIT./										

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FLIGHT CONTROL DELAY AND CANCELLATION EVENTS

ASN	NOMENCLATURE		A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
34-49-692-021	NAVIGATION UNIT, INS	PAA-157	PA	N655PA	EC	JFK	780606	01	IF	100	.35
34-49-692-021	NAVIGATION UNIT, INS	PAA-164	PA	N654PA	ED	LHR	780613	01	IF	167	1.35
	INS NBR 2 PLATFORM TUMBLED. ALL READOUTS ERRONEOUS. MALFUNCTION CODES 102 AND 104. SWAP NBR 2 AND 3 INS NAV UNITS. NBR 2 NOW OK.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-165	PA	N740PA	EC	LHR	780614	01	IF	103	1.18
	NBR 2 INS. UNABLE TO INSERT WAPOINTS. RECYCLED INS. INSERT THEN ALL OK. DUE NBR 3 INS NAV UNIT UNSERVICEABLE DUE PREV ITEM CAPT INSISTED THAT NBR 3 REPLACED. REPLACED NAV UNIT NBR 3 POSITION. OPS CHECK OK.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-134	PA	N750PA	EC	JFK	780514	01	IF	002	.45
	ON PREFLT, NR 2 INS DISPLAY FROZEN. RPLD NAV UNIT, AWAITED ALIGNMENT, OPERATION NRML.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-148	PA	N901PA	ED	HNL	780528	01	IF	871	.23
	AT DEPT, NR 2 INS WARNING LITE CAME ON, MALF CODES 03/24. C/B RECYCLE NO HELP. SWAPPED NAV UNITS, DLYD REALIGNING.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-142	PA	N732PA	EC	HNL	780522	01	IF	896	.40
	ON DEPT COCKPIT ADV'D THAT NR 2 INS RED WARNING LITE ON. SWAPPED NR 2 AND 3 NAV UNITS. AFTER ALIGN, OPS OK.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-150	PA	N655PA	EC	RIO	780530	01	IF	616	.85
	NR 1 NAV UNIT RECEPTICAL BURNED AND INS ONLY GOOD IN ATTITUDE MODE. AT DEPT, ATTITUDE MODE BECAME INOP ALSO. RPLD NAV UNIT AND ALL OPERATIONS WERE NRML FOR INS.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-210	PA	N535PA	EK	SIN	780729	02	IF	876	1.02
	BTB, NO. 2 INS CDU RED WARN LITE ON MALFUNCTION CODE 01/38. SWAPPED INS NAV UNIT TO NO. 3 POSN,										

FLIGHT DELAYS FOR PANAM B-747 FLEET DURING 1978
FLIGHT CONTROL DELAY AND CANCELLATION EVENTS

ASN	NOMENCLATURE		A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
34-49-692-021	NAVIGATION UNIT, INS	PAA-210	PA	N535PA	EK	SIN	780729	02	IF	676	1.02
	COOLING FAN CHK'D OK, ENTERED C.I. ALSO AT BLOCKS, APU WOULD NOT START, NO RPM AND VOLTAGE DROP NORMAL. 2ND ATTEMPT VOLTAGE DROPPED TO 8 VOLTS, USED GSE.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-171	PA	N742PA	EC	LHR	780620	01	IF	101	.50
	NBR 3 INS WARNING LIGHT ON, CODES 34-42-02-01, REPLACED NAV. UNIT, NBR 2 WARNING LIGHT ON CODES 33-42-01, IND. PLATFORM PROBLEM, REPLACED NAV UNIT. BOTH SYSTEMS CHECK OK.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-241	PA	N743PA	EC	TYO	780829	01	IF	830	.16
	NBR 1 INS PLATFORM FAILED JUST PRIOR TO DEPT. NAV UNIT NIS. SWAPPED NBR'S 1 AND 3 NAV UNITS. CN 73402 NIS REON NBR'S 495 7-10 AND 382 2-9.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-249	PA	N732PA	EC	LHR	780906	01	IF		.55
	AT DEPT, NBR 1 INS WARNING LIGHT CAME ON, REPLACE NAV UNIT CN 73402.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-254	PA	N530PA	EP	LHR	780911	01	IF		.62
	BTB NBR 1 INS WARNING LIGHT ON WHEN POWER TRANSFERRED FROM APU TO SHIPS POWER, RESET TO ATT AND STBY NO HELP. SWAPPED NBR 1 AND 3 NAV UNITS. SYSTEM CHECK OK.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-255	PA	N771PA	ED	MIA	780912	01	IF		.92
	NBR 1 INS RED WARNING LITE ON. COULD NOT INSERT NEW WAY POINTS. HSI DISPLAY ALSO INOP...DUE NBR 3 INS ALREADY INOP IN CI, AND NEW NAV UNIT NOT AVAIL, HAD TO WAIT TILL ARR FLT 307 N654 IN ORDER TO ROB NBR 3 INS NAV UNIT AND INST IN 771.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-261	PA	N533PA	EP	HKG	780918	01	IF		1.00

FLIGHT CONTROL DELAY AND CANCELLATION EVENTS

ASN	NOMENCLATURE		A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
34-49-692-021	NAVIGATION UNIT, INS	PAA-261	PA	N533PA	EP	HKG	780918	01	IF		1.00
	ITEM NBR 2 INS FAILED IN FLT, NBR 3 ONLY GOOD IN ATT MODE. REPLACED NAV UNIT.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-268	PA	N741PA	EC	WAS	780925	01	IF		.57
	NBR 1 INS HEADING WAS SHIFTING RAPIDLY, NO WARNING LIGHT OR MALFUNCTION CODE. SWAPPED NAV UNIT TO NBR 3 POSITION AND RELEASED NBR 3 INOP.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-327	PA	N747PA	EC	MIA	781123	01	IF		5.75
	NBR 1 INS INOP, CODES 01 13 31 34 35 42. NBR 3 INS IN C.I. INOP. SWAPPED NAV UNITS FROM 2 TO 1, 3 TO 2 AND 1 TO 3, NBR 1 NOW NORMAL. NBR 2 AND 3 RED FAILURE WARNING. NAV UNIT C/N 73402 NOT AVAIL. UNIT SHIPPED FROM JFK NA 85. REPLACED NBR 2 NAV UNIT AND NOW SYSTEMS 1 AND 2 NORMAL.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-339	PA	N659PA	EC	JFK	781205	01	IF		.48
	NBR 3 INS FAILED AT DEPT. MALFUNCTION CODES 02 15 16 45. REPLACED NAV UNIT, ALIGNMENT COMPLETED.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-349	PA	N538PA	EP	LAX	781215	01	IF		.33
	DURING PREFLIGHT, INS 1 TUMBLED. REPLACED NAV UNIT.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-354	PA	N733PA	EC	OSA	781220	01	IF		.45
	AFTER DOORS SECURED, CREW REPORTS NBR 1 INS INOP. SWAPPED NAV UNIT WITH NBR 3 POS AND NBR 1 INS OK.										
34-49-692-021	NAVIGATION UNIT, INS	PAA-357	PA	N743PA	EC	PPT	781223	01	IF		.33
	AT DEPT NBR 2 INS INOP, NO INS ITEMS. SWAPPED NBR 2 AND 3 INS NU'S.										

FLIGHT CONTROL DELAY AND CANCELLATION EVENTS

ASN	NOMENCLATURE		A/L	REG NO	MS	STA	DATE	ACTS	EOF	FN	DEL TI
34-49-692-021	NAVIGATION UNIT, INS	PAA-357	PA	N903PA	ED	LHR	781223	01	IF		1.22
	NBR 1 INS INOP. REPLACED NAV UNIT.										
34-51-000-001	VOR/LCLZR - GENRL	PAA-083	PA	N732PA	EC	FRA	780324	01	IF	455	.23
	PRIOR TO PUSHBACK, CREW REPORTED F/O'S VOR FLAG IN VIEW. RERACKED UNIT IN E/E COMPT, CREW ELECTED TO CONTINUE.										
34-51-000-001	VOR/LCLZR - GENRL	PAA-292	PA	N743PA	EC	WAS	781019	01	IF	-	1.33
	BOTH VOR'S WEAK, PICK UP SIGNALS FROM ABOUT 50 NM IN. SUSPECT ANTENNAS NOT SWITCHING FROM LOCALIZER ANT. A/C ROUTED TO NYC FOR FURTHER REPAIRS. ON 10/19/78, PA EXPERIENCED TWO DELAYS ON AIRPLANE N743 DUE TO BOTH VOR'S WEAK. THEY FOUND REF A ANTENNA WITH TWO BURNED AREAS, PERSUMABLY CAUSED BY LIGHTNING. PA BELIEVES THAT THIS IS THEIR FIRST SUBJECT LIGHTNING DAMAGE. THEY TALKED TO THE VENDOR WHO SAID THEY HAVE SEEN SEVERAL INSTANCES OF THIS AND SUGGESTED THAT THE LIGHTNING PROTECTION STRIP ON THE AERODYNAMIC COVER MAY NOT BE SUITABLY GROUNDED (CORROSION, ECT).										
34-51-136-022	CONNR, VOR/LCLZR ....(GENRL)	PAA-020	PA	N903PA	ED	MIA	780120	02	IF	307	.33
	NR 1 VOR UNUSEABLE VERY WEAK. RESEATED AND CKD ALL CONNECTIONS. OPS CK OK. ALSO APU INOP.										
34-51-410-061	RECEIVER, VHF NAV/VOR/LCLZR	PAA-069	PA	N658PA	ED	FRA	780310	01	IF	167	.17
	AT DEPT, CREW REPORTED VOR 1 FLAG AND NEEDLE ERRATIC, OK ON CROSS-OVER. RPLD NR 1 RCVR.										
34-51-410-061	RECEIVER, VHF NAV/VOR/LCLZR	PAA-248	PA	N656PA	EC	LAX	780905	01	IF		.27
	AT DEPT CREW ADV'D NBR 1 VOR WOULD NOT TEST AND FLAG SHOWING. REPLACED VOR RECEIVER AND OPER OK.										

APPENDIX F

RESOURCES AND COSTS FOR MAIN BASE OPERATIONS

This section includes data from Pan Am on the two main bases, New York and San Francisco.

Contents

TABLES

TABLE F1 MAINTENANCE AND ENGINEERING FUNCTIONS

MAIN OPERATING BASE--NEW YORK	MANPOWER DISTRIBUTION
Maintenance and Engineering Support	30%
Administration	
Quality Control	
Material and Logistics	
Industrial Equipment	
Engineering	
Maintenance Servicing	30%
Aircraft	
Appearance	
Sheet Metal	
Avionics (89 Technicians)	
Technical	
Line Support	
Component Repair	12%
Instrument Overhaul	
Aircraft Shops	
Avionics Overhaul (72 Technicians)	
Fuel, Pneumatics and APU Shop	
Hydraulics and Mechanical Accessory Shop	
Power Plant Repair	19%
SAN FRANCISCO MAINTENANCE BASE	
M. & E. Support, Aircraft Servicing (11 Technicians), Line Support and Component Repair	9%
	100%

TABLE F2--TOTAL SPARES
FOR PRIMARY MECHANICAL CONTROLS

Item	Part No.	Dollar Average Price of Unit	Total Spares
Trim and Centering Mechanism	72749	1,289	0
Trim Actuator	72786	694	4
Central Control Actuator	72708/70717	14,182	6
Aileron Programmer	72751	2,500	0
Aileron Programmer	72752	3,165	0
Spoiler Differential (Mixer)	72753	5,600	0
I/B Aileron Power Control Unit	72706	9,600	4
O/B Aileron Power Control Unit	72707	9,100	4
O/B Aileron Lockout Actuator	72788	1,027	5
O/B Aileron Lockout Mechanism	70718/72792	1,615/1,639	4
O/B Aileron Lockout Mechanism	72748/72791	1,615/1,547	11
O/B Aileron Lockout Gearbox	72737	2,922	10
Flight Control S/O Valve Module	72714/72799	646	9
I/B Spoiler Power Control Unit	72709/70765	6,212/6,500	7
O/B Spoiler Power Control Unit	72710	4,056	16
Control Surface Position Ind.	72775	1,122	12
Control Surface Position Xmtr.	72728	139	15
Feel Trim and Centering Mechnsm	72749	1,289	0
Aft Quadrant	65B82246-1		0
Ratio Control Unit	72730/70756	1,587/1,790	22
Ratio Changer Actuator (Servo)	72778/70723/ 70755	1,352/1,790	36
Ratio Changer Comparator	70724/70731	560	18
Power Control Unit	72705	16,473	6
Trim Actuator	72777	513	6
Control Column Wheel	70704	2,205	0
Control Column Wheel	70705	2,205	0
Rear Quadrant	65B80482-1		0
Feel Unit	72773	2,626	0
Feel Actuator	72774	3,816	2
Feel Computer	72711/70772	12,327/18,111	5
Inbd. Power Control Unit	72703	29,160	4
Outbd. Power Control Unit	72704	10,430	3
Stall Warning Computer	72795	1,896	10
Over Rotation Computer	72789	2,995	15
Hydraulic Motor	72716/70754	694/700	2
Gear Drive/Jackscrew	72731	32,835	2
Hydraulic Brake	72785	1,785	3
Shut-off Valve	72779	243	25
Control Module	72723	14,780	0
Control Lever Brake	72715	1,077	2
Sequence Mechanism	72754/70771	3,044	0
Ground Spoiler Control Valve	72722/70768	741/1,600	5
Ground Spoiler Actuator	72713/70770	2,682/8,441	4

TABLE F3--TOTAL SPARES
FOR FLIGHT ELECTRONICS

Item	Part No.	Dollar Average Price of Unit	Total Spares
Pitch Computer	72201	11,647	38
Roll Computer	72202	12,099	30
Yaw Damp Computer	72221	4,510	22
Monitor & Logic Unit	72204	9,892	23
Auto Stabilizer Trim Unit	72224	4,740	17
Auto Throttle Computer	72220	6,500	11
Normal Accelerometer	57381	660	9
Accessory Stabilizer Trim Box	72215	2,384	12
Accessory #1 Box	72217/72223	3,980	12
Accessory #2 Box	72216	5,909	12
Mode Select Panel	72222	15,120	26
A/P Flight Control	72203	2,475/2,489	23
Flight Mode Annunciator Light Set	73422	646	13
Attitude Director Indicator	73407	6,237	58
Navigation Receiver	73458	4,336	46
Low Range Radio Alt. Xcvr	73432	5,157	55
Inertial Navigation Unit	73402	69,425	54
Central Air Data Computer	73460	30,400	25
Central Air Data Computer	73404	30,400	3
MHR Compass Coupler	73412/73462	4,232/4,728	24
Auto Throttle Servo	72207	958	9
SP COMPONENTS			
Flight Mode Annunciator Light Set	42206	1,372	2
Yaw Damp Computer	42207	8,231	4
Accessory Stabilizer Trim Box	42208	5,220	3
Accessory #3 Box	42210	7,074	2
Central Air Data Computer	42211	7,749	5
Pitch Computer	42212	17,790	8
Monitor & Logic Unit	42213	38,000	3
Mode Select Panel	42214	41,000	3
Auto Throttle Computer	42217	6,500	1

TABLE F4 GROUND SUPPORT EQUIPMENT

Description	Part No.	Unit Cost ($)	Station Allocation					
			Category					Selective
			5	4	3	2	1	
MECHANICAL								
Aileron PCU Hoist	ALTOHME 65B81843-1	850						LON
Cable Tensiometer	27-00-D005	68						JFK, SFO, LON
Spoiler Locking Tool No. 6 and 7	5 MIT 65B02310	277						JFK
Elevator PCU Wrench Adapter	MIT 65B80549	78						JFK
O/B Elevator Lock Assy--RH	3MB 65B05730-2	1005						JFK
O/B Elevator Lock Assy--LH	3MB 65B05730-1	1199						JFK
O/B Aileron Lock Assy	ALTSME 65B02100-1	263	1	1				HNL + 1
I/B Aileron Lock Assy	ALTSME 65B02200-1	367	1	1				HNL + 1
Rudder Trim Knob Torque Adapter	SE27-2011	173						JFK

TABLE F5 GROUND SUPPORT EQUIPMENT

Description	Part No.	Unit Cost ($)	Station Allocation Category 5	4	3	2	1	Station Allocation Selective
AVIONICS								
Air Data Test Set	Milhard Engineering S82	5562						JFK
LRRA Tester	Bendix 2037028-0501	706						JFK
INS Simulator	4TSJ 60B00002	2698						JFK
ILS/VOR Test Set	T-30A	2435						JFK, BAH, BOM BRU, IST, KHI MEL, MEX, HNL NRT, SIN, SYD
Pitot Adapter	40007-A-44	55	2	2	1	1	1	LON + 2
Static Adapter	40007-B-46	55	2	2	1	1	1	LON + 2

TABLE F6 SHOP TEST EQUIPMENT FOR B747 FLIGHT CONTROLS

Equipment	Unit Cost	Qty	B747 Flt Cont. Allocation %	Cost B747 Units
			PRIMARY CONTROLS	
Hydraulic Test Stands	65,000	9	65	380,250
Servo Test System	70,000	2	65	91,000
Servo Test Upgrade to 999 IMC	42,000	2	65	54,600
Servo Test System (on order)	70,000	1	65	45,500
Fluid Purifier	8,000	1	65	5,200
Lab Analysis Equipment	2,000	A/R	80	1,600
Electronic Particle/ Sizing System	10,000	1	65	6,500
Electronic Flow Meter (PDQ)	7,000	2	100	14,000
				598,650
			AVIONICS	
Automatic Test Equipment	700,000	1	100	700,000
Semiautomatic Test Equipment	187,000	1	100	187,000
				887,000

TABLE F7--MAIN BASE COMPONENT MANHOURS AND MATERIAL COSTS FOR PRIMARY MECHANICAL CONTROLS

Item	Part No.	12 Month Count	Shop Activity Dollar Material Cost 12 Mo Period	Shop Activity Manhours 12 Mo Period	Dollar Outside Service Cost 12 Months
Trim and Centering Mechanism	72749	0	0	0	0
Trim Actuator	72786	1	96	3	0
Central Control Actuator	72708/70717	19	20,338	2013	0
Aileron Programmer	72751	0	0	0	0
Aileron Programmer	72752	0	0	0	0
Spoiler Differential (Mixer)	72753	1	0	0	0
I/B Aileron Power Control Unit	72706	12	15,090	666	0
O/B Aileron Power Control Unit	72707	7	1,657	353	0
O/B Aileron Lockout Actuator	72788	1	14	3	0
O/B Aileron Lockout Mechanism	70718/72792	0	0	0	0
O/B Aileron Lockout Mechanism	72748/72791	0	0	0	0
O/B Aileron Lockout Gearbox	72737	0	0	0	0
Flight Control S/O Valve Module	72714/72799	13	2,348	344	0
I/B Spoiler Power Control Unit	72709/70765	1	0	21	0
O/B Spoiler Power Control Unit	72710	16	23,112	1172	0
Control Surface Position Ind.	72775	65	4,773	520	0
Control Surface Position Xmtr.	72728	1	198	18	0
Feel Trim and Centering Mechnsm	72749	0	0	0	0
Aft Quadrant	65B2246-1	0	Non-Inventory		
Ratio Control Unit	72730/70756	22	759	115	0
Ratio Changer Actuator (Servo)	72778/70723/ 70755	17	3,008	103	0
Ratio Changer Comparator	70724/70731	9	6,027	133	0
Power Control Unit	72705	10	27,534	2030	0
Trim Actuator	72777	0	0	0	0
Control Column Wheel	70704	0	0	0	0
Control Column Wheel	70705	0	0	0	0
Rear Quadrant	65B80482-1	0	Non-Inventory		
Feel Unit	72773	0	0	0	0
Feel Actuator	72774	1	0	5	0
Feel Computer	72711/70772	14	59,167	1788	0
Inbd. Power Control Unit	72703	33	65,748	3049	0
Outbd. Power Control Unit	72704	7	1,470	218	0
Stall Warning Computer	72795	13	222	51	0
Over Rotation Computer	72789	10	0	0	974
Hydraulic Motor	72716/70754	0	0	0	0
Gear Drive/Jackscrew	72731	0	0	0	0
Hydraulic Brake	72785	0	0	0	0
Shut-off Valve	72779	0	0	0	0
Control Module	72723	0	0	0	0
Control Lever Brake	72715	1	0	0	601
Sequence Mechanism	72754/70771	0	0	0	0
Ground Spoiler Control Valve	72722/70768	1	125	7	0
Ground Spoiler Actuator	72713/70770	2	0	14	0

TABLE F8--MAIN BASE COMPONENT MANHOURS AND MATERIAL COSTS FOR FLIGHT ELECTRONICS

Item	Part No.	Shop Activity: 12 Month Count	Shop Activity: Dollar Material Cost 12 Mo Period	Shop Activity: Manhours 12 Mo Period	Dollar Outside Service Cost 12 Months
Pitch Computer	72201	345	58,671	4380	0
RollComputer	72202	290	40,230	3331	0
Yaw Damp Computer	72221	85	950	664	0
Monitor & Logic Unit	72204	97	14,499	787	0
Auto Stabilizer Trim Unit	72224	133	7,810	807	0
Auto Throttle Computer	72220	28	2,911	640	0
Normal Accelerometer	57381	0	0	0	0
Accessory Stabilizer Trim Box	72215	31	1,695	80	0
Accessory #1 Box	72217/72223	9	205	56	0
Accessory #2 Box	72216	4	0	19	0
Mode Select Panel	72203	115	9,848	698	0
A/P Flight Control	72203	20	903	169	0
Flight Mode Annunciator Light Set	73422	22	1,477	164	0
Attitude Director Indicator	73407	89	13,837	1046	0
Navigation Receiver	73458	198	7,122	3884	0
Low Range Radio Alt. Xcvr	73432	246	6,142	3156	0
Inertial Navigation Unit	73402	93	972	3367	1,134,000
Central Air Data Computer	73460	397	16,402	3161	0
Central Air Data Computer	73404	22	16,032	35	0
MHR Compass Coupler	73412/73462	118	605	154	0
Auto Throttle Servo	72207	0	0	0	0

The following items are used on the SP fleet and are presently repaired by the vendors per warranty terms. Costs, if any, are shown in the "Outside Service" column.

SP COMPONENTS	Part No.	12 Month Count	Dollar Material Cost 12 Mo Period	Manhours 12 Mo Period	Dollar Outside Service Cost 12 Months
Flight Mode Annunciator Light Set	42206	--	--	--	546
Yaw Damp Computer	42207	--	--	--	157
Accessory Stabilizer Trim Box	42208	--	--	--	0
Accessory #3 Box	42210	--	--	--	0
Central Air Data Computer	42211	--	--	--	0
Pitch Computer	42212	--	--	--	4,500
Monitor & Logic Unit	42213	--	--	--	2,600
Mode Select Panel	42214	--	--	--	900
Auto Throttle Computer	42217	--	--	--	0

MAINTENANCE TRAINING COSTS

At Pan Am during 1978, eight instructors taught 747 flight control subjects which are covered in nine different courses. These subjects represent an average of 15% of the total course.

Of the 58 classes conducted, about 70 days were spent on 747 related flight control instruction. Average class size was ten trainees.

The instructor costs to provide this training . . .

Salaries (inc. preparation time)	$14,400	
--Related Payroll Expense (TAX & WEL) 20%	2,900	
--Overtime	1,800	
Travel Expenses	2,700	
Supplies and Equipment (est.)	1,200	
		$23,000
Overhead Factors		
--Supervisory and Adm. Support (est.)		1,200
Facilities		
--Office/Classroom (inc. phone) (est.)		3,100
TOTAL COST TO PROVIDE TRAINING		$27,300

WORK INTEGRATED TRAINING

Salaries (inc. preparation time)	$15,000	
--Related Payroll Expense (TAX & WEL) 20%	3,000	
--Overtime	600	
Travel Expenses	500	
Supplies & Equipment (est.)	500	
		$19,600
Overhead Factors		
--Supervisory & Adm. Support (est.)		1,000
Facilities		
--Office/Classroom		1,600
TOTAL COST TO PROVIDE W.I.T.		$22,200
TOTAL TRAINING COSTS		$49,500

Trainees' salaries and expenses incurred during training are not part of direct maintenance, but covered as part of burden.

The above figures were extracted from the whole maintenance training department expenses for 1978 as follows:

Trainees' salaries	$561,000
Payroll expenses	105,300
Other expenses Supplies, equipment, etc.	40,500
1978 TOTAL	$706,800

A total of 2,579 employees received maintenance training during 1978.

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15. Supplementary Notes

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16. Abstract

Primary and automatic flight controls are combined for a total flight control reliability and maintenance cost data base using information from two previous reports and additional cost data gathered from a major airline.

A comparison of the current B-747 flight control system effects on reliability and operating cost with that of a B-747 designed for an active control wing load alleviation system is provided.

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