NASA Contractor Report

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Application of Advanced Electric/Electronic Technology to Conventional Aircraft

R. L. Heimbold, M. J. Cronin, W. W. Howison

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HONEYWELL INCORPORATED

CONTRACT NAS9-15863
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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF TABLES

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This study was the product of the diverse talents and hard work of a large number of people working in the four cooperating companies and in NASA. The authors wish to express their thanks to all these people and especially to Mr. S. A. Rowe, leader of the AirResearch and Manufacturing Company team, to Mr. J. C. Larsen who headed up the Honeywell, Inc. team, and to Mr. J. W. Phillips who headed up the Lockheed-Georgia Company effort. Appreciation is also expressed to the technical management at the Lyndon B. Johnson Space Center, in particular to Mr. R. C. Kennedy who started the program in the right direction and Mr. J. P. Bigham who guided it to a successful conclusion.

1. INTRODUCTION

The study described in this report had as its objective the determination of the improvements and productivity of commercial aircraft that can be realized through the transfer of digital multiplex fly-by-wire and related flight control technologies developed for the space shuttle to commercial aircraft design. An industry team headed by Lockheed-California Company and including the Lockheed-Georgia Company, AiResearch Manufacturing Company of California, and Honeywell, Inc., Avionics Division, cooperated in this effort. In the course of the study the flight control technologies of the shuttle and related adjunct technologies currently under development at the NASA Johnson Space Center were applied to three advanced commercial aircraft designs to find the payoffs which were made possible therefrom.

Historically the Space Shuttle fulfilled an important pioneering role in the application of advanced electronic flight control technologies. Redundant digital fly-by-wire was pioneered and successfully flown in the shuttle. Shuttle avionics are totally integrated in central computers resulting in increased efficiency of its configuration. Shuttle computer architecture developments including multiple multiplex bussing, mux-demux units, higher order language, and comprehensive computer software management and maintenance monitoring techniques are also important contributions to the state of the art of flight control systems. Electronic displays, including keyboards to allow interaction of the pilot with the system, have found their way from the Shuttle into today's transport aircraft. The shuttle program also led the way to effective software management techniques, the use of an efficient higher-order language, and software verification methods for complex applications. The software associated with the system redundancy management of today's FBW controls is continually being developed to a higher state.

The study described herein evaluated these technologies in detail in commercial aircraft applications. Good near-term payoffs were realized from the transference of these technologies to large commercial transports. Important adjunct technologies were also evaluated. Most important of these was the use of an all-electric secondary power system which exhibited the most impressive weight and cost payoffs of all the technologies studied. The adjunct technologies are those which are not currently incorporated in the Shuttle but are under review as potential improvement areas. Besides the all-electric technology, the other adjunct technologies studies were: ring laser gyros and fiber optics.

This study was performed under contract to the NASA Lyndon B. Johnson Space Center in Houston, Texas. It began in July of 1979 and was completed in July of 1980. The contract number for this effort was NAS9-15863.

A four-member team was assembled for this program to ensure that all parts of this multifaceted study were covered with an adequate depth of technology. Lockheed-California Company, the prime contractor, had responsibility for the administration of the contract, the execution of all tradeoffs, as well as the configuration of baseline aircraft. Honeywell, Inc. provided data related to the electronic equipment in the airplane and to technologies such as ring laser gyros and fiber optic devices. AiResearch and Manufacturing Company contributed data in the areas of secondary power systems designs, electric actuation systems, and environmental control systems. The Lockheed-Georgia Company having had prior experience in the configuration of all-electric aircraft functioned as a consultant.

SUMMARY

The study showed greater than expected cost savings from the advanced systems, especially the all electric airplane (AEA). The AEA showed a payoff approaching 2.5 billlion dollars for the fleet of 300 ATA aircraft using $0.60/gal. fuel. Utilizing all of the technologies and with $1.80/gal. fuel the payoff is 9 billion dollars. These savings are major and rank in importance with advanced aerodynamic, propulsion and structures technologies.

Seven technologies were evaluated in the course of this study for applications to commercial aircraft. These technologies are either part of the shuttle flight control system as it exists today or are the subject of consideration for possible future application on the shuttle. The technologies are:

- Digital Fly-By-Wire
- Multiplexing
- Ring Laser Gyro
- Integrated Avionics
- All-Electric Secondary Power System
- Electric Load Management by Software Monitoring/Management
- Fiber Optics

These seven technologies were traded off using three baseline aircraft. These aircraft are shown in figure 1. The largest, called the advanced transport aircraft (ATA), is a 500-passenger subsonic airliner. The second two are basically short-haul aircraft, one being a 50-passenger and the other being a 30-passenger commuter-type aircraft.

Important parameters for this study are listed in table 1. Table 2 is a list of baseline aircraft parameters.

The results of the study tradeoffs for near-term (1980's) application are briefly outlined in table 3. This table indicates in a qualitative sense whether or not the tradeoffs yielded a positive payoff for each of the three baseline aircraft. The large aircraft, the ATA, realized a positive payoff from all of the technologies with the exception of the last two: load management and fiber optics. The load management scheme, while not yielding a payoff, was found to be in reality, a necessary part of the all-electric airplane. Fiber optics did not yield an economic payoff but is considered to be a possible useful method of ensuring lightning protection for the all-electric flight control system.

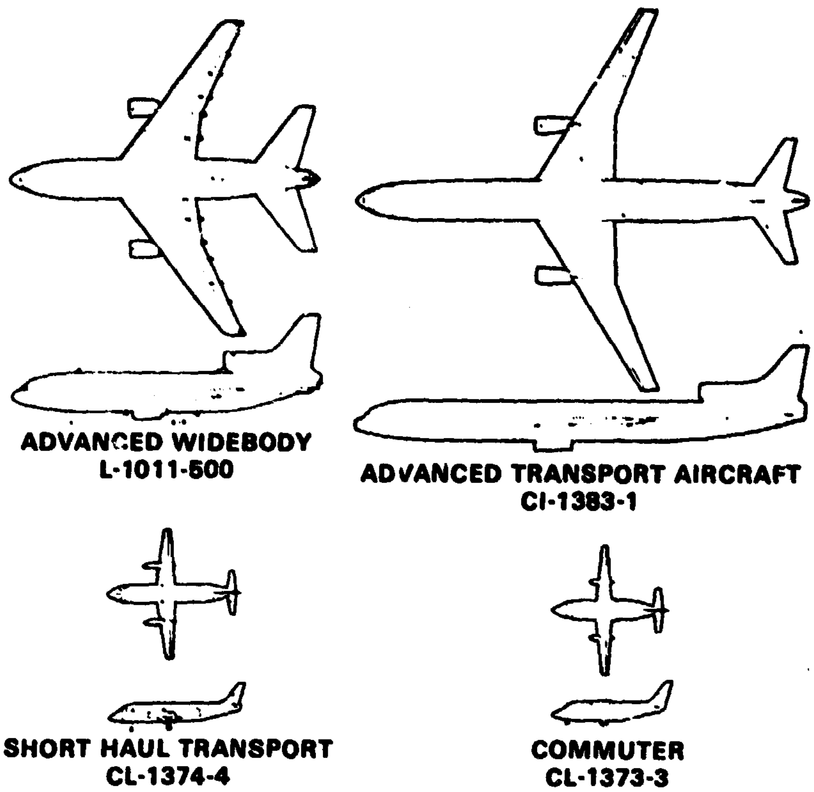

Figure 1. - Aircraft general arrangement drawings.

The 30- and 50-passenger aircraft did not realize a positive near-term payoff with the digital fly-by-wire multiplex technology, the use of ring laser gyros nor integrated electronics of the configuration used in the study. The all-electric aircraft technology, however, may have a useful payoff for both of these smaller aircraft.

Table 4 is an estimate of far-term payoffs; i.e., those expected for 1990s application. This table, unlike table 3, is not based on analysis. It is based on the judgement of the study team members and it shows that all the Shuttle technologies are judged to have positive payoffs except the load management technologies, which are again viewed as a necessary enabling technology for the all-electric aircraft. The near-term weight and cost impacts of each of the technologies are listed in tables 5 and 6. There are a number of ways of portraying weight and cost data. In the tables, the candidate system weights and the cost impacts of the technology during the life of the airplane (referred to as net value of technology) are presented. In the body of the report, other important weights, such as takeoff gross weight and empty weight, and detailed contributors to the above cost parameter are also described.

Referring again to table 6, it is noted that the fly-by-wire technology has two entries. The first reflects the weight payoff that accrues from changes and improvements in the flight control system that result from progressing from conventional to fly-by-wire control. The second larger entry includes a typical additional payoff that fly-by-wire makes possible when the aircraft is rebalanced further aft to accommodate a supercritical airfoil having a nose-down

TABLE 1. - TRADEOFF PARAMETERS

	ATA	SH-50	SH-30
Crew Cost	$468/blk-hr	$125/blk-hr	$75/blk-hr
Maint. Labor	$13/hr	$10/hr	$10/hr
Maint. Burden Factor	2.23	0.8	0.8
Block Time	Flt. time + 10 minutes	Flt. time + 10 minutes	Flt. time + 10 minutes
Insurance Rates	0.304% x total price	1.5% x total price	1.5% x total price
Spares Factor	12%	12%	8%
Depreciation Life	16 yr	12 yr	12 yr
Utilization	3636 hr	2800 hr	2800 hr
Fuel Cost	$0.60/gal & $1.80/gal	$1.00/gal & $1.80/gal	$1.00/gal & $1.80/gal
Base Year	1979	1979	1979

TABLE 2. - AIRCRAFT DESIGN AND PERFORMANCE CHARACTERISTICS

	ATA	SH-50	SH-30
CONFIGURATION	TRIJET	TWIN	TWIN
POWER PLANT	HI BYPASS TURBOFAN	TURBOPROP	TURBOPROP
WING AR	10	10	12
WING SPAN (FT)	200.1	71.1	65.5
BODY LENGTH (FT)	228.3	74.7	58.7
BODY DIAMETER (FT)	19.6	9.5	9.5
GROSS WEIGHT (LB)	459,437	40,427	28,606
EMPTY WEIGHT (LB)	238,019	25,063	18,512
BLOCK FUEL (LB)	83,425	2,816	2,146
OPERATING COST (¢/ASM)	1.66 ($0.60/GAL FUEL)	3.76 ($1.00/GAL FUEL)	4.98 ($1.00/GAL FUEL)

TABLE 3. - NEAR-TERM PAYOFFS (1980'S)

TECHNOLOGY	ATA	SH-50	SH-30
FLY-BY-WIRE	YES		
MULTIPLEXING	YES		
RING LASER GYRO	YES		
INTEGRATED ELECTRONICS	YES		
ALL ELECTRIC AIRCRAFT	YES	YES	YES
LOAD MANAGEMENT	REQUIRED	REQUIRED	REQUIRED
FIBER OPTICS	POSSIBLY ALL-ELECTRIC		

pitching moment. Here we see that the role of fly-by-wire may be mainly that of enabling other high payoff aerodynamic technologies to be applied. The economicpayoff of fly-by-wire is shown in table 6. Note that this technology realizes a dual payoff: cost reduction associated with the flight control equipment and concurrent payoffs resulting from reduced fuel tankage and consumption which result from the supercritical wing technologies. Other technologies such as multiplexing, ring laser gyros, and integrated electronics have worthwhile weight and cost benefits for the ATA aircraft, but like fly-by-wire do not have an apparent payoff for short haul aircraft in the near term 1980s. The all-electric aircraft technology has a remarkably good weight and cost payoff for the larger aircraft and worthwhile payoffs for the short haul designs.

It was attempted to use software load management to achieve further weight reduction in the all-electric aircraft; however, the short-term, high-power flight control loads which dictate the design of a conventional hydraulic system can be handled in the electro-thermal inertia of the electric system without extra capacity being required. Although no additional payoff could be achieved, load monitoring and management will be required in event of generator or engine failure to prioritize loads. As in the shuttle, extensive use of digital software will be made for maintenance and failure monitoring. Fiber optics were briefly reveiwed. It was determined that fiber optics had negligible weight advantage and limited value for protection from electromagnetic interference (EMI) and lightning because the area multiplex arrangement would only make use of MUX in the fuselage, where lightning effects in a wide body aircraft are minimal, not in the wings and empennage, which are more vulnerable to lightning

TABLE 4. - FAR-TERM PAYOFFS (1990'S)

TECHNOLOGY	ATA	SH-50	SH-30
FLY-BY-WIRE	YES	YES	YES
MULTIPLEXING	YES	YES	YES
RING LASER GYRO	YES	YES	YES
INTEGRATED ELECTRONICS	YES	YES	YES
ALL ELECTRIC AIRCRAFT	YES	YES	YES
LOAD MANAGEMENT	REQUIRED	REQUIRED	REQUIRED
FIBER OPTICS	YES	YES	YES

TABLE 5. - SYSTEM WEIGHT PAYOFF

	ATA kg (lb)	SH-50 kg (lb)	SH-30 kg (lb)
FBW vs Conv	+214 (472)	-46 (102)	-85 (188)
MUX vs FBW	+191 (421)	-52 (114)	-54 (119)
RLG vs MUX	+17 (38)		
IA vs RLG/MUX	+23 (51)	+5 (12)	+5 (12)
AEA vs IA	+2415 (5325)	+124 (272)	+106 (233)

IA = Integrated Avionics
AEA = All Electric Airplane
Conv = Conventional, Baseline

\+ Numbers are payoff
\- Numbers are loss

TABLE 6. - ECONOMIC PAYOFF ($ MILLION)

	ATA	SH-50	SH-30
FBW vs Conv.	107	-75	-97
FBW + RSS vs Conv.	881		
MUX vs FBW	109	-49	-48
RLG vs MUX	91		
IA vs RLG/MUX	57	0	-2
AEA vs IA	2402	+94	+83

RSS = Relaxed Static Stability
Fuel - $0.60/Gal

strikes. For the all-electric aircraft, however, fiber optics may be useful forcommunicating with the actuator electronics which are mounted remotely, close to each actuator installation.

The final aircraft weight and cost data was obtained by use of the ASSET program. ASSET, which stands for Advanced Systems Synthesis and Evaluation Technique, is an aircraft design program developed by Lockheed which was adapted for use in this program to reflect the impacts of system variations upon the overall weight and cost parameters of the aircraft.

Capsule descriptions of the tradeoff results are presented in the following paragraphs.

2.1 Digital Fly-By-Wire

The digital fly-by-wire (FBW) system designed for the ATA is a quadraplex digital system using hydraulic actuation. The FBW control system's secondary actuators are electrohydraulic devices and they drive into the existing main power actuators of the conventional system. The digital FBW technology of itself has a positive weight cost payoff. More important, however, is the fact that an FBW control system makes possible the introduction of certain advanced aerodynamic technologies, such as certain supercritical wing designs which yield larger economic payoffs than fly-by-wire itself because of the fuel economies that they produce. The fly-by-wire system is 213 kg (470 lb) lighter than the conventional flight control system which results in a TOGW reduction of 440 kg (971 lb). When used to provide stability for an aft-balanced advanced wing installation the TOGW is reduced 2300 kg (5060 lb).

Although not found to be applicable for the smaller aircraft in the near term, use of FBW should prove to be viable in the 1990s. FBW components will be smaller and cheaper and in the future there will be a much more comprehensive use of redundant electronics in these aircraft, for example: to accomodate Category III landing. It is also felt that 1990s aircraft of all sizes will be using aerodynamic features which cause the airplane to be considerably unstable, necessitating full-time electronic augmentation. The combined impact of these two influences will be to necessitate the use of a fly-by-wire solution. In the context of a redundant autopilot and Autoland® system, the additional electronics required for FBW controls will be comparatively trivial.

2.2 Multiplexing

This technology is an adaptation of the area multiplexing on the shuttle. The digital fly-by-wire computers communicate with the various sensors and actuators in the aircraft through multiplex/demultiplex (MDM) units. These units are quadraplex and are mounted at the wing roots and at the aft section of the airplane. There are three sets which were adapted for the ATA airplane in contrast with the two sets of MDMs used in the space shuttle. The weight savings from the use of multiplexing accrues entirely from the reduction in wiring weight which MUX makes possible. In a far-term application, the area

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multiplex scheme would give away to a completely multiplexed arrangement, where the communication to the actuators is through two-way digital bussing technology. In the near-term multiplex scheme, the bussing arrangement used is in conformance with ARINC spec. 429. These are one-way busses which, it is felt, would enhance the safety of the near-term system. A far-term bussing arrangement would make use of two-way bussing to save the weight of the wiring which would accrue from the proliferation of one way busses.

Multiplexing will also have a payoff for the short-haul aircraft in the 1990s when these aircraft are equipped with fly-by-wire control systems. The weight payoffs which are realized will accrue from the same reasons as in the large ATA aircraft. However, because of the shorter wire runs the results will not be quite as dramatic.

2.3 Ring Laser Gyro

This technology has been demonstrated to have a financial payoff for the ATA when used as a navigation sensor. It will be used on aircraft going in service in the 1980s such as the 757 and 767. In this study, the ring laser gyro was applied from the point of view of serving not only as a navigation sensor but also as a sensor which provides rate and attitude information to the FBW flight control system, thus eliminating rate gyros and attitude gyros completely from the aircraft.

Ring laser gyros as a navigation device will probably not be required for the short-haul aircraft in the far-term. Area navigation and possibly satellite navigation will provide all the required navigational accuracy. However, it is felt that the short-haul aircraft, if using technologies which cause aerodynamic instability, can make good use of the ring laser technology as a source of attitude and rate information, which will be required for dynamic and static stabilization of the airframe. In the near term, such technologies are not anticipated; however, in the 1990s their use will be expected.

2.4 Avionics Integration

The shuttle makes use of a totally integrated avionics concept in which all flight controls, avionics, and other computational functions are resident in four control computers plus a backup. Total centralization is not considered beneficial in today's aircraft. Rather, integration of functions in an optimum number of distributed processors is considered a more effective use of digital processing equipment. In this study a near-term integration scheme was adopted in which the conventional flight controls, navigation systems, and displays computerized were integrated into a smaller number of computer housings to achieve a modest weight, cost, and logistics payoff.

2.5 All-Electric Aircraft

This technology had the most dramatic improvement for the three candidate airplanes. On the ATA aircraft alone it was responsible for a systems weight reduction of 2860 kg (6300 lb), which translates into 8500 kg (18 700 lb) of takeoff gross weight for the airplane. Not only was weight reduced, but there were other significant benefits to the total airplane design: maintenance costs, first costs, and airplane design costs were all reduced by the introduction of this technology. Of all the seven technologies studied, the all-electric airplane was the one which was found to have a clear-cut payoff for all three of the candidate aircraft. This tradeoff necessitated a substantial preliminary design effort in order to be able to produce meaningful tradeoff data.

The all-electric power system made use of 270 vdc to power primary flight control actuators and to supply an inverter for avionics 400 Hz requirements. Other needs were supplied with AC power having voltage and frequency that varied with engine speed. This unregulated power, which accounts for about 85 percent of all power generated, provided a very lightweight generation and distribution system. One of the main economic benefits comes from the elimination of bleed air for the environmental control system (ECS). Bleed air extraction exacts a heavy fuel penalty from the engine.

2.6 Electrical Load Management (Software Monitoring/Maintenance)

It was attempted at the outset of the study to realize a reduction in system weight by using the software to prioritize short-term loads, particularly from the flight control system, in such a way that other lower-priority loads such as the galley or the ECS system would be temporarily cut back for the duration of the short-term loads. However, in the course of analysis it was determined that the duration of these short-term loads for devices such as the flaps and landing gear were such that their peak currents could be handled by the inherent overload capability of the generating devices. Hence, there was no definable payoff for the use of load management by means of the system software with all systems operating. In the case of failures of the generating equipment or of the engines which drive the generating equipment, some sort of load management is a necessity and software in the system will be required to accommodate such management. Other features of the shuttle software, such as the use of a higher order language/structured programming and widespread use of software maintenance and performance monitoring, were found also to be required for the application of both fly-by-wire and all-electric aircraft systems. These technologies have already become state of the art for commercial aircraft digital systems.

2.7 Fiber Optics

The fiber-optic trade-off was not done in as much depth as the other trade-offs; it was determined that for the near-term however, fiber optics is a marginal technology. The use of an area multiplex scheme which would then allow the fiber optics to be used only for the busses which communicate from the flight control computers to the mux-demux units (MDMs) certainly limits potential payoffs of the fiber-optic technology as a means of reducing the vulnerability of electronic systems to lightning strikes or EMI sources. Based on prior Lockheed studies, there appears to be an insignificant weight payoff from the use of fiber optics in the flight control system in the area multiplex scheme. The all-electric system which uses digital links to the actuators may, however, make good use of fiber optics.

It was felt that fiber optics is much more appropriate for the far-term technology for two reasons. In the first place the coupling devices for fiber optics, which may have to serve many remote terminals in a completely multiplex system, will be more developed in the 1990s time period. Additionally, the widespread use of composites in the 1990s may make the use of fiber-optics signal transmission devices for flight controls throughout the aircraft more appealing because it is generally felt that the composite aircraft skin will not have the same level of relative invulnerability to lightning interference that the metal skin airplanes of today have.

2.8 Technology Assessment

The applications of shuttle technologies found to be of value in this study were assessed from the standpoint of acceptance by the commercial aircraft users. In general, flight-critical technologies were arranged into development plans that were evolutionary in nature to ensure that each recommended advancement was solidly based on accumulated experience with its predecessor technology and was capable of certification. For example: rather than take the step to full fly-by-wire in the 1980s, it is recommended that an interim system be used on the next generation flight controls in which fly-by-wire digital electronics are backed up with a simplified mechanical system. After millions of hours of in service experience, accumulated confidence would build in the full-time electronic control system and future full FBW would be accepted as safe.

2.9 Report Organization

Section 3 describes the approach taken to perform the various technology tradeoffs. It presents an overall view of the evaluation cycle. Section 4 contains a description of tradeoff guidelines established for this study. Section 5 contains detailed descriptions of the baseline systems of the three candidate aircraft, against which the advanced technologies were traded off. Section 6 describes the trade-off methodology. Section 7 describes the tradeoff systems and the separate tradeoff results. Section 8 is a compilation of tradeoff results. Section 9 is an assessment of the various technologies, their value to commercial aircraft operation, and their respective development needs. Development strategies are recommended to advance the state of the art of the promising technologies, with the eventual goal of certification and introduction to the U.S. commercial aircraft fleet.

3. APPROACH

The approach taken in this study was to determine if space shuttle technologies are suitable for commercial aircraft application by determining if economic payoffs would result from their use. Payoffs were evaluated for three commercial aircraft designs. These aircraft were a 500-passenger wide-body designed for Mach 0.8 cruise; and two short-haul aircraft, 50- and 30-passenger turboprops designed for Mach 0.7 and Mach 0.6 cruise, respectively.

The technologies were compared, or traded off, against baseline configurations to determine their respective payoffs. Baseline avionic and flight control systems were defined for the three aircraft and careful cost, weight, and reliability estimates were made to establish a valid standard for comparison of the shuttle technologies. These baseline configurations, which are described in Section 5, are representative of the state of the art of today's aircraft.

Most emphasis was placed on the largest aircraft, the Advanced Transport Aircraft (ATA). New technologies are often pioneered on these larger aircraft because of the availability of development capital, with the smaller aircraft following after development is complete. The ATA baseline system designs were extensions of Lockheed L-1011-500 data with some modification. For example, ARINC 700 avionics were postulated for the baseline avionic suite.

The technologies traded off were: digital fly-by-wire, multiplexing, ring laser gyros, integrated avionics, all electric aircraft, load management, and fiber optics. Each technology was evaluated for each of the three aircraft. To keep the tradeoffs to a manageable number, each tradeoff was compared against a baseline which incorporated the tradeoffs completed before it. The first tradeoff, digital fly-by-wire, was traded off against conventional configurations of the three baseline aircraft. The second technology (multiplexing) was applied to the digital fly-by-wire control system and compared against the aircraft with digital fly-by-wire alone. Succeeding technologies were accordingly traded off against the aircraft including all the previously completed technologies. This approach was adopted because tradeoffs of the many practical combinations of the technologies would have necessitated a level of effort greater than the resources of this study.

The bulk of the study effort was expended on definitions of baseline aircraft designs and then the careful synthesis of systems that applied the candidate shuttle technologies to three aircraft. System designs were advanced to the point where accurate weight, cost, reliability, and maintenance data could be obtained. In some cases, as in actuators for example, accurate aerodynamic loads were used and detailed design analysis was completed in order to obtain representative system characteristics. An equivalent level of effort was required for most of the rest of the secondary power system equipment, the environmental control system, and the engine starting equipment. The team approach served two useful purposes: (1) expertise was provided in the many technical areas of involvement and (2) The team members served as a built-in check and balance on each other -- very important when trying to complete a large amount of original work in a short time.

The technology tradeoffs were conducted in such a way that the maximum payoffs were realized. For example, a weight savings in a system such as the flight control system was reflected also in the airframe weight and fuel fraction. The three baseline aircraft were in effect "rubberized" meaning that the payloads and missions were kept constant but the basic airplane was designed with each tradeoff to exactly account for changes in system weight. Accordingly, a reduction in system weight would result in a reduction in gross weight (approximately twice as great) and a subsequent reduction in lifetime fuel costs. This approach is appropriate to future airplane designs because the maximum realizable payoffs are computed and lifetime cost savings can be compared using a common payload requirement which is usually a fixed starting point for a new design.

An alternative approach would be to take advantage of reduced system weight by assuming greater range or more passengers, but this approach has the disadvantage that the tradeoffs would result in a number of dissimilar payloads and/or ranges. Moreover, a certain amount of rubberizing would be required anyway to provide room for additional passengers. This study, with its rubberized aircraft, maintained the same passenger payload for all tradeoff configurations with comparison made between important cost parameters such as direct operating cost and lifetime cost differentials (net value of technology).

A key tool in the tradeoff process was the aircraft design program called Aircraft Systems Synthesis and Evaluation Technique or ASSET. This program, developed for synthesizing aircraft designs, was pressed into use as a means of evaluating advanced system payoffs on the entire aircraft. The three baseline aircraft used in this study were already programmed in detail on ASSET for other NASA studies, saving considerable cost and time. The ATA was programmed for the Energy Efficient Transport study sponsored by NASA Lewis Research Center and the other aircraft for the NASA Ames Short Haul Study. ASSET is described in more detail in Section 6.0.

4. TRADEOFF GUIDELINES

A comprehensive compilation of economics, mission, and design guidelines was prepared to ensure that the tradeoffs were based upon realistic assumptions and realizable configurations.

4.1 General Requirements

- Baseline or conventional configurations included electrical/electronic systems representative of current commercial aircraft.
- The Advanced Transport Aircraft (ATA) preliminary design was based on the L-1011-500 data base.
- The short-haul aircraft systems data was adapted from the ATA but modified to suit the avionics suite and control sizing requirements.

- Calculation of economic characteristics were based on 1979 dollars. This included escalated fuel costs.

- Direct Operating Cost (DOC) was calculated using the guidelines of Table 1.

- All of the tradeoff systems were designed for FAA certification.

- Dispatch reliability was made equal to or better than that of the corresponding baseline system.

- The aircraft productivity was designed to be equal or better than the baseline aircraft.

- Crew workload was designed to not exceed work levels of today's aircraft.

4.1.1 Digital Fly-By-Wire Design. - The flight control system was designed to comply with the following guidelines:

- There shall be no single failure points in the flight control system that are flight critical. The flight control electronics shall be quadruply redundant. No more than two of the four parallel channels of sensors, electronics, and other flight control equipment shall be housed together. Consideration shall be given to the use of analytic redundancy to enhance operation following sensor failures. A direct electronic link (DEL) mode shall be available in case of total failure of feedback sensors. Control shall be by centerstick or sidearm control.

- The probability of catastrophic failure of the flight control system shall not exceed 1×10^{-9} failure per flight. The probability of failure of the stability augmentation shall not exceed 1×10^{-7} failures per hour.

- Built-in test equipment shall detect 100 percent of first- and second-parallel electronic flight control failures. In the event of third-parallel failures, undetected by on-line monitoring, the system shall revert to a fail-safe configuration. This requirement applies to the fly-by-wire control system including the Autoland system. Preflight checkout shall be automatic and shall check out all flight control equipment and auxiliary systems.

- Asymmetry detection shall be provided for spoilers, flaps, and slats. Flap and slat locking shall be provided to prevent asymmetric deflection in case of failure.

- Electrohydraulic actuators shall be used to communicate electronic signals to the power actuators in the initial tradeoff. As part of the all-electric airplane tradeoff, electromechanical actuators shall be substituted for the electrohydraulic command and primary actuators.

- The flight control system was designed in accordance with the following FAA documents.

FAR Part 25, plus all current Amendments	Airworthiness Standards: Transport Category Airplanes (FAA)
FAA AC 20-57A	Automatic Landing Systems
FAA AC 25.1329-1A	Automatic Pilot Systems Approval
FAA AC 120-28B	Criteria for Approval of Category IIIA Landing Weather Minima
FAA AC 120-29	Criteria for Approving Category I and Category II Landing Minima for FAR 121 Operators

4.1.2 Multiplexing. - Multiplexing for the digital fly-by-wire flight control system shall be applied with proper consideration given to the quantity and placement of MUX remote terminals that best reduces wiring weight while preserving system reliability and safety goals. All tradeoffs subsequent to the MUX tradeoff will make use of MUX technology.

4.1.3 Ring Laser Gyro (RLG) Integrated Sensors. - This tradeoff shall make use of an RLG configuration that provides required redundancy for flight safety, meets system reliability standards and provides the angular rate and position data required for both the avionics and the flight control systems.

4.1.4 Integrated Avionics. - This tradeoff shall take the shuttle concept of total integration of electronics and update it to a 1980s level of commercial computer architecture and data handling. Systems to be integrated shall include: primary and secondary flight controls, automatic flight control, flight management, CADC, display electronics, navigation.

4.1.5 All-Electric Aircraft. - This tradeoff shall investigate the payoffs of replacing hydraulic and pneumatic secondary power systems (SPS) with an all-electric SPS. The results shall be presented in such a way that comparisons may be made between important tradeoff parameters (such as actuator weights, wiring, etc.) in the conventional and in the all-electric systems.

4.1.6 Load Management Technique. - A tradeoff shall be made to determine if a significant weight or cost advantage can be achieved by computer-controlled prioritization or sharing of the loads of the all-electric SPS.

4.1.7 Fiber Optics. - Replacement of the hardwire MUX links with fiber optic links shall be studied as a means of reducing electrical interference from other aircraft systems and from the environment.

4.2 Aircraft Utilization Model

The utilization definitions to be used for this study include the following:

- Total demand (market requirements)
- Types of aircraft
- Production quantity
- Aircraft life
- Mission profile

Total demand for worldwide aircraft for the 1990s was established, by aircraft type and size, using the projected passenger demand depicted in figure 2 and the projected route structures required to meet this demand.

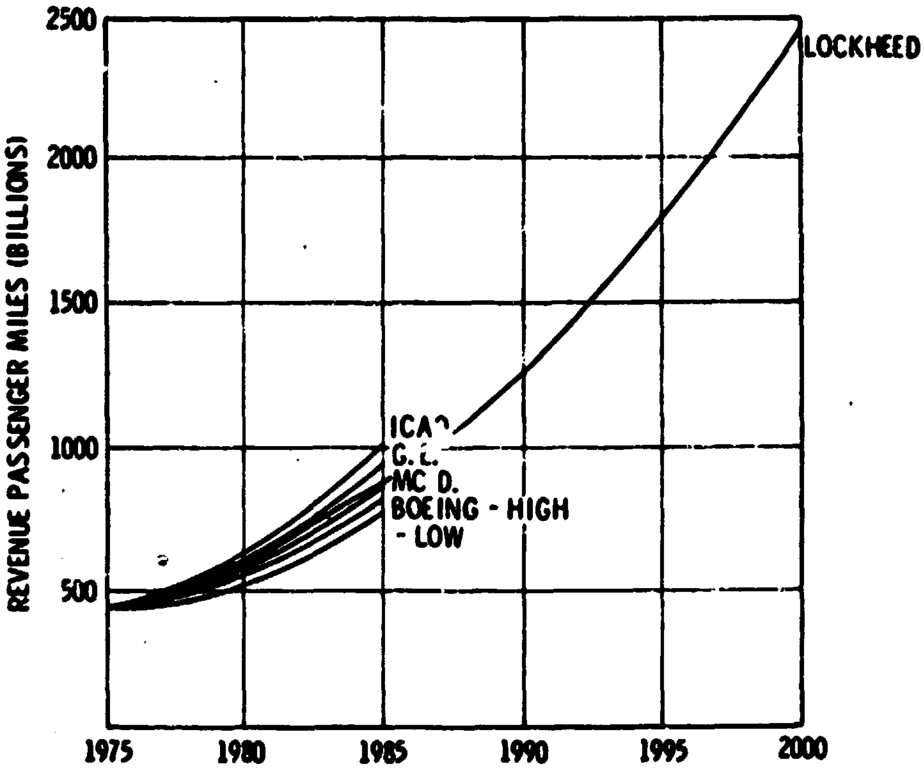


Figure 2. - ICAO world traffic comparative forecast.

Aircraft selected to fulfill the demand requirements were segregated into categories of required design ranges and cruise speeds to obtain the best match of aircraft performance. This segregation resulted in the following aircraft types:

- Trijet configuration with high-bypass turbofan engines for transcontinental range and Mach 0.8 cruise speed with high density passenger capability.

- Twin turboprop configuration for short/medium range with low passenger density and Mach 0.7 cruise speed.

- Twin turboprop configuration for commuter application and cruise speeds up to Mach 0.6.

Production quantities and aircraft life parameters were established as follows:

	ATA	Short-Haul	Commuter
PROD. QTY	300	250	250
LIFE	16 yr.	12 yr.	12 yr.

4.3 Mission Profiles

The mission profiles are shown in detail in Appendix A. Profiles include fuel reserves as specified by applicable federal air regulations. The mission profiles are summarized as follows:

A T A

SEGMENT	TIME MINUTES	SPEED MACH	ALTITUDE° METERS (KFT)
Takeoff	1.3	0	0
Climb	16.1	0.38	0
Accelerate	2.0	0.69	9,144 (30)
Climb	6.7	0.8	9,144 (30)
Cruise	355.5	0.8	11,277 (37)
Descent	3.8	0.8	12,496 (41)
Decelerate	0.9	0.8	9,144 (30)
Descent	16.8	0.69	9,144 (30)
Loiter & Land	3.0	0.33	457 (1.5)

SH-50

SEGMENT	TIME MINUTES	SPEED MACH	ALTITUDE METERS (KFT)
Takeoff	1.0	0	0
Climb	2.5	0.38	0
Accelerate	0.5	0.46	3,048 (10)
Climb	34.5	0.55	3,048 (10)
Cruise	37.7	0.7	11,095 (36.4)
Descent	8.8	0.7	11,247 (36.9)
Decelerate	0.6	0.55	3,048 (10)
Descent	3.9	0.45	3,048 (10)
Loiter & Land	3.0	0.28	457 (1.5)

SH-30

SEGMENT	TIME MINUTES	SPEED MACH	ALTITUDE METERS (KFT)
Takeoff	1.0	0	0
Climb	4.3	0.38	0
Climb	54.9	0.45	3,048 (10)
Cruise	33.6	0.6	9,022 (29.6)
Descent	8.2	0.6	9,1144 (30)
Descent	3.5	0.46	3,048 (10)
Loiter	3.0	0.25	457 (1.5)
Land	2.0	0.37	457 (1.5)

5. BASELINE AIRCRAFT

This section describes the aircraft configurations and defines the aircraft systems requirements for the baselines to be used as reference during the course of this study effort. Three different aircraft were selected as baseline configurations: a large subsonic transport with transcontinental range, and two small, short-haul transports. Utilization of the above baseline designs provided an opportunity to evaluate the potential benefits available with advanced-technology electrical/electronic systems for a wide range of commercial aircraft designs. Each of the baseline aircraft were previously optimized for minimum DOC characteristics at their respective design range and mission.

5.1 Advanced Technology Aircraft

The advanced technology aircraft (ATA), as depicted in figure 3, is a large subsonic commercial air transport for transcontinental routes, expected to be operational in the late 1980's or early 1990's. The baseline ATA is an advanced technology version, or derivative, of the Lockheed L-1011 commercial air transport and is designed to carry a payload of 500 passengers over a 3000-nautical-mile range. This aircraft was used as one of the designs for the NASA-sponsored Energy Efficient Engine (E^3) studies (Contract NAS1-20646). Design and technology features of ATA are depicted in table 7.

Advanced technologies which have been incorporated into the ATA are: supercritical wing for increased aerodynamic efficiency, structural efficiency (airfoil thickness) and lighter structural weight; active controls systems for wing load relief and relaxed static stability; advanced composites (approximately 50 percent) for both primary and secondary structure; and advanced technology high bypass turbofan engines.

Preliminary design studies were previously accomplished at Lockheed to fully characterize the design, performance, and economic attributes of the ATA. These characteristics, which establish the basis for evaluation of the benefits to be gained through incorporation of advanced technology electrical/electronic systems, are depicted in table 8.

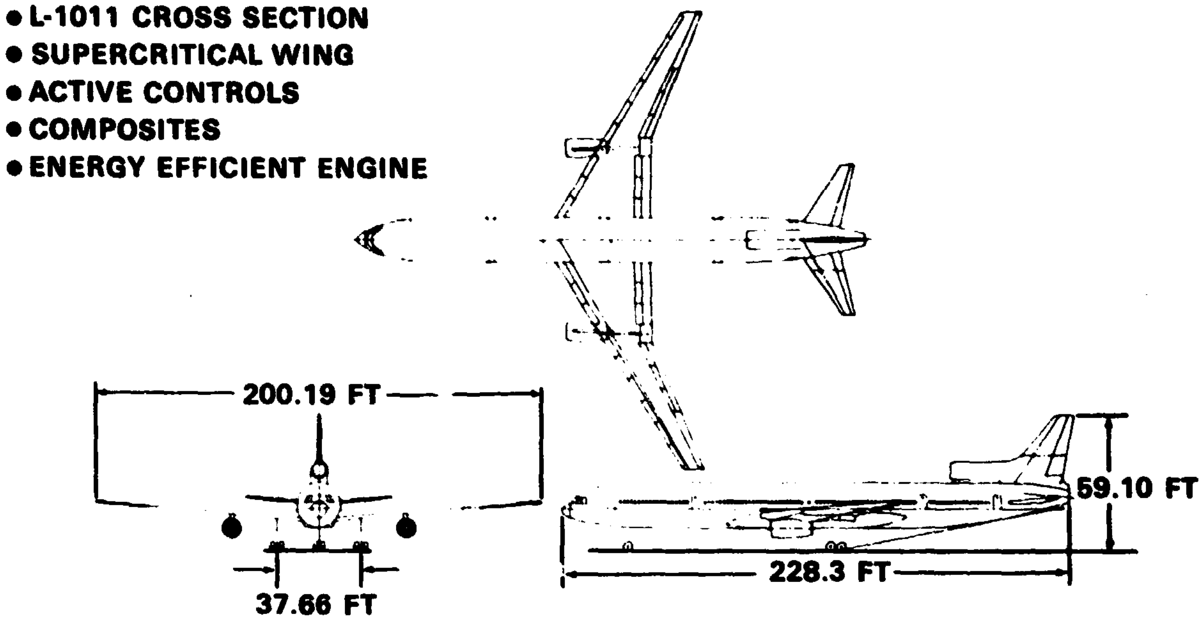


Figure 3. - Advanced transport aircraft.

5.1.2 Flight Controls. - The baseline flight control system includes the primary and secondary flight controls including stability augmentation, autopilot, spoilers; and auto throttle. The baseline system is similar to the existing L-1011 system but is sized for the ATA aircraft and includes pitch control augmentation for an increment of relaxed pitch stability and active ailerons for gust aleviation, maneuver load control, and elastic mode suppression. The baseline system uses mechanical cable control of servo valves which control full power hydraulic actuators moving the aerodynamic surfaces. Figure 4 shows the location of the flight control surfaces.

Figure 5 is a simplified block diagram illustrating the relationship between the mechanical and electronic flight controls. Autopilot and stability augmentation inputs are applied in parallel with the column inputs in the pitch axis and dual mode servo valves in the roll and yaw axis.

Figure 6 is a simplified block diagram showing the electronic flight control system. The flight control computer is digital and quadruply redundant. The primary flight control computer is mainly analog and contains stability augmentation circuits, stall warning, altitude alert, system monitor, direct lift control, automatic ground speed brake, and fault isolation monitor. The trim computer provides dual segregated subsystems for manual and automatic pitch trim, Mach trim, and Mach feel. The interconnections to sensors, servos, and instruments are analog; the interconnection with the navigation computer is digital. The significant features of the flight control electronic system are:

TABLE 7. - DESIGN AND TECHNOLOGY FEATURES - ATA

Aircraft Type	Wide body trijet 6m (235 in.) fuselage diameter 9-abreast seating
No. of Engines and Location	2-wing mounted 1-center mounted
Payload Capacity	45 350 kg (100 000 lb) (500 pax)
TOGW Class	227 000 kg (500 000 lb)
Engine Thrust Class	200 000 N (45 000 lb)
Mission Characteristics	
Design Range	5500 km (3000 n. mi.)
Cruise Speed	0.80 Mach
Cruise Altitude	11 000 m (35 000 ft)
TOFL	2000 m (7000 ft)
Approximate Speed	70 m/s (135 kt)
Advanced Technologies	
Supercritical Wing	3% reduction of wing weight - increased thickness of airfoil AR = 10 t/c = 13% Sweep = 30^0
Active Controls	-5.5% wing weight
Load Relief	-1% body weight
Relaxed Stability	3% fuel consumption improvements
Advanced Composites	-8.7% M.E.W.
Primary Structure	
Secondary Structure	

- Roll and pitch attitude hold with control wheel steering
- Heading select and hold
- Altitude select and hold
- Vertical speed select and hold
- Indicated airspeed and mach hold
- Auto control from VOR and area nav.
- Speed control and auto throttle
- Active symmetric aileron control for maneuver load alleviation and gust alleviation
- Cat III ILS auto approach and land

TABLE 8. - ATA DESIGN AND PERFORMANCE CHARACTERISTICS

Mission Characteristics	
Design range	5556 km (3000 n.mi.)
Cruise speed	0.80 Mach
No. passengers	500
Initial cruise altitude	11 278 m (37 000 ft)
Field length	2126.3 m (6976 ft)
Approach speed	69.45 m/s (135 kt)
Design Characteristics	
Configuration	3-engine Trijet
Power plant	P&WA STF505M-7C
Sweep (0.25c)	30^0
W/S	5497 N/m^2 (114.8 lb/ft^2)
T/W	0.255
AR	10
E/C (%)	13
TOGW	208 400 kg (459 437 lb)
OEW	108 000 kg (238 019 lb)
Wing span	61 m (200.1 ft)
Body length	69.59 m (228.3 ft)
Body diameter	5.97 m (19.6 ft)
Performance Characteristics	171 661 N (38 591 SLS, lb)
Block fuel	37 840 kg (83 425 lb)
DOC (¢/ASM)	1.66

*DOC calculated with $0.60/gallon fuel cost.

- Takeoff and go-around guidance
- Yaw and nose wheel steering for rollout
- Lift compensation during turns
- Failure protection and warning
- Auto fault isolation

5.1.2.1 Pitch Control: Figure 7 shows the pitch control system. The horizontal stabilizer rotates for pitch control and trim input. The elevator portion is geared to the stabilizer through a nonlinear mechanical drive train for added control effectiveness. Four parallel hydraulic actuators operate in unison to drive the stabilizer. The actuators are controlled by four servo valves each supplied by one of four hydraulic systems. The valves are combined in assemblies of two. Each assembly has one mechanical input linkage and two feedback linkages, one for each valve. The input is mechanically connected to

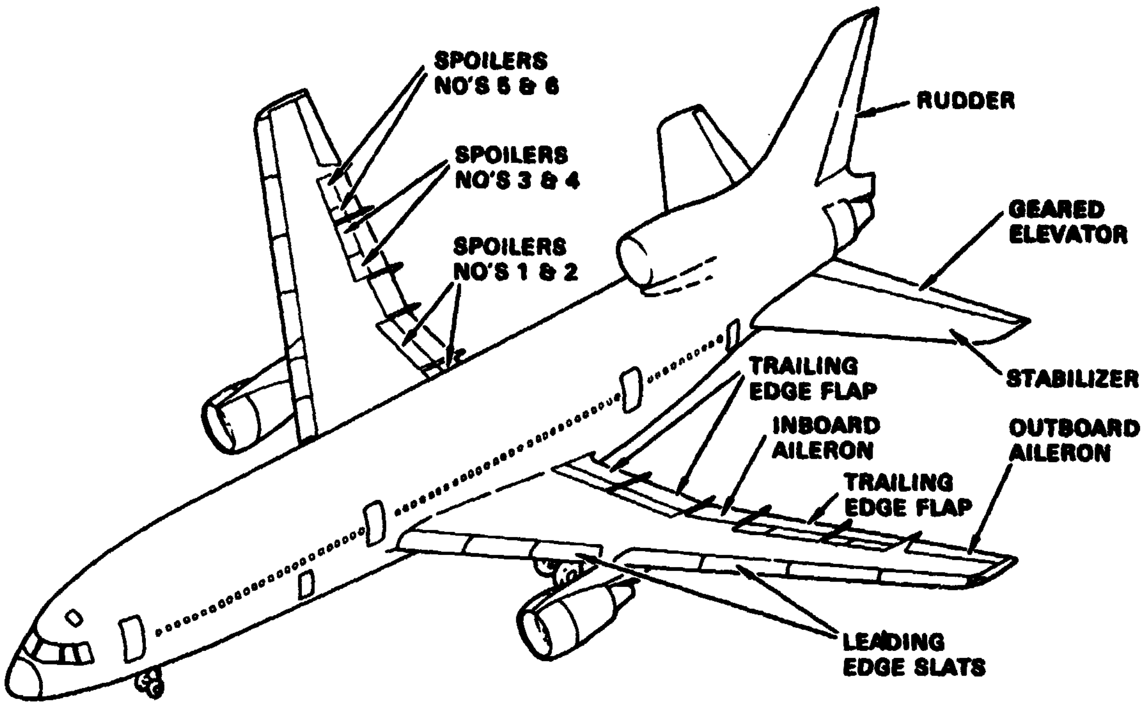


Figure 4. - Flight control surfaces.

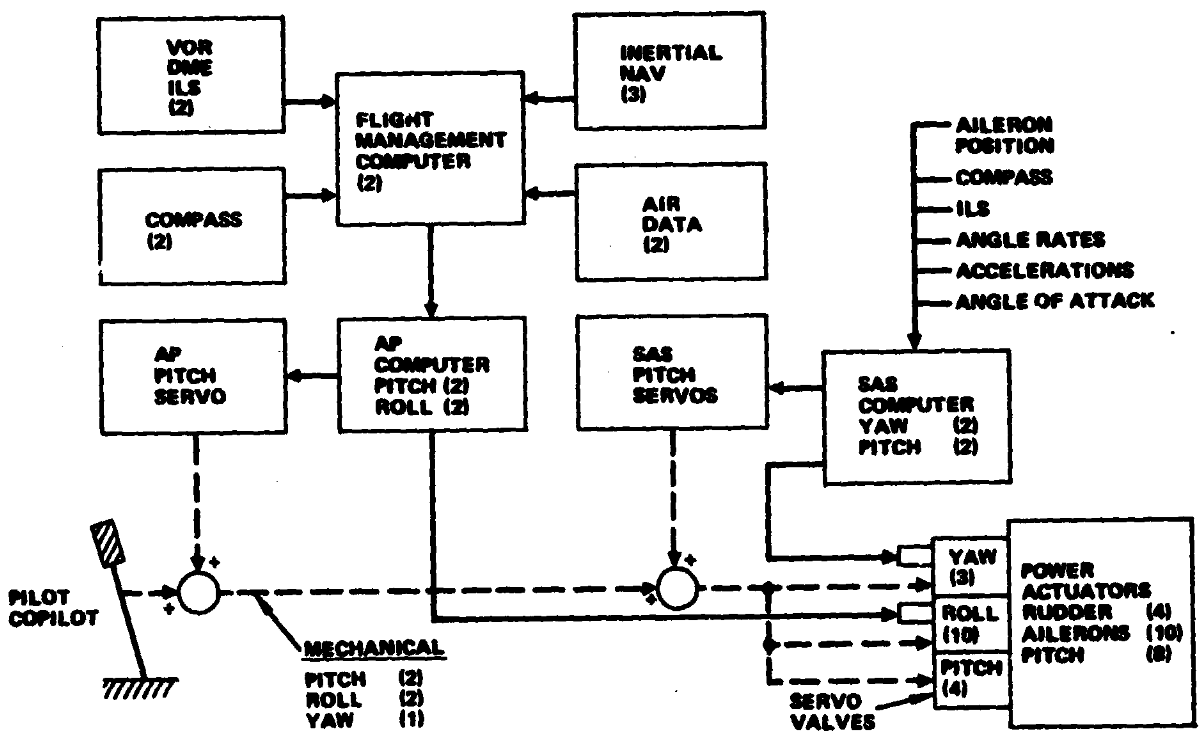


Figure 5. - Baseline flight control and navigation.

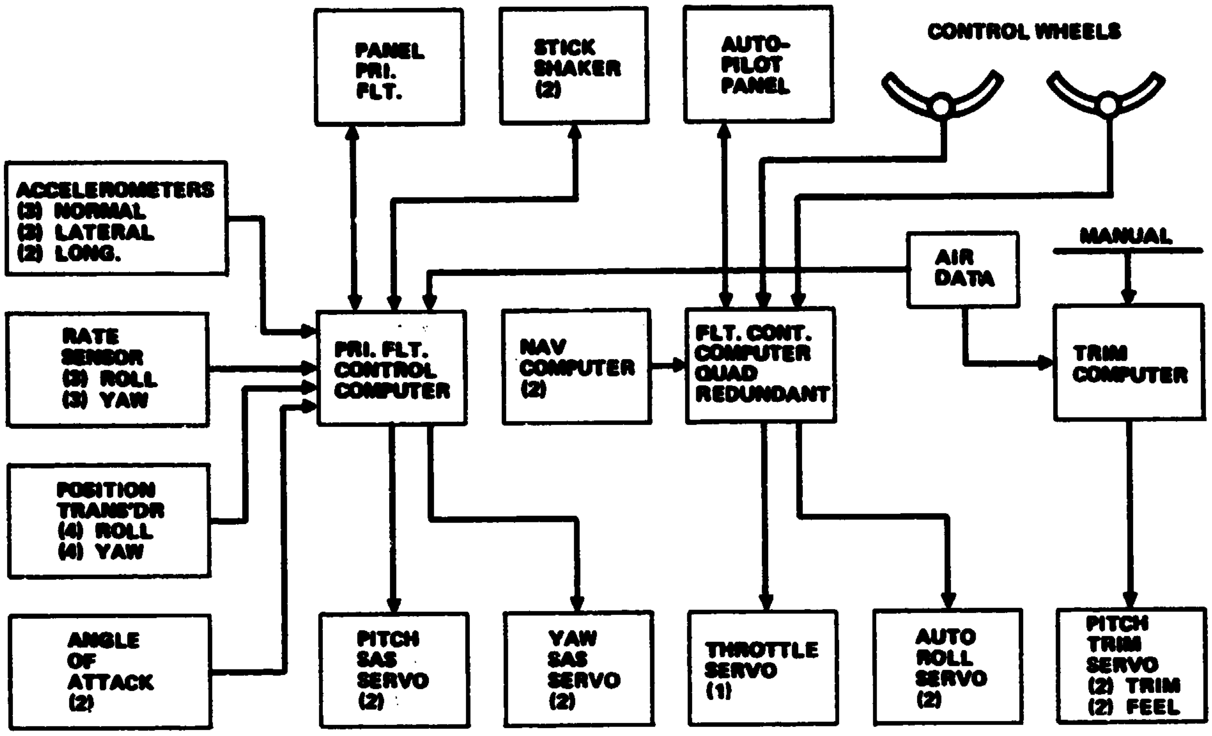


Figure 6. - Baseline digital flight control.

the feedback linkages to close the servo loop. The primary control path is entirely mechanical up to the servo valves, however, this control is modified with powered limited authority inputs from the autopilot, trim system and feel system. The mechanical cable/push rod systems are dual, one for the pilot and one for the first officer (copilot). They are coupled so that both work in unison under normal conditions. The forward coupler can be disconnected manually by the pilot or first officer. The aft coupler located as a part of the stabilizer servo system, is electrically disconnected only when both servos on one side are de-energized. Decoupling, either aft or forward, is required only in case of a system jam.

As the stabilizer leading edge moves from one degree up to 14 degrees down, the geared elevator moves in the same direction as the stabilizer from zero (faired) to 28 degrees trailing edge up.

- Pitch Feel and Trim System: Figure 8 is a simplified diagram of the feel trim system. The trim motor, operated by a manual switch on the control column, is primarily a combined series/parallel trim to decrease column excursion required for trimming. The series trim input moves the linkage from position A to position B. The parallel trim input moves the linkage through the feel spring which moves the control column and linkage from position C to position D. The resultant motion moves linkage E to F (figure 8) thus moving the stabilizer. The feel spring constant is further modified by the trim angle and the Mach number. The pilot's feel force is the product of control column

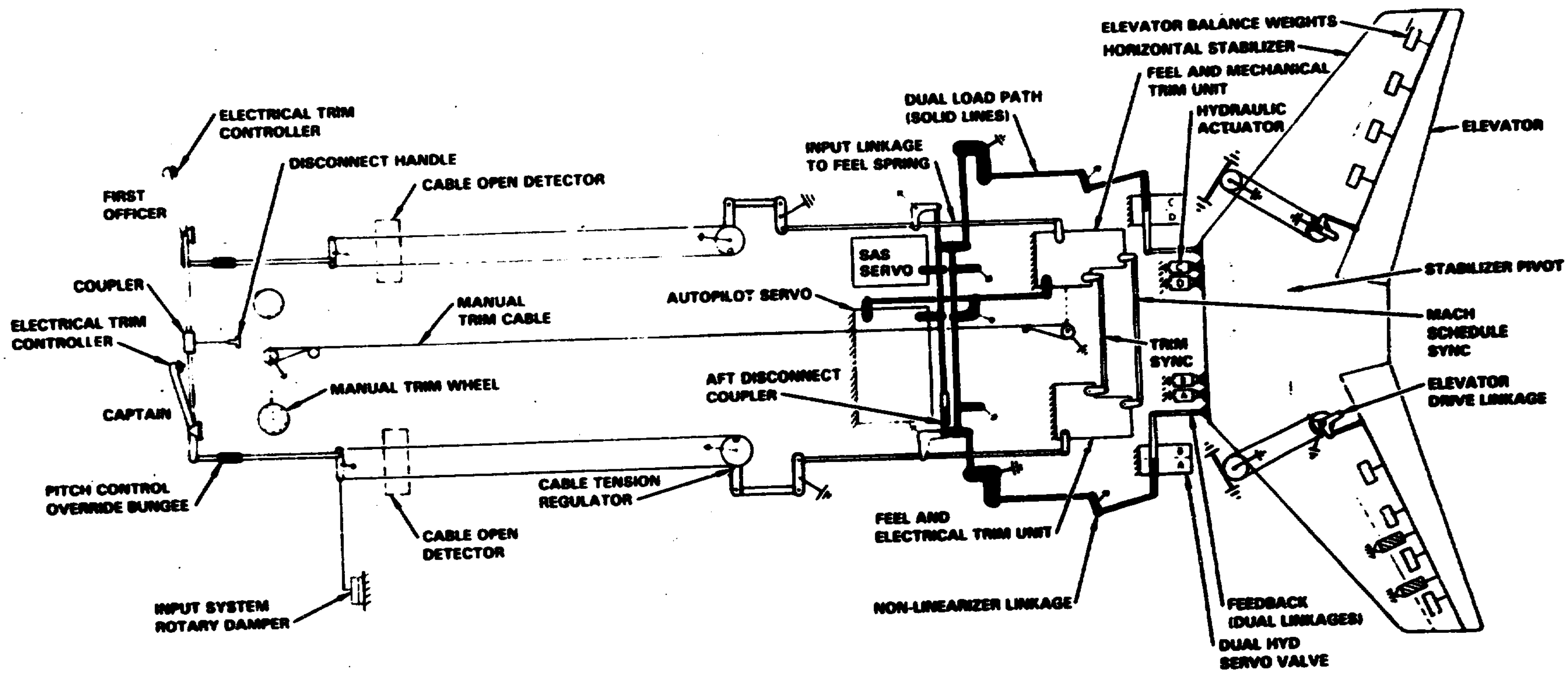


Figure 7. - Conventional system pitch axis.

displacement from trim and the spring constant. The trim motor is also controlled automatically by the autopilot when engaged; and by the Mach number to compensate for movement of aerodynamic center of pressure.

The pilot may override the output of the trim motor with a manual trim wheel through cable, gears, and a ball clutch. The feel force is a maximum of 378N (85 pounds) at the column and can be overriden by the pilot. No matter where the trim is set, the pilot can obtain full excursions of the stabilizer with reasonable column forces.

- Pitch Monitoring System: A monitoring system detects jams and open links in the mechanical system. The sensing system consists of bungees (springs) in the cable systems and aft coupler that are instrumented to detect motion when the force exceeds bungee preload force, and cable integrity sensors instrumented to detect loss of continuity. A logic network uses the signals to determine the location of the jam or open and the appropriate action required. Warning lights direct the pilot to remove hydraulic power from the appropriate servos and manually disconnect the forward coupler. The aft coupler opens automatically when power is removed from the servo valves. Control is maintained by the redundant cable system and the remaining set of servos, however, the feel force is reduced to one-half of normal when the coupler is open.

- Stall Warning System: An artificial stall warning is provided by means of two shakers which vibrate the pilots' control columns whenever the aircraft speed is less than 1.07 times the stall speed. The stall speed is computed using a combination of air data, angle of attack, slat, and flap positions. The system is inoperative when the landing gear struts are compressed (aircraft is on the ground). The system commands the spoilers to retract when a stall warning is indicated. Sensor and power faults are annunciated in the cockpit and channel selection capability is provided.

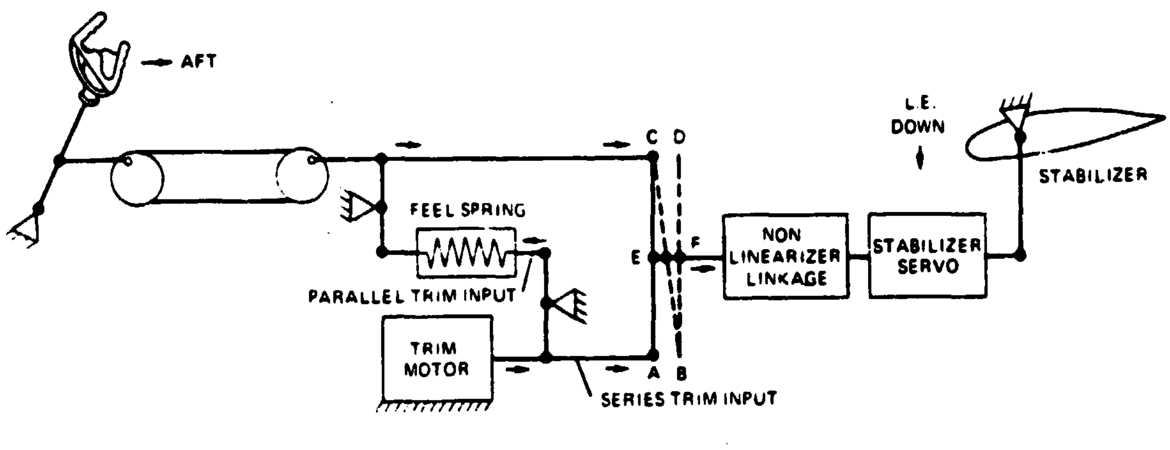


Figure 8. - Pitch trim system.

5.1.2.2 Roll Control System: Figure 9 is a roll control schematic diagram. Pilot control inputs are communicated mechanically from the control wheels to the servo valves at the ailerons. Separate paths are provided from each control wheel to the inboard aileron on the corresponding side (left or right). In normal operatrion the control wheels are coupled and the left and right ailerons operate in unison asymmetrically. If a jam occurs, the wheels can be manually decoupled.

All four aileron surfaces deflect ± 20 degrees. Aileron roll control is supplemented by spoilers during low speed (flaps extended) flight. Spoiler deflection is a nonlinear function of aileron deflection with 40 degrees of up spoiler corresponding to 20 degrees of up aileron on the same wing. Similarly, 2.5, 12.5, and 17 degrees of aileron correspond to 0, 10, 20 degrees of spoiler, respectively.

- Aileron Servos: Three hydraulic actuators and three servo valves serve each inboard aileron; and two actuators and two servo valves serve each outboard aileron. Each actuator for a particular aileron is supplied by a separate hydraulic system. The servo valves for a particular aileron are assembled with a common input torque shaft. Two feedback rods are provided at each servo valve. Two input rods are provided at the inboard servo valves, one at the outboard. The dual input and feedback rods operate on opposite ends of the common input torque shaft for the servo valve assembly. In addition to mechanical commands, two of the three left inboard servo valves accept electrical commands from the autopilot. When on autopilot, the position of the left inboard aileron is fed mechanically to other ailerons through the primary mechanical system.

- Roll Feel and Trim: Artificial feel and centering for the roll control system is provided by a single compression spring cartridge in the left control path. The ground point of the feel spring is shifted by the roll trim actuator, thereby providing parallel roll trim. Over-travel is provided so that full roll control is available irrespective of the trim actuator position. The trim system can provide up to +7 degrees of aileron travel. Spoiler operation is affected by aileron trim in the same manner as by other aileron inputs.

- Monitoring System: Two torque limiters and a cross-tie bungee are included to permit continued roll operation in the event of opens or jams in the mechanical control paths. The cross-tie bungee does not have a deflection switch but it does permit relative motion between the two ailerons. The torque limiters each permit relative motion between control wheels and cable system and contain sensors to detect deflection for use in the monitor display system. If a jam occurs downstream of the limiter in either control path, continued control is possible by overcoming the breakout force of the affected limiter and controlling through the other control path. Operation of the torque limiters is displayed to the pilot for manual shutdown of the affected aileron and spoiler actuators.

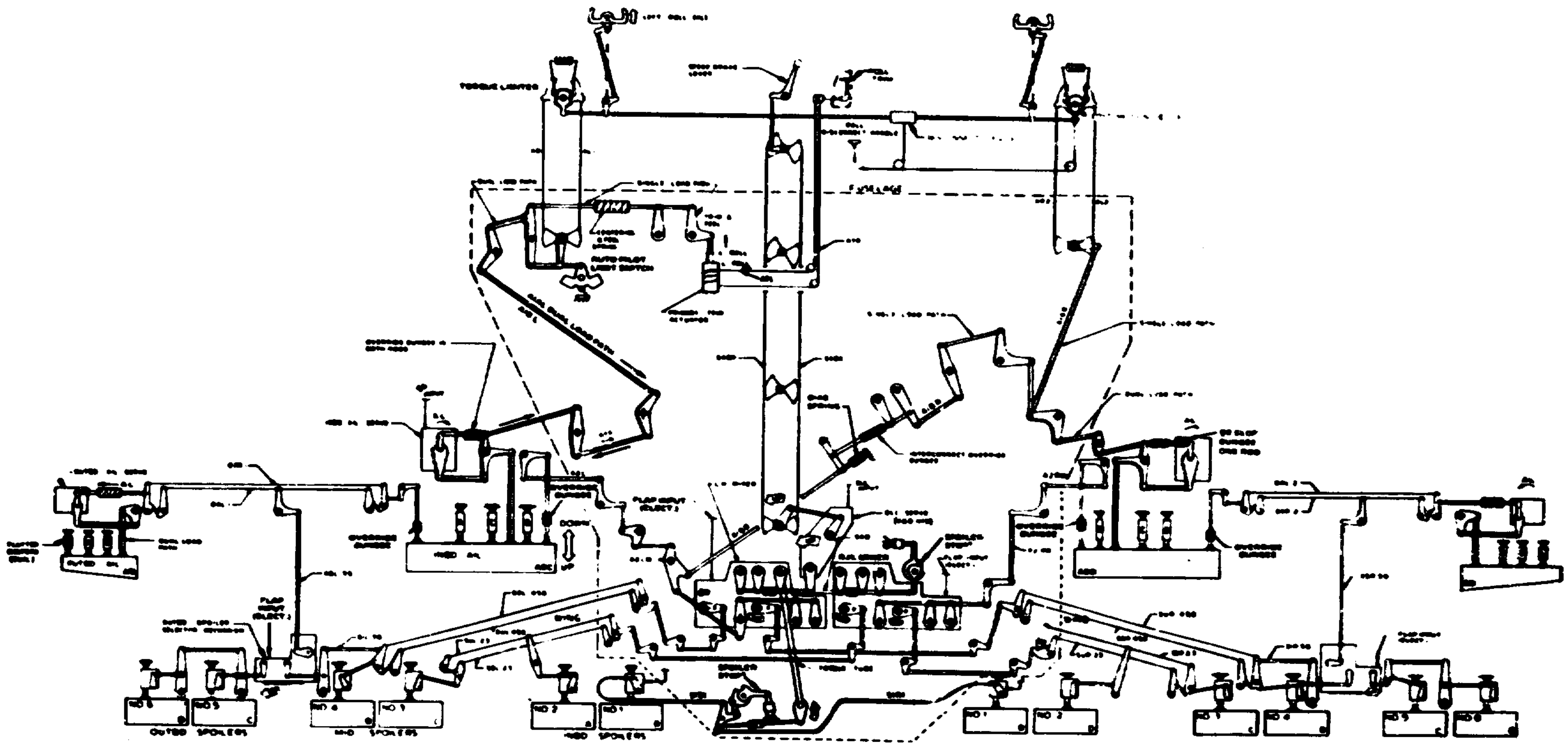


Figure 9. - Conventional system roll axis.

5.1.2.3 Spoiler Control System: The spoilers are used for roll control, direct lift control, and speed brake. Figure 9 is a schematic diagram of spoiler control. Each of the twelve spoilers is operated by a separate servo valve and actuator. The spoilers may be commanded manually for low-speed roll control or for speed brakes, or automatically for four different purposes:

- Direct lift control
- Automatic ground spoilers for landing or rejected takeoff
- Automatic retraction for go-around and for incipient stall
- Maneuvering direct lift control (MDLC) for pitch stabilization

The normal control for direct lift and speed brake is through a dual servo (DLC servo). The output is mechanical to the mechanical control system, to the spoiler servo valves. The input to the DLC servo is mechanical for manual control and electrical for automatic control. The DLC servo is not used for roll control, the roll input is supplied mechanically from the two mixer units. These mixer units combine, mechanically, the inputs from the aileron position and direct lift and speed brake commands to give the proper combination of asymmetric and symmetric spoiler deflection. The speed brake control lever can mechanically override the DLC servo.

The modulating signal for low-speed roll control comes from the mechanical position of the ailerons as commanded by the aileron mechanical control system. This signal gives a nonlinear relationship as calculated by the mixer and described in the roll control section.

The modulating signal for direct lift comes from the autotrim transducer in the autopilot pitch servo. It does not depend upon selection or engagement of the autopilot and is essentially a stabilzer-out-of-trim signal. Altitude changes are thus produced largely from operation of the DLC spoilers rather than the stabilizer, with much reduced pitch attitude excursions.

Spoiler automatic operation for landing, rejected takeoff, go-around, and incipient stall is determined by logic in the flight control electronic system. Inputs are from flap handle, throttle levers, thrust reverser levers, stabilizer control system, landing gear control handle and landing gear strut compression. During a normal landing; landing gear is down, flaps are extended, landing gear switches indicate aircraft touch down, computer asks for 12 degrees spoiler deflection after a half-second delay, struts fully compress, spoilers extend to 60 degrees. If throttles are advanced and reverse thrust is not selected, a go-around will be assumed and spoilers retracted. In takeoff configuration, reverse thrust selection on any two engines will extend the spoilers. Operation of the stall warning system will retract the spoilers.

5.1.2.4 Yaw Control System: Figure 10 is the rudder control schematic. Rudder pedals operate through a single mechanical control path to the rudder servo valves. The manual trim system provides a second mechanical path for rudder control. Jam protection is not provided since the aircraft can be safely flown without rudder control. Shutting off the hydraulic power permits the

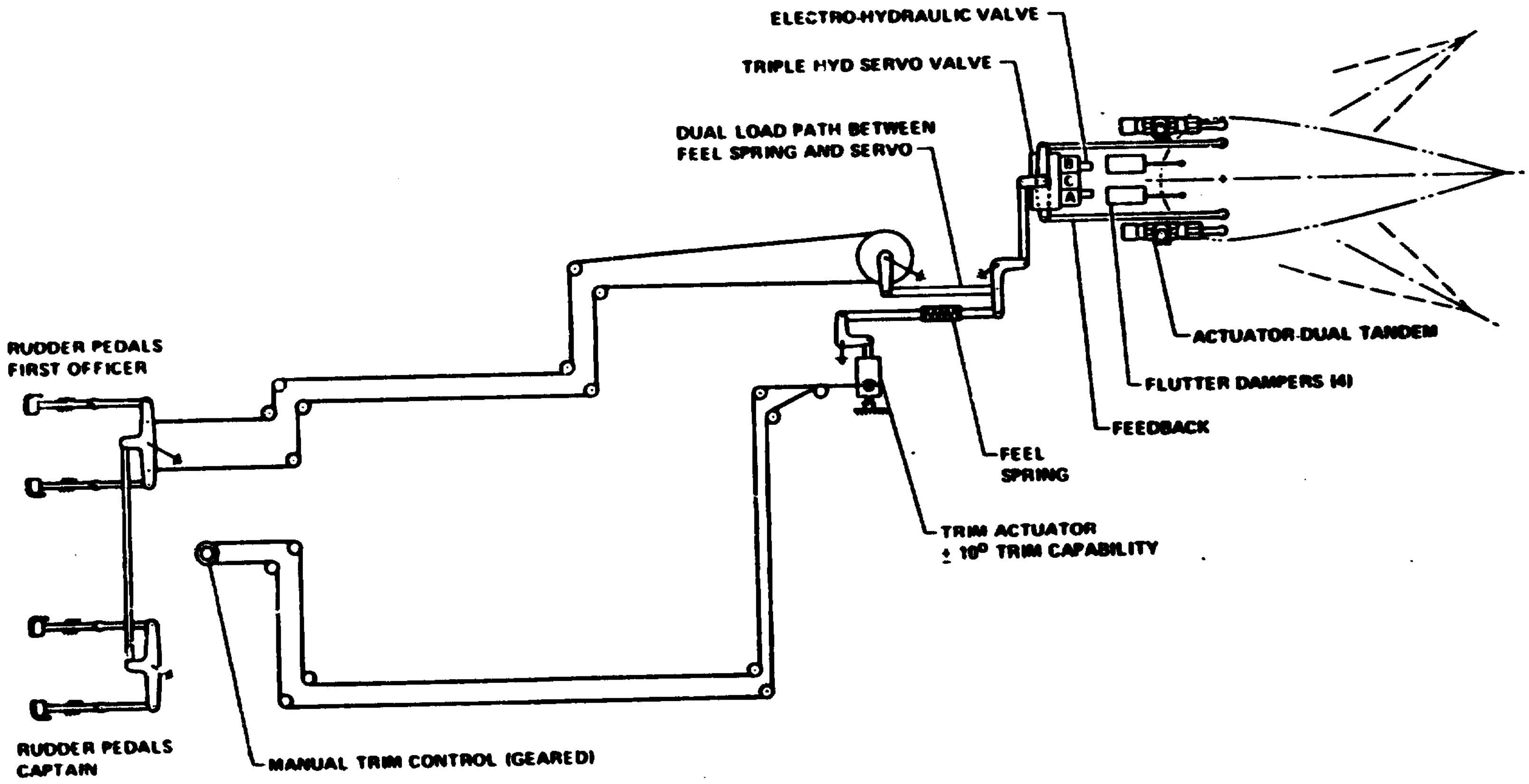


Figure 10. - Rudder control schematic.

rudder to center by aerodynamic forces. If airspeed is greater than 84.37 m/s (164 knots) and flap position is less than three degrees, then rudder deflection is limited to $\pm$8 degrees, otherwise rudder deflection has a limit of 30 degrees. Limiting rudder deflections is accomplished by dual positive mechanical stops operated by solenoid operated hydraulic actuators. There are four rudder actuators arranged in two dual tandem sets. Three servo valves are provided assembled side by side with separate input push rods to each side of the common input shaft. Each servo valve has input from a separate hydraulic system (A, B, and C). One valve serves two actuators. Two of the valves have electrical inputs in addition to the mechanical input. The electrical input is used for yaw stability augmentation.

The rudder is controlled automatically for dutch roll damping and turn coordination during all phases of flight and for runway alignment and roll out during "Autoland". In the basic SAS, the control is independent of autopilot status and allows pilot inputs to be added via the rudder pedals. SAS and turn coordination are achieved by processing inputs from the three rate gyros and four aileron position transducers. For approach and land, the aileron signals are switched out. The runway alignment signal is a function of instrument landing system (ILS) error, heading error, altitude and yaw rate. The alignment scheme is a limited forward slip maneuver in which up to eight degrees of initial crab angle is removed by lowering a wing and slipping the aircraft. After touchdown, the autoland computation uses ILS error and yaw rate to direct the aircraft down the runway with rudder control and limited nose wheel steering.

5.1.2.5 Autopilot: Figure 11 is a block diagram of one-half of the autopilot (one axis); the block diagram for the other axis is the same. There are four channels in each axis for approach and land, and there are only two which are active for cruise. The system has two dual computers, autopilot A and B. A and B can be engaged independently or simultaneously, either in the autopilot mode (in approach/land only) or flight director mode. Thus, either or both flight directors may be used to provide flight director steering information to the pilot, with or without autopilot engagement. With autopilot engagement, the flight director may be used to monitor autopilot operation. Each pitch system (A and B) has a servo with mechanical input into the mechanical control, figure 7. The roll output (A and B) is electrical, directly to the aileron actuator servo valves of the left inboard aileron, figure [illegible]. In either case, the autopilot outputs operate in parallel with the control wheel inputs. The pilot can mechanically overpower the autopilot servos through the control wheel.

Each autopilot (A and B) contains a single cruise channel and two approach/land channels. The voters, figure 11, each of which accepts inputs from all operating computation channels, reject unreasonable signals, calculate the median, reject out of tolerance signals and recalculate the median. This median value is then adopted by all four voters as output to the servo system. All of the autopilot modes except approach/land use a single cruise channel in each autopilot. A lock prevents engagement of both autopilots. For example, if Autopilot A is engaged, one pitch computation from computer A is connected to all four voters, figure 11, and both servos and flight directors are operated even though only autopilot A is engaged. In the approach/land mode, the ILS

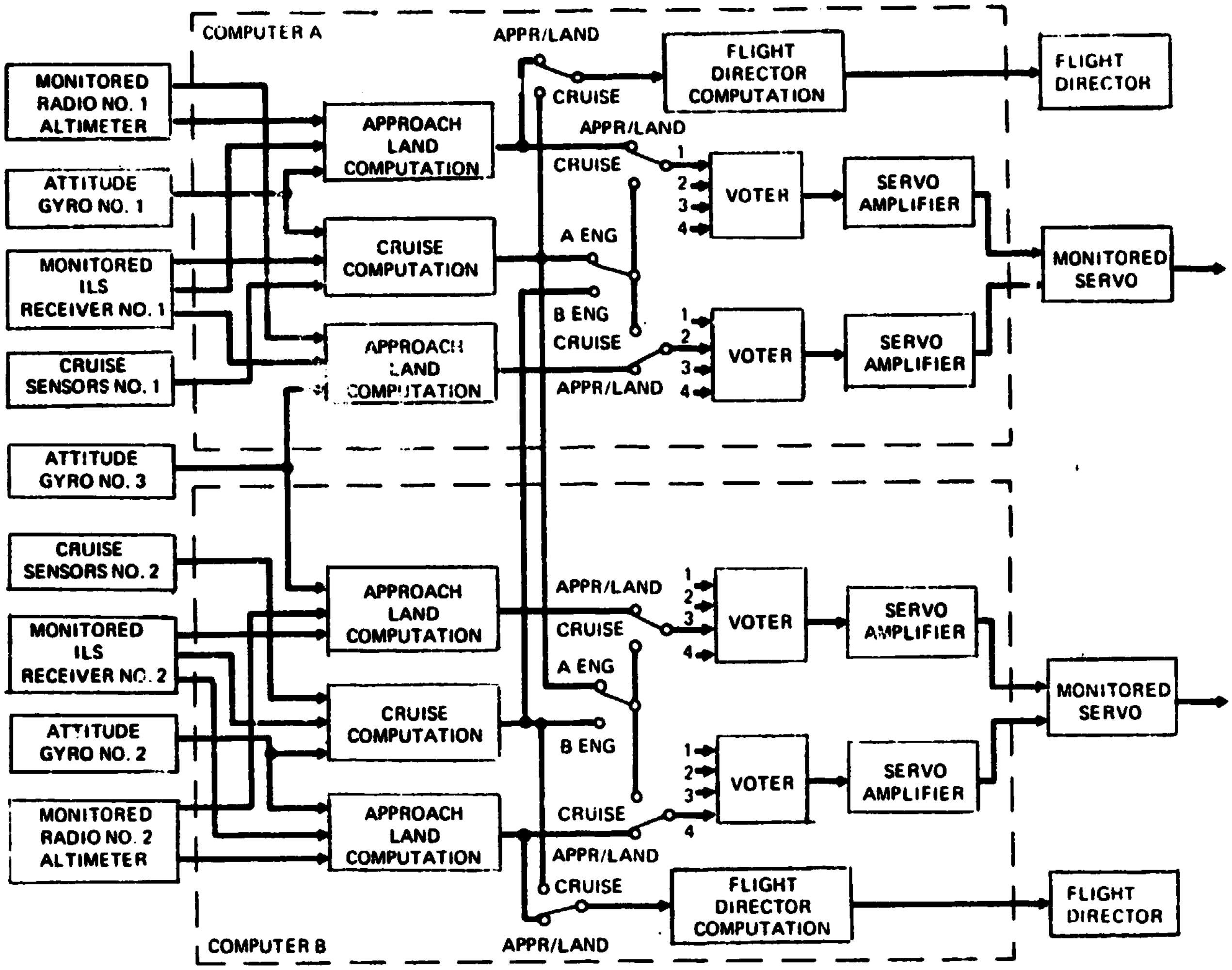


Figure 11. - Autopilot block diagram, one axis.

capture of both the localizer and the glideslope is also single channel; subsequently, through glideslope tracking and landing, two-channel or four-channel computation and one or two servos are used depending on whether one or both autopilots are engaged.

The basic autopilot mode is 'parameter hold' with the pilot able to input change through control wheel steering. The autopilot command mode provides automatic control in response to a computed guidance signal.

The voting logic in the cruise mode, figure 11, is: computer A computes an attitude error signal using inertial navigation system (INS) 1 and 3 (attitude gyro 1 and 3). B computes an attitude error signal using INS 2 and 3. These four error signals, which include rate limiting and rate feedback, are sent to each of the four voters. Each voter selects a median signal from among the four input signals resulting in identical signal output from all four voters. The output of each voter is applied to a separate servo amplifier which drives dual coil servo valves in each channel engaged. There are four servo valves;

autopilot A roll, B roll, A pitch, B pitch. Each servo valve has two coils. The resulting 8 coils are operated by the four roll voters and the four pitch voters.

An automatic trim system acts to center the autopilot servos to prevent transients when the autopilot is either manually or automatically disengaged. There are two automatic pitch trim systems and at least one must be operative to engage either autopilot. The altitude signal for altitude hold and altitude select is a rate-and-displacement-limited barometric altitude error signal which is gain scheduled as a function of true airspeed. An integration path is provided to compensate for long term error signals. The control signal is mixed with pitch attitude and attitude rate signals for control loop damping. As the altitude approaches the selected altitude, the altitude rate and altitude error are used to compute the point at which the maneuver to capture the desired altitude is initiated. At initiation, an exponential flare maneuver to capture the desired altitude is commanded. When the maneuver is completed, the altitude hold mode is automatically established and annunciated.

Roll attitude/heading hold is the basic roll axis autopilot mode. Upon engagement, the autopilot will maintain heading if the bank angle is less than five degrees and will maintain bank angle if over five degrees. Control wheel steering can be used to establish a new roll attitude or heading reference.

In the navigation mode, the autopilot will direct the aircraft to capture and follow a VOR beam or an Area Nav course, if these systems are operating.

The approach/land mode will capture the localizer beam, follow the localizer beam, capture the glide slope, follow the glide slope, align with runway at 45 m (150 ft) altitude, perform flare at 15m (50 ft) altitude, and maintain heading down the runway on roll out.

The glideslope capture maneuver is inhibited until localizer track is established and glide slope deviation is less than 30 microamperes. The flare gain is scheduled as a function of radio altitude, radio altitude rate and normal acceleration to provide essentially zero rate at zero altitude.

The turbulence mode is normally engaged when the aircraft is flying in turbulence. The autopilot reverts to the parameter hold configuration with reduced gains to provide softer control.

5.1.3 ATA Baseline Electric System. - The design of the baseline ATA electric system follows the design of the L-1011-500 airplane in that it is a part of a conventional secondary power system in which the engine bleed system and the hydraulic systems are major contributors to the power demands and services in the aircraft. The electric system in the ATA furnishes power to the following.

- External/internal lighting
- Galley loads
- Passenger service/entertainment

- Windshield defogging/anti-ice
- Instrumentation
- Avionics
- Miscellaneous motor loads, vis-a-vis: fuel transfer, fuel-boost, recirculation fans, etc.
- Linear and rotary electric actuators
- Transformer rectifier (T/R) units
- Control power for solenoids, valves, instruments/indicators, etc.

The capacity of the above loads increase mainly as a result of the large number of passengers and the effects of the passenger-change on the cabin lighting, galley loads, passenger service, etc. The increased wing span of the ATA has marginal impact on the new power system capacity since hot bleed anti-icing of the wings is retained in the baseline ATA.

Based on the above changes, the power-generating system capacity is changed from three 75/90 kva engine-driven integrated drive generators (IDGs) to three 120/150 kva IDGs. Figure 12 is a photo of an IDG, as used in the L-1011-500. This is a typical 2:1 input speed range IDG using pressurized oil-cooling and separate (dedicated) heat exchanger. The generator in the ATA baseline IDG is a conventional 4-pole, 3-phase 200/115V 120 kva ac machine generating 400 Hz power, at 12000 rpm synchronous-speed. This combination constant-speed drive (CSD) and generator are installed and removed from the airplane as a complete assembly.

Table 9 is a load summary and figure 13 is a schematic of the power generator system configuration. It is a three-generator paralleled system which relies on supervisory panels (in each channel) to permit paralleling of the three generators via a synchronising tie-bus. Such bus ties occur when the voltage, phase-sequence, frequency, and phase angle of the generators are correct. Incorporated in each IDG channel is a supervisory panel, to control the complete power system, during normal and abnormal operating conditions. These supervisory panels provide the following features.

- Automatic/manual ON/OFF control of system
- Automatic paralleling
- Kilowatt load sharing (when paralleled)
- Kilovar load sharing (when paralleled)
- Overexcitation/underexcitation control
- Overvoltage/undervoltage control
- Overfrequency/underfrequency control

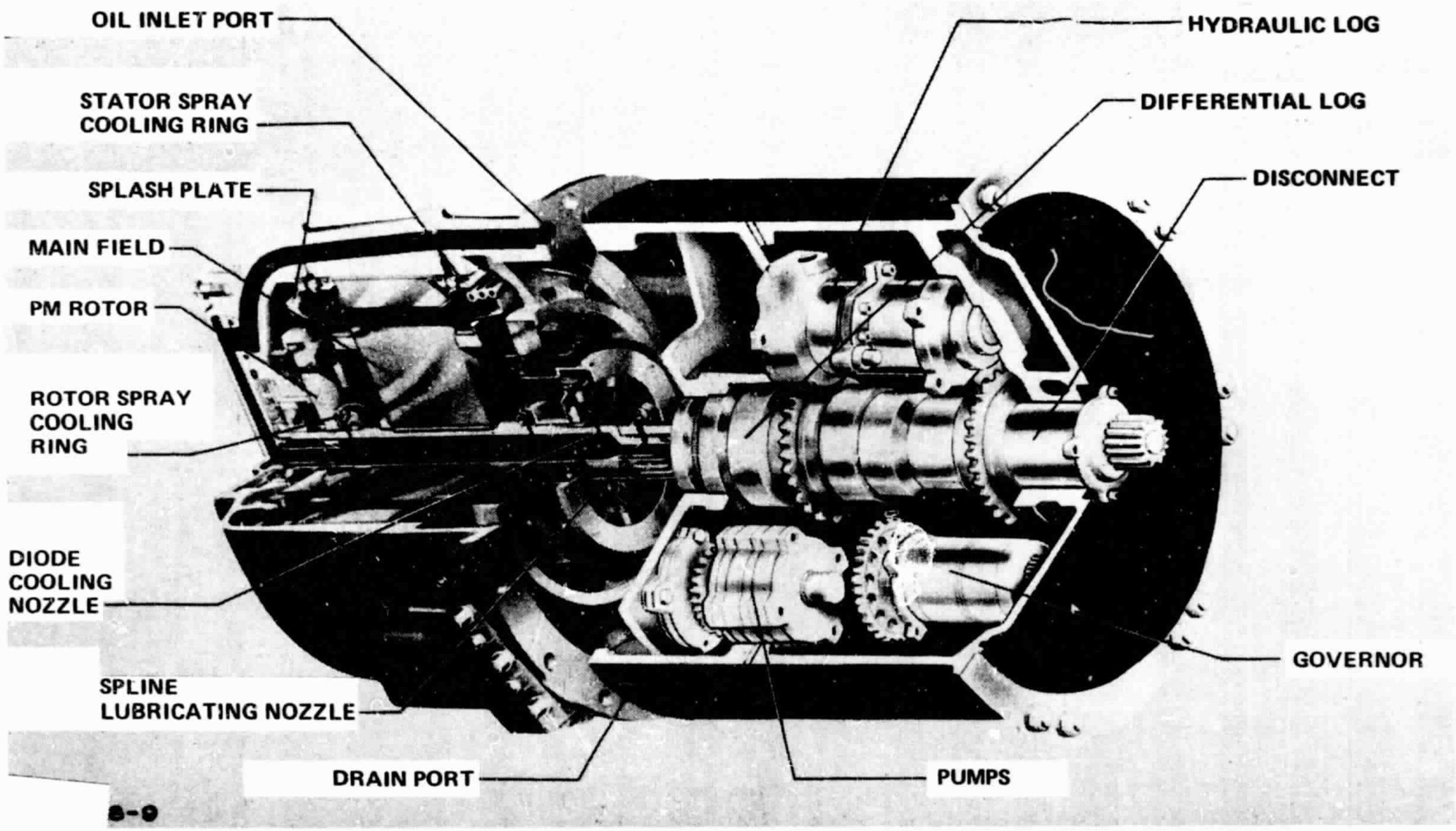


Figure 12. - Integrated constant speed drive and ac generator.

TABLE 9. - ALL-ELECTRIC ATA: LOAD SUMMARY

	kVA
ECS	330
Interior / Exterior Ltg	15
Fresh-Air / Recirc. Fans	12
Galley	150 (1)
Boost / Transfer Pumps	15
FCS Avionics	30
Conv. Avionics	12
28 Vdc System	10
Miscellaneous hour-FCS Actuators	35 (1)
Passenger Services	10
Passenger Entertainment	

= 619 x 0.7 (2) = 433.3 kVA

(1) Peak

(2) Diversity Factor

- Phase sequence detection
- Differential feeder fault protector

In addition to the above features, the supervisory panels monitor the CSD's for operational anomalies, such as overtemperature, loss of hydraulic pressure, etc. Also integral with the IDG are metal chip detection, clogged filter detection, and oil-level indication. Figure 14 is a picture of the control panel used for the three generator system in the L-1011.

Power distribution in the baseline ATA is accomplished using a conventional radial distribution system in which power from each of the three IDG's is taken directly into the main electric center, MELC (see figure 15). From the MELC, power distribution feeders establish load-busses at the flight station and the empennage area (see figure 16). At each of these load centers, power is fed to the individual loads via conventional trip-free thermal circuit breakers (CBs). These CBs have manual trip/reset buttons and they are located in the right, rear section of the flight station and on overhead panels. In the L-1011-500 use is made of a small number of remote control circuit breakers (RCCB) for certain nonessential power-feeders and galley loads. These RCCBs are normally closed, but they can be manually opened by the crew, or automatically opened in response to any overload detection.

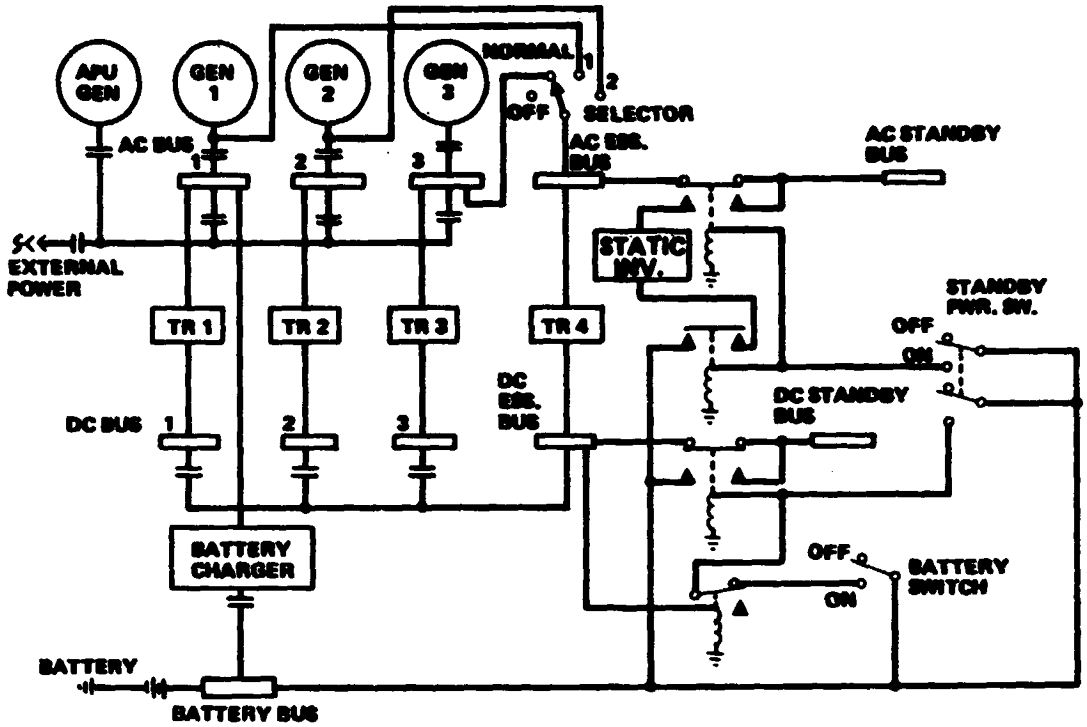


Figure 13. - Electrical power system.

There are over 1000 circuit breakers in the L-1011. In the baseline ATA there will be a significant reduction in the number of these circuit breakers by the utilization of solid-state power controllers (SSPC), another advanced load management technology. Control and management of these SSPCs will be effected via on-board processors through low-level-logic/MUX control.

As shown in figure 13, special consideration is given to the ac essential bus, which furnishes power to the MELC and flight station loads by tapping it into the IDGs on the supply side of the bus-contactors. This run-around system gives the essential ac bus primary access to the three IDGs in the event the generators are isolated from the main ac busses. During this emergency operational mode, T/R4 feeds the dc essential bus which is backed up by an on-board nickle-cadmium battery. Emergency 400 Hz ac power for engine ignition, instruments, etc., is supplied by a static inverter. For an all-engine-out condition, safe flight control of the airplane is maintained by a ram air turbine (RAT) driven hydraulic pump while the emergency electrical loads are supplied by the battery-inverter system.

5.1.4 Hydraulic System. - In the ATA baseline the hydraulic system powers the following:

- Primary flight surface controls
- Secondary flight surface controls

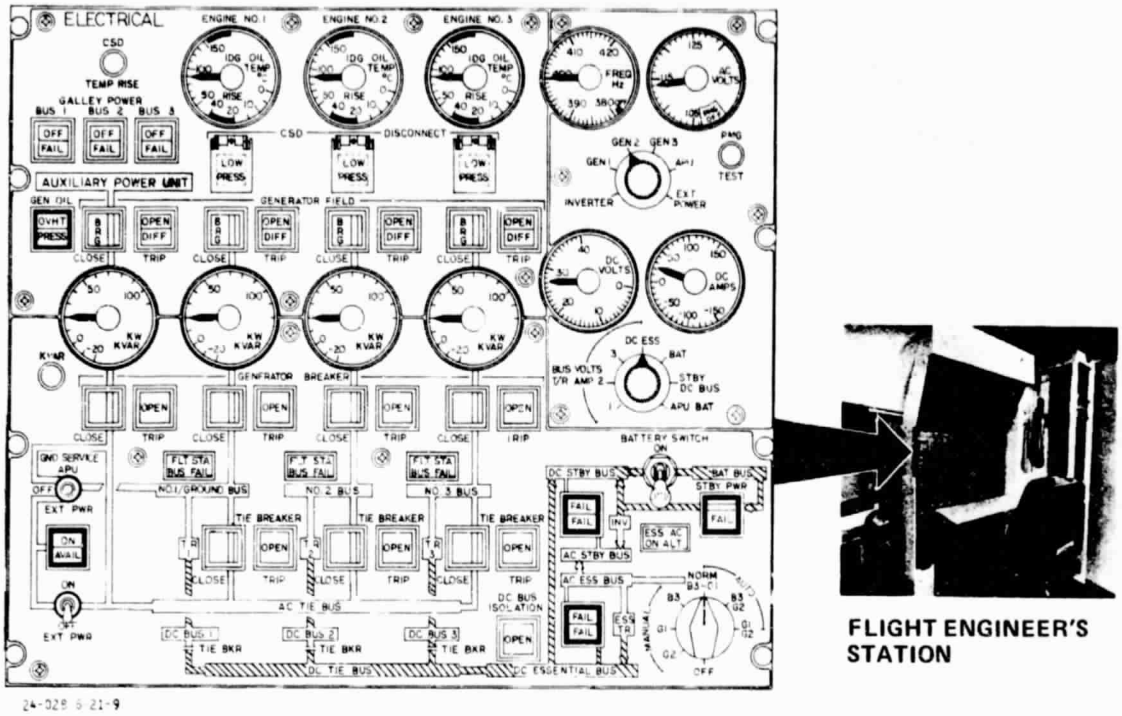


Figure 14. - Electrical system panel.

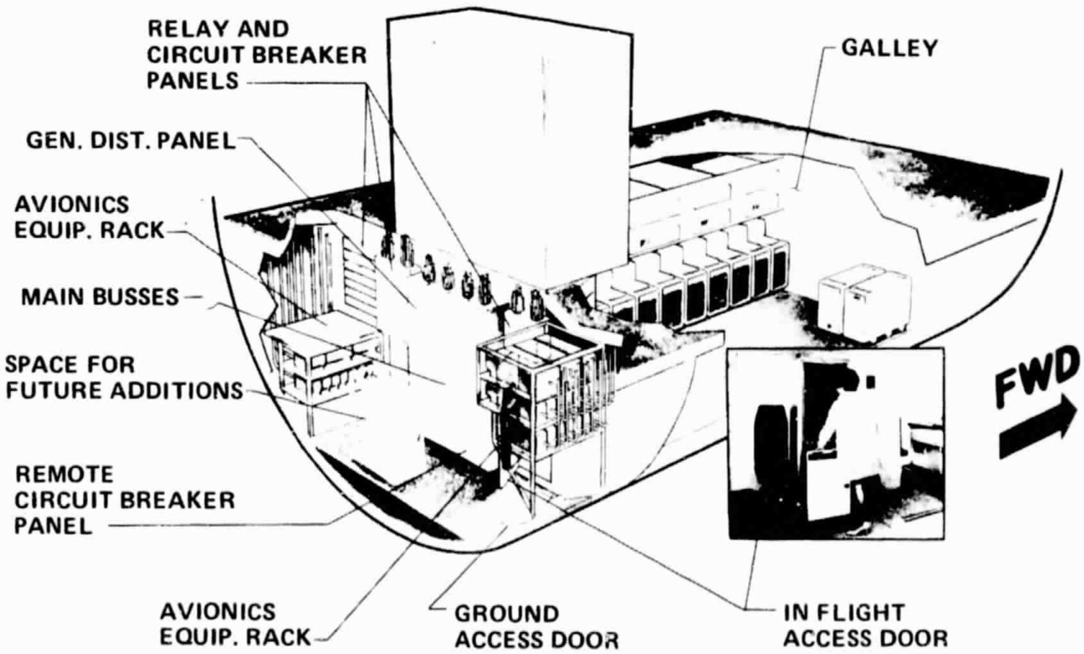


Figure 15. - Main electrical service center.

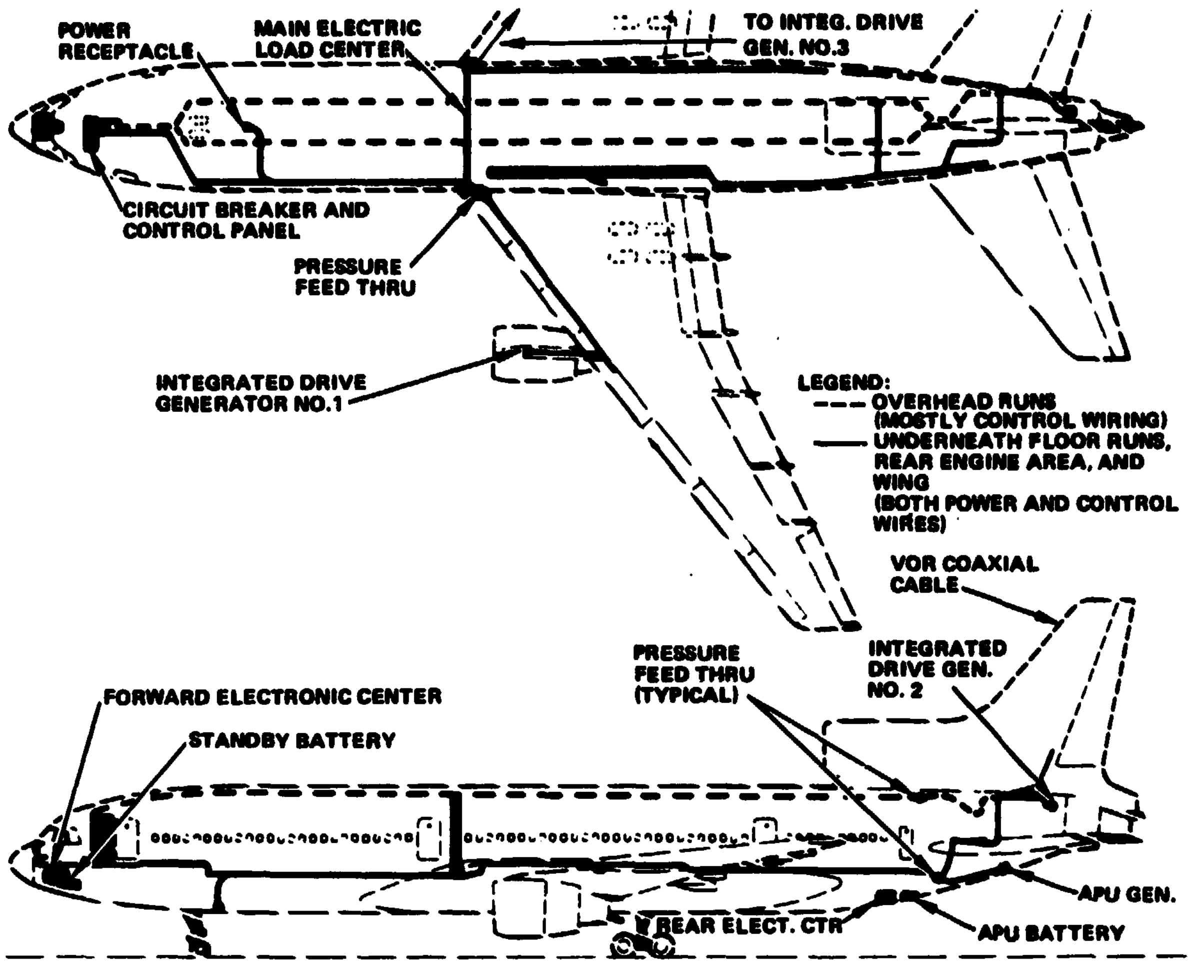


Figure 16. - Major wire routing and electrical equipment installation.

- Main and nose landing gears
- Main and nose gear doors
- Truck leveling (leveling of the MLG bogie)
- Nose wheel steering
- Brakes
- Miscellaneous jacks/door locks, etc.

The L-1011-500 hydraulic system configuration is used as the basis for the trade studies in the AE/ET study. The main differences will be that the ATA baseline will use a six-wheel bogie landing gear and a slightly larger capacity hydraulic system. The passenger complement of 500 (versus 340 in the L-1011-500) is offset by the lower structure weight, consequent upon use of advanced alumimum alloys/composits, etc. The ATA also uses a smaller tail, but the design-load power requirements for some of the primary and secondary surface controls are increased. The displacement of each of the six engine driven pumps is approximately 4.916×10^{-5} m^3/rev (3 cu in. per rev), or approximately 3.15×10^{-3} m^3/s (50 gpm.). Figure 17 is a schematic of the system and figure 18 shows a typical flight station control panel for the hydraulic system.

In addition to the engine-driven pumps, two air turbine motor-driven pumps are connected into the B & C systems and these in turn are tied into the A & D systems via power transfer units (PTUs), which allow a power interchange between systems A & B/C & D without any fluid-exchange. The other major components of the four-channel hydraulic system are two ac motor-driven pump units and a RAT pump unit; the latter furnishes flight-critical hydraulic power in the unlikely event of a three-engine failure. During such an all-engine-out emergency, a load priorization schedule cuts off noncritical hydraulic loads to maximize the use of the $9.46 \times 10^{-4}/1.26 \times 10^{-3}$ m^3/s (15/20 gpm) RAT-pump unit.

While the air turbine motor (ATM) pump units are used to support the main (engine-driven) pump, they also furnish hydraulic power on the ground, when the engines are not running. During ground operation, the APU-driven compressor may be used to power the ATMs as well as the air cycle machinery of the environmental control system (ECS). A further role of the APU compresser is to provide engine-start power.

Steady state and peak flow demands are exemplified by figure 19 which illustrates the flow demands on one of the four systems - System B. The short-term flow demands show that, because of the speed-dependent flow characteristics of the engine driven pump units, support is needed from the ATM pump to furnish the peak demand of 3.785×10^{-3} m^3/s (60 gpm), during ground operation. Typically, this chart also shows the high short-term peaks of hydraulic flow demand, compared to the steady-state flow conditions. These are differences that are important to the comparison in the study of the conventional ATA versus the all-electric ATA. The sizing (pump displacement) criteria with respect to the peak flow demands are penalizing compared to the electric system, where high short-time power demands can be absorbed within the electro-thermal capacity of the generators. As a result, the electric power system is less impacted by short-time power demands brought on by operation of landing gear, flaps, and other short time loads in a typical airplane.

Figure 17 shows the major loads on the hydraulic system and the degree of redundancy that is offered to the flight control surfaces (FCS). As shown in the schematic, and as tabulated below, the hydraulic system offers the following redundancy support to the primary FCS.

	Redundancy Level			
	4	3	2	1
Horizontal Stabilizer	X			
Ruddeer		X		
I/B Ailerons		X		
O/B Ailerons			X	
Spoilers				X

It is to be noted that while the spoilers show single redundancy, there are six spoiler panels per wing providing a high degree of aerodynamic redundancy. The redundancy levels shown in the tabulation refer to the number of actuators per panel.

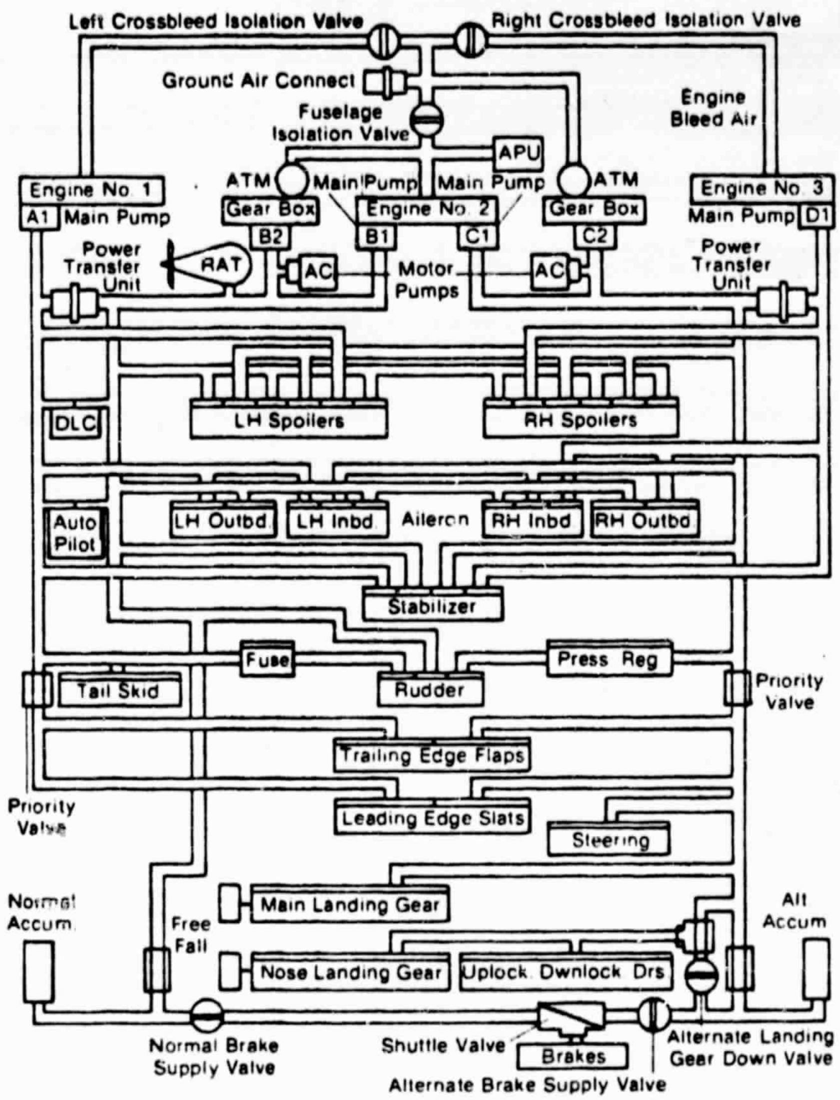


Figure 17. - L-1011 hydraulic system schematic.

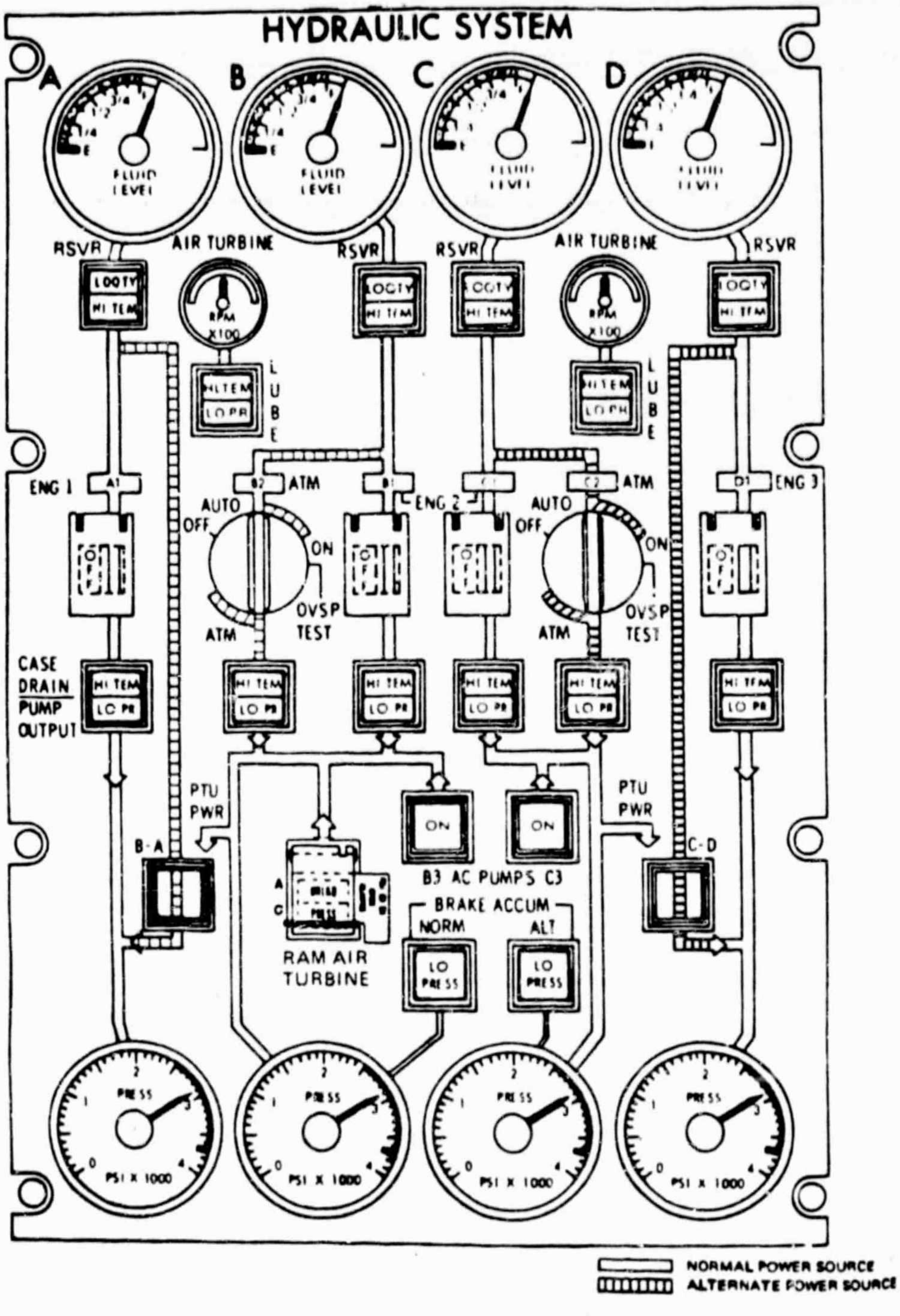


Figure 18. - Flight engineer's panel.

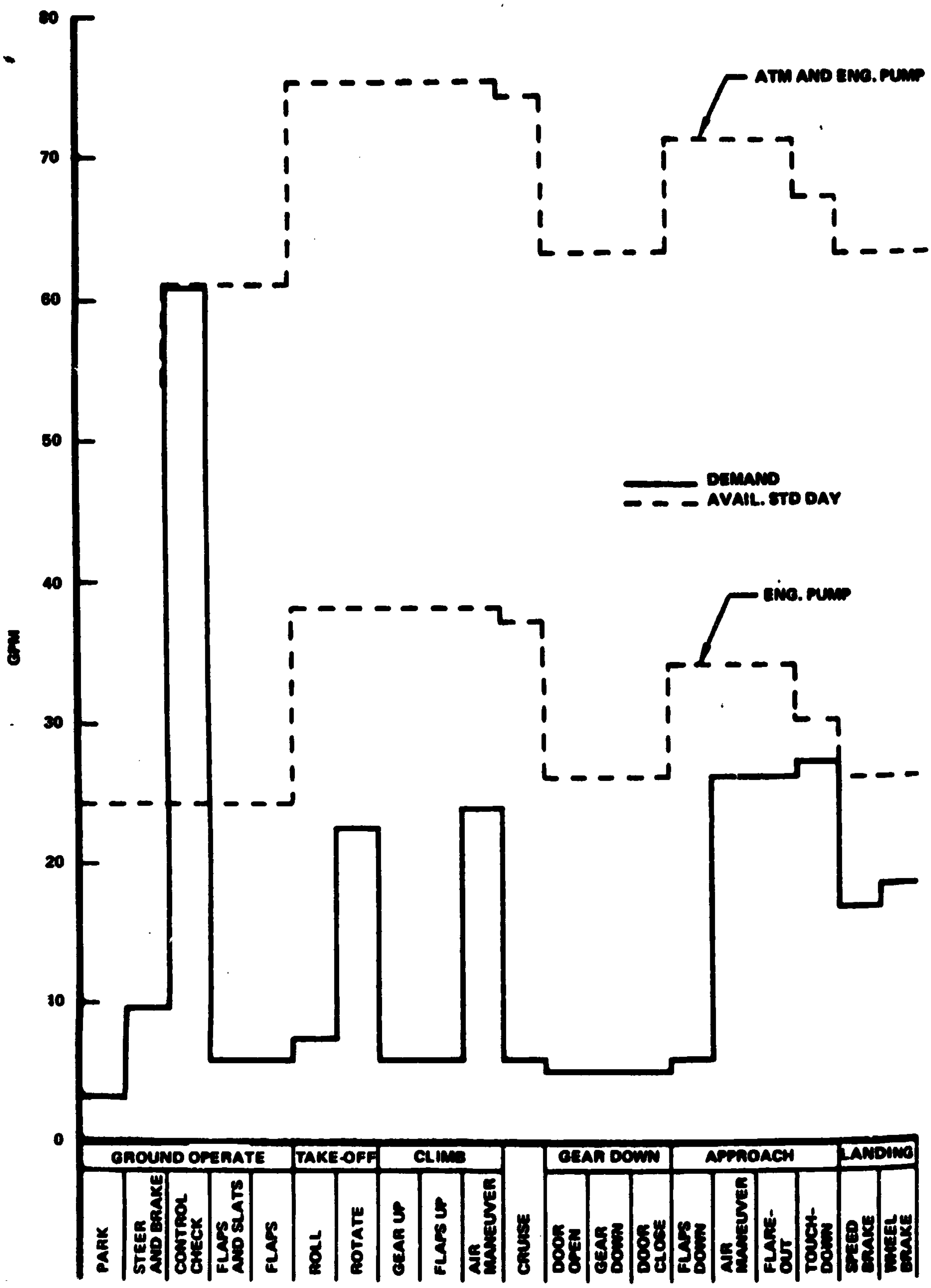


Figure 19. - Hydraulic flow demands.

The secondary flight control surfaces include the leading edge slats and the trailing edge flaps. Both systems use a power drive unit (PDU), which is a centrally located gearbox, having dual-output (left and right) torque tubes, driving screwjacks connected to the panel sections. In both cases, two separate hydraulic motors powers the PDU and either one is capable of actuating the leading edge slats and trailing edge flaps at rated load and speed.

Other major hydraulic loads, in the ATA baseline, are the main landing gears, the nose landing gear, gear doors/locks, nose wheel steering, and brakes.

Physically, the hydraulic installation in many aircraft is a major undertaking, and in an ATA-sized aircraft, it takes on significant proportions. Not only are there eleven different fluid power sources with reservoirs, filters, noise attenuators, etc., but there is a major distribution complex of hydraulic lines. Figure 20 shows the hydraulic load center in the L-1011 aircraft. This is well-planned, well designed installataion which has been most successful in the L-1011, but it exemplifies the compexity of the hydraulic plumbing and the custom nature of the installation. It is evident also that accurate and sophisticated hydraulic production mock-ups are necessary to validate the installation of the components, and the routing of the hydraulic lines, with their attachments, in a reasonable facsimile of the aircraft structure. Leakage noise and contamination are the other legacies of the hydraulic system and their elimination (or mitigation) impacts adversely on the design/installation complexity of the hydraulic system. In a wide-body jet aircraft, the following statistics are typical.

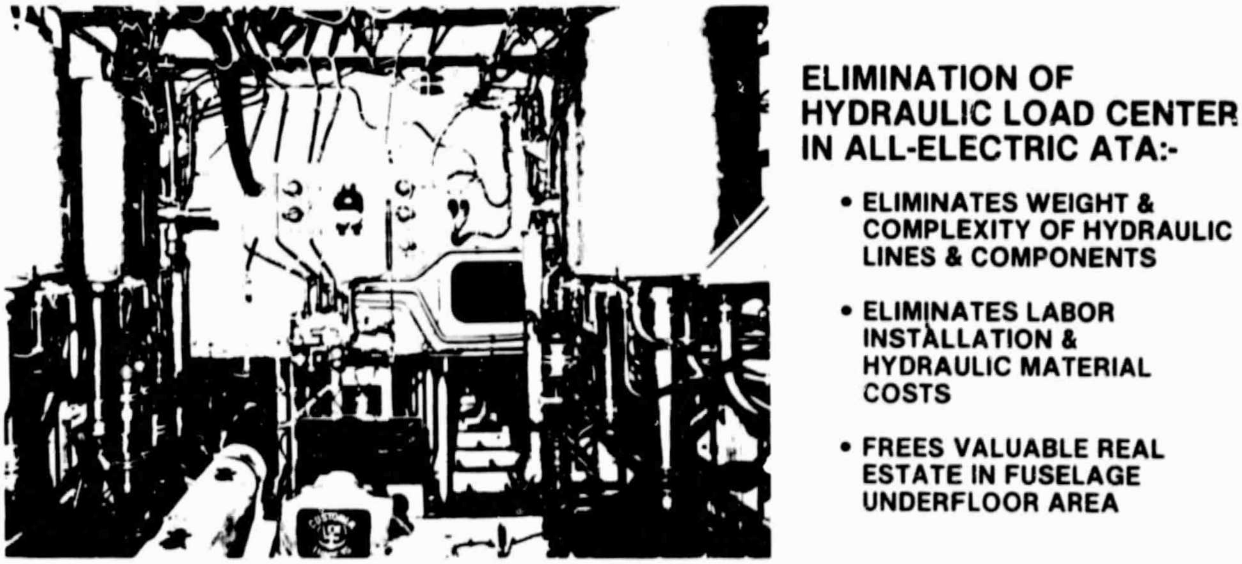


Figure 20. - Hydraulic load center: L-1011-500.

- Number of tubes (steel) 800
  (alum.) 420

- Number of welds (bench) 1000
  (ship) 300

- Swaged fittings (tubes) 1800
  (component adapters) 800

- Hydraulic lines 5000 ft

For most installations, #1808 steel lines are used for the pressure lines and aluminum for the return and suction lines. Practically, the system involves the use of bench-brazed assemblies, many swaged in-line fittings (unions), and many component-adapter interface fittings. A specific weight parameter for a typical hydraulic line installation is about 0.01 kg/hp ft (including fluid, brackets, fittings, etc.). Therefore, to transmit 100 horsepower through 100 feet, the weight would be: $10^4 \times 0.01 = 100$ kg (220 lb), approximately.

For a major hydraulic line installation with an average 0.5 inch line, the following filled line weight would be typical.

	WT Per Foot			Total
	Line	Fluid	Fitting	Wt
2300 ft. press. line	0.079 kg (0.174 lb)	0.231 kg (0.51 lb)	0.079 kg (0.174 lb)	416 kg (917 lb)
2300 ft. Ret. line	0.033 kg (0.072 lb)	0.02 kg (0.047 lb)	0.028 kg (0.061 lb)	188 kg (414 lb)
TOTAL WT.				604 kg (1331 lb)

The above shows that the filled hydraulic line weights are significant. A 20 to 25 percent weight reduction is possible with the use of titanium, but this is at the expense of an increase in cost, different tooling/production processes, etc.

5.1.5 ECS. - The environmental control system provides conditioned air for pressurizing, heating, cooling, and ventilating the cabin and the flight station. Heated air is also ducted to the forward and aft baggage areas.

The basic L-1011-500 environmental control system was scaled up to meet the requirements of the ATA baseline (and the all-electric ATA), which carries 500 passengers, compared to the 340 passengers in the L-1011. The longer fuselage and the larger number of windows in the ATA increase the solar input to the cabin (on hot days) and increases the cabin thermal losses (on cold days).

The basic L-1011 system, which uses three ECS packs, is retained for the ATA baseline, except that the heating/cooling capacity of the units is increased and the cabin distribution ducts are increased in proportion to the number of passengers.

The principal and significant difference between the baseline ATA and the all-electric ATA is the prospective elimination of engine bleed air and bleed air ducts from the baseline airplane. Figure 21 is a schematic of the ECS in the baseline airplane. Mid-stage and last stage air are tapped from the engine compressor, and after passing through ejector/coolers, the hot pressurized air is cooled in the primary heat exchangers and then taken into the bootstrap air-cycle machines. A secondary heat exchanger cools the air between the compressor and turbine, after which it is expanded (cooled) through the turbine, or passed directly into a cabin plenum via the water separators.

The airflow schedule is prorated to correspond approximately to that shown in Section 7, figure 58. A 1830m (6000 ft) cabin is maintained up to 10700m (35000 ft) and an 2440m (8000 ft) cabin up to 12800m (42000 ft). Unlike the L-1011-500, the fresh air is reduced to 50 percent by taking advantage of re-circulation. The all-electric ATA uses vapor cycle cooling and could take advantage of a higher degree of recirculation but for the study, the same 50 percent was assumed. With 50 percent air recirculation, the fresh air supply in the ATA is approximately 136 kg/min (300 ppm), 45 kg/min (100 ppm) per ECS pack.

The maximum cooling load occurs on the ground on a 40°C (104°F) hot day, with a full passenger compliment. This cooling load is estimated at approximately 102000w (350000 btu/hr). At 10700m (35000 ft), Mach 0.8 cruise, same conditions, the cooling load is estimated at 48000w (165000 btu/hr).

The maximum heating-load requirement occurs with a minimum passenger complement, on a -45°C (-50°F) ground temperature or a -65°C (-85°F) temperature in flight. The ECS heating capacity is designed to yield a pull-up from -32°C (-25°F) to 21°C (70°F) in 30 minutes; the system can maintain a 21°C (70°F) cabin with no passengers, with an OAT of -45°C (-50°F). At 9100m (30000 ft), cold-day operation, the heating load is estimated at 160000 btu/hr. Heating in the ATA baseline is achieved by modulation of the air louvers which control the ram air (or fan-propelled air) through the heat exchangers. In the all-electric ATA, heat-of-compression furnishes the heating requirement.

One of the more significant factors in the ECS trade (baseline versus all-electric) is the impact of engine bleed on the engine thrust and specific fuel consumption (SFC). The consideration in this regard revolves upon the mismatch of engine bleed to the ECS demand and upon the changing energy levels of the bleed air as a result of altitude/power setting changes on the engines. The key and pertinent aspect is that the bleed-demand impacts far more critically and unfavorably on the engine thrust/SFC than does mechanical horsepower extraction (HPX). The following are Pratt and Whitney/General Electric data based on the P&W STF 505-M7C and the GE E^3 engines.

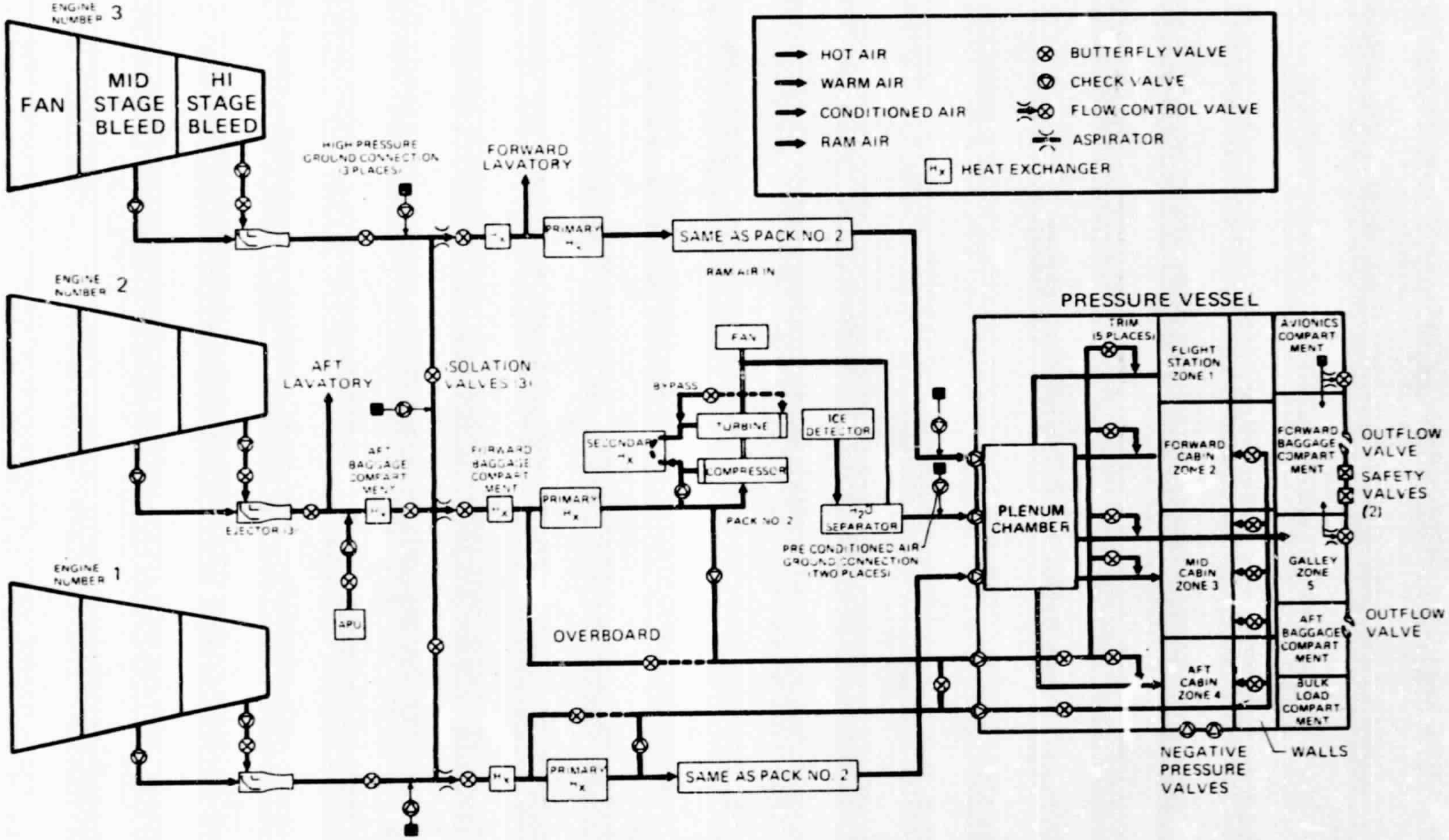


Figure 21. - Air conditioning schematic.

P & W (STF 505-M7C)
0.8 Mach, 35000 ft, 8200 lb thrust

Bleed	- F_N	3.4%/pps
	+ SFC	1.24%/pps
HPX	- F_N	0.8%/100 hp
	+ SFC	0.4%/100 hp

Uninstalled SFC 0.562

GE E^3 ENGINE
0.8 Mach, 35000 ft, 8425 lb thrust

Bleed	- F_N	2.08% per % 5th stage
	+ SFC	0.84% per % 5th stage
HPX	- F_N	0.83% per 100 hp
	+ SFC	0.37% per 100 hp

Using the P&W data, a typical 1.4 kg/sec (3pps) fifth stage bleed/demand reduces the propulsive thrust/engine from 36500N (8200 lb) to 32700N (7347 lb), or a total thrust loss of 11400N (2558.4 lb) thrust: at 600 mph this is equivalent to a hp loss of 3053 kW (4,093 hp). If a mechanical compressor produces the same airflow, at a PR 3.2:1, the equivalent HPX/engine would be appproximately 225/0.75 = 300. Using the P&W HPX sensitivity factor of 0.8%/100 hp, the total thrust reduction would be 7.2% or 1770 pt, equivalent to 2100 kW (2830 hp) or HPX of 942 kW (1263 hp) in favor of mechanical power extraction. The HPX and SFC penalties are discussed further in the all-electric ATA description. This further discussion addresses the differences in mission fuel for a five hour flight.

The physical differences between the ATA baseline and the all-electric ATA, reside in the elimination of hot bleed air ducts (from the engine nacelles, pylons, and wings) and the installlation complexity. Much of the ducting is in stainless steel, which is heavy, costly, and demanding of a large number of installation hours. The weight of the ducting, valves, attachments, aircontrol ejectors, etc. is assessed as 1150 kg (2538 lb). Ducting in the engine nacelle has a complex routing (figure 22) and the mechanical interface of the high-pressure/medium-pressure ducts (and hydraulic lines) with the pylon impacts unfavorably upon the engine removel/installation time. Simplification and elimination of the ECS/starter cross-bleed ducts (plus hydraulic lines) stand as one of the most attractive aspects of the all-electric airplane. Overall, there are some eighteen hot-air valves associated with the engines and because of the temperature/contamination problems, these valves are listed as a maintenance-suport/reliability item.

A final aspect of the bleed/pneumatic duct installation is the ballooning of the lower side of the nacellle contour; again, this is evident from figure 22. Low engine inlet profile drag has been of concern to NASA, the military, and the airframe/engine companies to the extent that funded studies have evaluated the

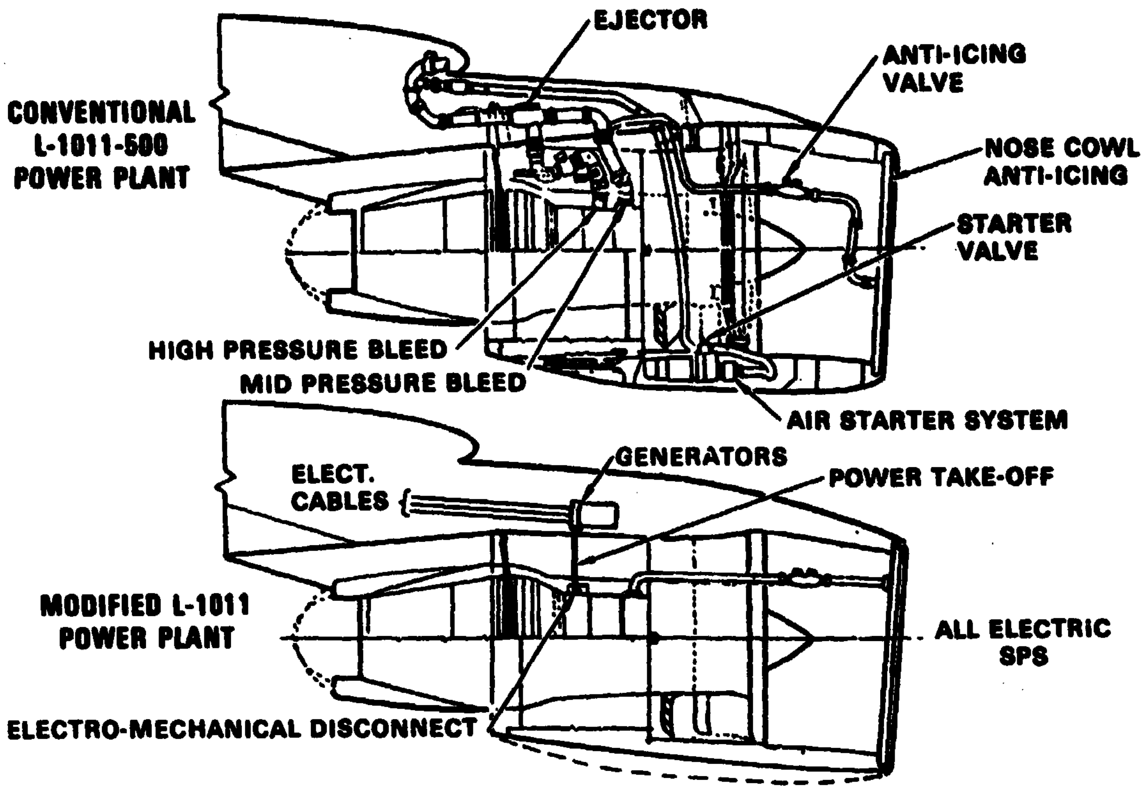


Figure 22. - Power plant configurations: Conventional vs all-electric ATA

prospective reduction in engine frontal areas by the use of austere accessory gearboxes, or their elimination via the use of a power takeoff (PTO) shaft. One Pratt & Whitney study[(1)] developed the following data based on waist section gearbox elimination, through the use of an integrated engine generator (IEG) and nose-cone-mounted accessories.

Frontal Area Reduction	Engine Weight Reduction	Accessory G/B Weight Reduction
30%	9.5%	35.4%

The aspects of engine gearbox weight reduction is discussed further in the all-electric ATA evaluation and study. It is evident that very significant advantages and improvements come from the elimination of the ECS ducting/cross bleed ducting and all the control valving in the all-electric ATA.

5.1.6 Avionics. - The L-1011-500 avionic suite was modified to ARINC 700 series avionic equipment in the flight control and flight management areas to provide a realistic baseline ATA avionics for the 1980s. The overall avionics system is shown in figure 23 and consists of the following subsystems:

(1) "Lightweight Small Frontal Area Accessory & Drive System. NASA/P&W FC3254, June 1969"

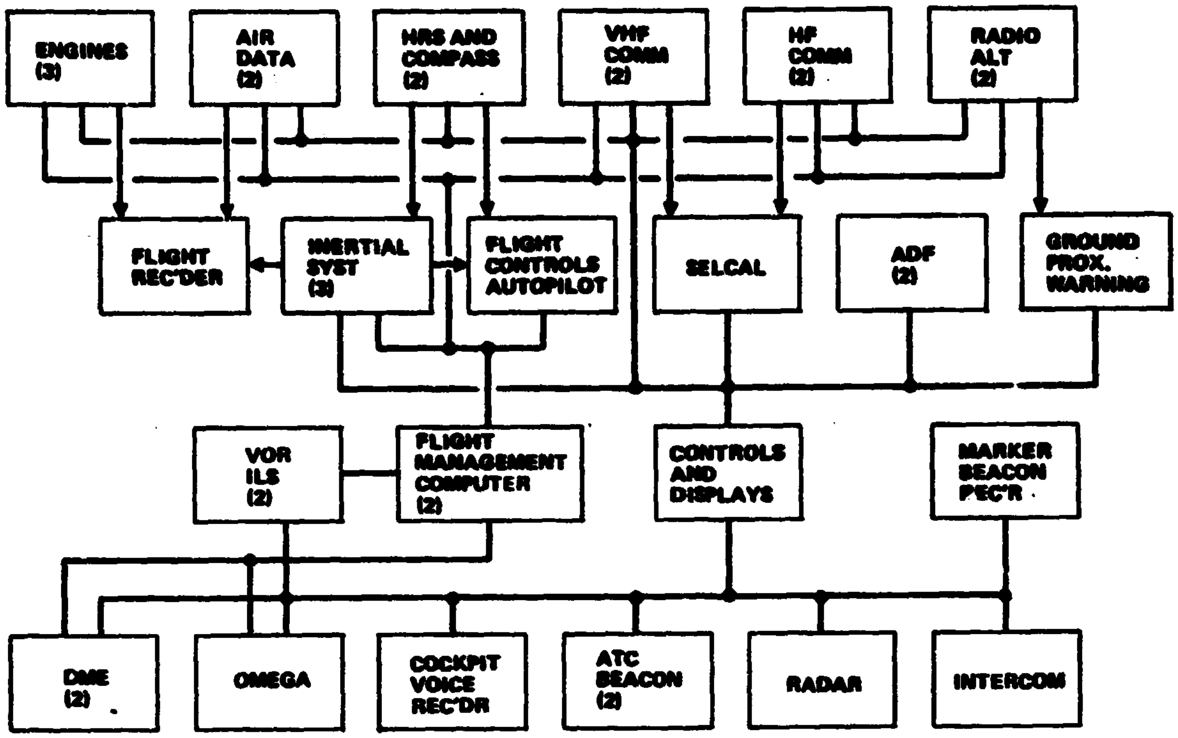


Figure 23. - Avionics block diagram.

- <u>Communications</u>

  VHF Transceiver (2)
  SELCAL
  HF Radio (2)
  Intercom
  Passenger Services
  Cockpit Voice Recorder
  Note: The communications system was not subject to trade off in this study. Information is included for background and to suggest future integration possibilities.

- <u>Navigation</u>

  Inertial Nav. (3)
  Flight Management (2)
  Omega
  VOR (2)
  ILS (2)
  DME (2)
  Marker Beacon
  Heading Reference System (2)
  ADF (2)
  Radio Altimeter (2)
  Ground Proximity Warning
  Weather Radar
  ATC Transponder (2)

- <u>Flight Controls</u>
  - Primary Flight Control Avionics
  - Autopilot (2)
  - Air Data System (2)
  - Instruments

The flight management system provides area navigation, fuel-efficient performance control, and cockpit management functions. The autopilot is digital in its internal computations. With the autopilot and the flight management system, the aircraft can automatically follow an optimum path in all phases of the flight in four dimensions (space + time).

The major avionics are mounted in equipment racks in conformance with ARINC 404 and are located in the forward bay below the flight station floor. The avionics boxes are listed in table 10. Flight controls and autopilot are discussed in Section 5.1.2.5.

5.1.6.1 Communications: The basic communication systems are VHF, HF, a selective calling system (SELCAL), various audio systems and passenger entertainment.

The VHF communications consist of two ARINC 566 tranceivers, two low drag blade antennas, and two sets of controls and readouts. The transceivers are Collins type 618M-3. Frequency coverage is from 118 MHz through 135.95 MHz in 50 kHz increments.

SELCAL relieves pilots of the radio monitoring task. The system has two channels, each of which can monitor calls on any of the VHF or HF receivers. When a properly coded incoming call is received, a display lights and a chime sounds.

The HF radio consists of two tranceivers, a flush-mounted antenna, two antenna couplers and dual controls. The transceiver is ARINC 599, Collins type 628T-1. The antenna is located in the front spar of the vertical stabilizer.

Two intercom systems are provided, flight intercom and service intercom. The flight intercom has two channels, cabin intercom and galley intercom. The cabin intercom links the flight station and the ten flight attendant stations. The galley intercom links the galley and the principal service areas; fore, middle, and aft in the cabin. The service intercom links 20 major servicing areas throughout the aircraft for use during ground service functions.

The passenger address system has speakers in the flight station, cabin, galley, and lavatories. Inputs are from the cabin hostess stations and flight station. Two-way interconnections are provided with the passenger entertainment system. The passenger entertainment/service multiplex system provides stereophonic sound, hostess call, and remote controlled reading lights and air outlets. This is a digital multiplex system.

TABLE 10. - AVIONIC LRU'S, BASELINE ATA

	Pounds
FCES Pnl. (Flight Control Electronic System)	4.4
AFCS Warning Ind. (2) (Avionic Flight Control Syst.)	3.4
AFCS Warning Ind. (2)	3.8
AFCS Mode Annunc. (2)	4.8
AFCS Mode Annunc. (2)	5.4
DAFCS Computer (2)	90.0
FIDD Computer (Fault Isolation Data Display)	34.0
FIDD Pnl.	10.0
Pwr Supply (2)	15.0
Stick Shaker (2)	13.0
DAFCS Pnl.	12.0
Lateral and Normal Accelerometers (2)	3.2
Yaw Rate Gyro	3.3
FCES Computer	24.1
PFCS Pnl.	3.7
Trim Aug Computer	21.7
Alpha Sensor	2.8
Auto Throttle Servo	3.6
Long. Accelerometer	1.2
Brake Control Unit	7.0
Brake Control Unit Mount	0.7
Brake Control Unit Pnl.	1.9
Active Aileron Computer (2)	60.0
Q Sensor (3)	5.7
Accelerometer	1.5
Accelerometer (2)	3.0
Pwr Supply	6.3
HF Xcvr. (2)	50.6
Xcvr. Adapter (2)	13.4
Coupler (2)	33.8
Coupler Mount (2)	3.4
Comm Control	3.6
Decoder, Selcal, Motorola NA-135	9.5
Control	1.1
VHF Xcvr (2) ARINC 566, Collins 618M-3	26.4
Control (2)	5.5
Passenger Address System Amp. (2) ARINC 560	19.8
Microphone (4)	2.4
Microphone (7)	4.4
Audio Distribution Unit	4.7
Tape Deck, Passenger System	18.0
Main Multiplexer	2.6
Submultiplexers (3)	4.5
Column Time Decoders (6)	10.0
Installation Parts	0.6
Cable & Parts, Seat Electronic Unit	2.4

TABLE 10. - AVIONIC LRU'S, BASELINE ATA (Continued)

	Pounds
Seat Electronic Units (232)	213.4
Cables, Seat to Seat	102.6
Decoders (232)	255.2
Service Interphone Amp.	2.5
Audio Amp.	2.5
Audio Select Pnl. (5)	17.8
Headset (5)	3.0
Headset Boom Mic. (3)	1.2
Hand Mic. (5)	3.0
Monitor Spkr. (2)	2.8
Voice Recorder, Fairchild	21.9
Control	1.2
Flt. Data Recorder, Pinger	24.1
Accel., 3 Axis	1.0
Recorder	18.4
Flt. Cont. Surface Position Ind.	1.6
Control Wheel, Aileron (2)	13.2
Flap Posit. Ind.	3.5
Electronic Clock	1.5
Electronic Clock	1.5
Electronic Clock	0.9
Master Time Unit	0.7
Time Base Unit	4.5
Clock Module	1.8
Pitot-Static Tubes (2)	5.3
Pitot-Static Tubes (2)	5.3
Standby Altimeter, AeroMech	1.0
Standby Airspeed, AeroMech	0.7
AirData Syst, Sperry (2)	43.0
Baro Altimeter, Sperry	7.8
Baro Altimeter, Sperry	9.6
Airspeed Ind., Sperry (2)	10.3
Vert. Speed Ind., Sperry (2)	4.3
Air Temp., Simmonds	1.2
Instrument Comparison Monitor, Sperry	3.8
Inst. Failure Warning (2)	2.2
AHRS Vert. Gyro Sperry	15.7
AHRS Vert. Gyro Mount	5.3
Compass Hd. Coupler (2)	16.4
Compass Cont. Pnl. (2)	1.6
Compass Mag. Compensator (2)	1.1
Flux Valve (2)	3.0
ADI	18.6
ADI	21.0
Standby Horizon Ind., SFENA	0.5
Standby Horizon Ind., SFENA	3.5

TABLE 10. - AVIONIC LRU'S, BASELINE ATA (Continued)

	Pounds
Radio Altimeter Xcvr (2)	24.0
Radio Altimeter Ind. (2)	4.6
Mkr Beacon Recr	3.4
Mkr Beacon, Light Set (2)	0.3
Flt. Management Computer (2)	41.0
Control & Display Unit (2)	16.0
Inertial Nav. Unit (3)	158.4
CDU (2)	8.4
Battery (3)	49.2
Mode Select (2)	1.3
Omega	30.0
CDU	5.0
Ant. Coupler	6.0
Weather Radar	100.2
Weather Radar Mount	15.7
PPI Indicator	24.3
PPI Indicator Mount	2.3
Antenna	43.0
Control	2.4
Ground Prox. Warning Computer	7.1
DME Interrogator King 7000B	37.0
ATC Transponder King KXP-7500 (2)	17.8
Control	1.7
ILS Recr. ARINC 578 (2)	17.8
VOR ARINC 547 (2)	19.6
VOR Preamp (2)	1.2
VHF Nav. Cont. Pnl. (2)	4.2
HSI Sperry (2)	18.4
ADF Recr. (2)	16.0
ADF Recr. Control	2.4
ADF Recr. Loop Ant. (2)	9.8
QEC (2)	0.3
RDDMI (2), Radio Digital Distance Magnetic Indicator	8.7
Standby Compass	0.8
TOTAL	2142.0

Notes: Quantities shown thus (2), Weight is for both/all.
Black boxes only, no installation, antennas or servos included (except as noted).

A cockpit voice recorder, ARINC 557, is in the aft fuselage. It records cockpit conversation. A flight data recorder, ARINC 5733, is also in the aft fuselage. An underwater sound pinger is attached to the data recorder. The system records 32 analog and 30 discrete signals involving altitude, speed, acceleration, control surface positions, and engine operation.

5.1.6.2 Navigation: The navigation centers around the flight management system and the triple inertial reference system. Integrated into this system is Omega, VOR, and DME.

The inertial system consists of three sensor systems, ARINC 571. Interfaces are shown in figure 24. The three separate outputs of the navigators are input to each of the two flight management computers and are also available for manual selection and display.

The flight management system is shown in figure 25. The capabilities of the FMS are in three categories:

- Performance management for fuel/cost conservation
- Navigation and guidance
- Assistance in the cockpit management task such as programming of communications, radio aids to navigation and engine and fuel management.

Performance management operates in cruise, climb, and descent modes. The cruise mode calculates optimum speed for a given altitude. The speed is then held approximately by automatic throttle, and more precisely by slight pitch variations. These pitch variations do not disturb altitude more than ±15m (±50 ft). The optimizing calculation takes into consideration predicted winds and the desire for maximum cruise speed consistent with best fuel consumption or lowest cost. The system can display the optimum cruise altitude taking into consideration length of flight and fuel to climb.

The climb mode automatically and continuously adjusts pitch attitude and throttle settings to give optimum fuel usage or cost. The optimum schedule considers various engine deratings, minimum fuel and minimum cost at the pilot's option.

A step-climb option is provided, which provides:

- A prediction of the optimum time to go to the initiation of a climb to a more optimum altitude
- A determination of whether the climb is worthwhile based on cruise distance remaining and wind
- Automatic control of the climb and transition to new cruise altitude when initiated by the pilot

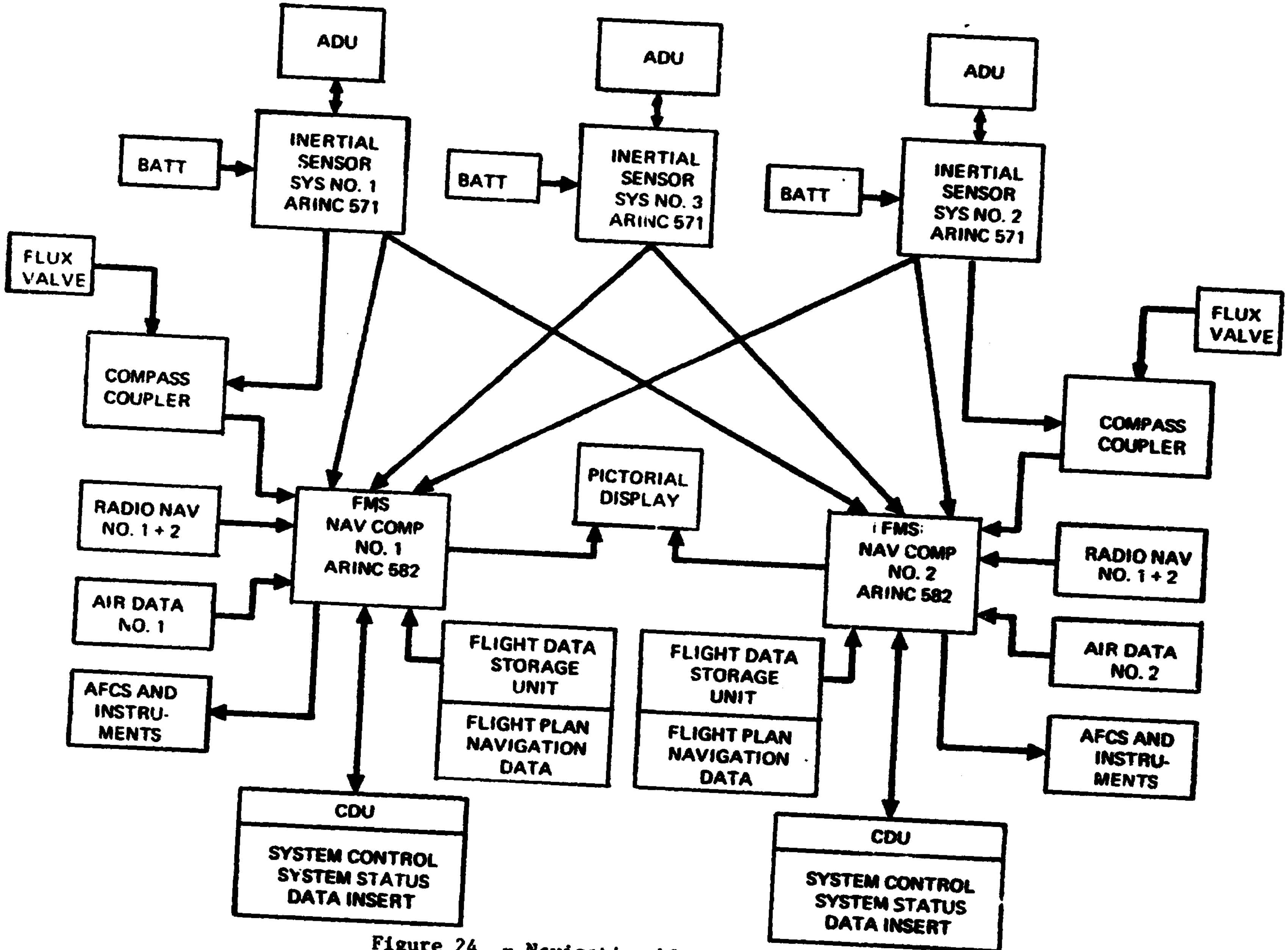


Figure 24. - Navigation block diagram.

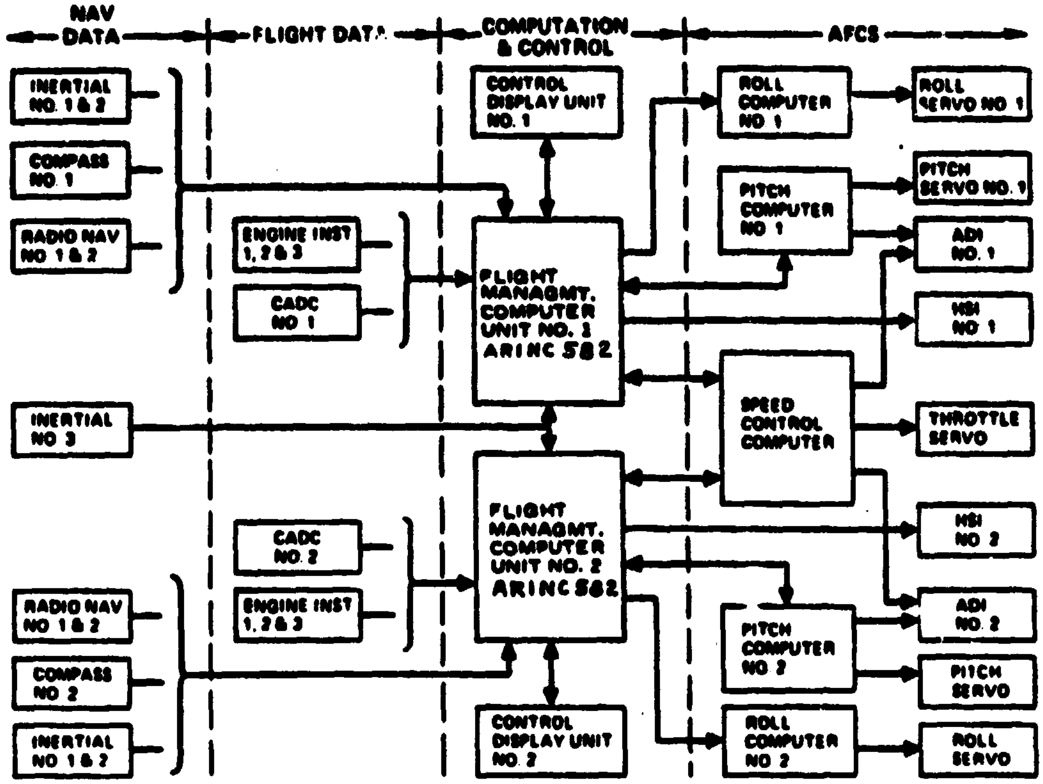


Figure 25. - Flight management system.

The descent mode provides an optimum descent profile taking into consideration predicted aircraft weight at start of descent, temperature, cruise altitude and speed, desired descent speed schedule, altitude capture geometry, and the desired end of descent position, altitude, speed, and time.

The navigation capability of the FMS is obtained by integrating the inertial systems, VOR, DME, and Omega. In the terminal area, the VOR and DME are the more accurate and when available are used to update, calibrate, and adjust the inertial. The FMS contains the logic to compare and select the outputs of the navigation subsystems for the most reliable and most accurate overall result. The navigation calculations are input to the performance management functions, and based upon the waypoints and desired arrival times at the waypoints, the FMS calculates and guides the aircraft in the optimum path in space and time. The present location and predicted path are available for display.

The pilot assistance (cockpit management) capabilities of the FMS include preprogrammed acquisition of the enroute VOR, DME, and communications facilities, and monitoring of the engines and fuel. The engines are monitored for out-of-tolerance temperature, pressure ratios, and fuel flow. The fuel is monitored and transferred for cg control. Aircraft weight and cg is continuously calculated starting with aircraft weight at takeoff obtained from load sensors in the landing gear.

The FMS has two separate computers each of which performs all computations in parallel and compares the results. Each computer performs independent self-check at two cycles per second. Results of the comparison and self-check are presented to the pilot for selection of the controlling system.

- VOR/ILS: The VOR/ILS provides position and guidance signals to the pilots' displays, flight management system, and autopilot. Two VOR receivers, ARINC 547, and two ILS receivers, ARINC 578, are provided. Two remote manual controls are provided in the flight station as well as automatic control from the flight management system. Three dual antenna systems are provided; glide slope, localizer, and VOR. The VOR is Collins 622-3599-001, the ILS is Collins 792-6021-002, and the VOR preamp is Collins 792-6504-001.

- DME: Two DME interrogator units, ARINC 568, are provided. Output is to the flight management system and also to two Radio Digital Distance Magnetic Indicators of the four digit type. Two L-band blade antennas are provided on the bottom of the aircraft.

- HRS: The horizontal reference system consists of two flux gate compass systems damped by the inertial system. The flux valve is accurately aligned to an indexing plate to permit rapid replacement without the need for a compass swing. The compass data is supplied to the inertial systems for initializing the alignment sequence, providing a signal for failure monitoring and for degraded mode operation.

- ADF: The automatic direction finder (ADF), radios are in accordance with ARINC 570. Two loop antennas, quadrantal error correctors, and extended-range sense antennas with coupler are located in the bottom of the fuselage. The ADF is low and medium (broadcast) frequency operating in the 190 to 1750 kHz frequency range. The receivers are Collins 51Y-7, the antennas Collins 137A-6 and the error corrector Collins 382C. The output is visual display only, with no input to the flight management system.

- Radio altimeter/ground proximity system: The altimeter operates with altitude above terrain from zero to 760 m (2500 ft). The two radio altimeters are independent except for a cross connection to prevent mutual interference. Failure monitors detect faults, activate flags, and signal the autoland system. Two radio altimeters are provided, ARINC 552, Collins 522-3698-001. The ground proximity warning computer is ARINC 594, Sundstrand 965-0376-070. The ground proximity warning computer detects abnormal altitude and altitude closure rates with respect to the terrain.

- Weather radar: The weather radar is an X-band transceiver, ARINC 564. Two PPI indicators are provided for the two pilots. The antenna and associated waveguide assembly is in the nose radome. The radome is protected from lightning and erosion. The radome hinges allow one man to safely open the radome and service components within the radome area. Gain is automatically controlled on the basis of receiver noise level sampling. Antenna tilt is adjusted by a control accessible to both pilot and copilot. The operating modes are NORM., CONT., and MAP. The CONT. mode provides iso-echo contour mapping to indicate precipitation density in storm areas. In the MAP mode, a change in the antenna beam provides a ground-mapping presentation on the indicators. The maximum range is selectable; 50, 150, and 300 n.mi. The antenna is stabilized in two axes using attitude signals from the inertial navigator, a 180-degree forward section is scanned. The radar is Bendix type RDR-1F.

- ATC transponders: Two transponders with altitude reporting capability, ARINC 572, are provided. Two L band blade antennas are provided on the bottom center line of the fuselage. The transponder can be set to Mode A (domestic identification and altitude) or Mode B (international identification and altitude). Control knobs and a code display are provided to enable selection of any of the 4096 codes for the A and B modes. An IDENT pushbutton allows the system to respond with the special position identification when requested. The transponders are Collins 621A-6A.

- Air Data: This system provides two air data computers. The inputs are pressure from the pitot-static tubes and total air temperature. The outputs and their corresponding range of measurements are:

Pressure Altitude	-31 to +15,000 m (-100 to +50,000 ft)
Altitude Rate	0 to ±100 m/s (0 to ±20,000 fpm)
Altitude Hold	0 to ±305 m (0 to ±1,000 ft)
Computed Airspeed	50 to 450 knots
Airspeed Hold	0 to ±20 knots
True Airspeed	150 to 599 knots
Mach No.	0.2 to 1.0 Mach
Static Air Temp.	-99° to $+50^{\circ}C$

The computers are ARINC 565 and provide outputs for the air data instruments and recorders as well as the flight management system, the automatic flight control, the stability augmentation systems, and the Mach/trim feel. The computers are made by Sperry and use digital computing techniques.

- Instruments: Flight instruments are standard electromechanical, conforming to ARINC 415-2. Dual instruments are used throughout. DC torquers are used in servoed instruments. An instrument warning system indicates malfunction and status of the basic attitude sensors and guidance systems. Warning is accomplished primarily through warning flags in each associated display or by retracting the display. Monitor coverage is continuous and automatic. No arming or resetting is required. Comparison monitoring is provided for the primary airspeed, attitude, and altitude systems.

5.1.6.3 Updated Avionics: As noted previously, the avionics in the area of flight control and flight management were updated to ARINC 700 new-technology avionics as follows:

- Stability Augmentation System (2)
- Automatic Flight Control Computer (2)
- Flight Management Computer (2)
- Inertial Reference System (3)
- Air Data Computer (2)

- Thrust Management Computer (2)
- Gyro-Accelerometer Package (2)
- Display Generators (6)
- Horizontal Situation Indicator (2)
- Vertical Director Indicator (4)

5.2 Short-Haul Aircraft

Two current-technology, short-haul aircraft were selected for inclusion in this study effort. The short-haul aircraft, one 30-passenger capacity and one 50-passenger capacity, employ conventional, state-of-the-art design concepts and are optimized for minimum DOC at a 1100 km (600 n.mi.) range. The current technology baseline aircraft are depicted in figures 26 and 27.

5.2.1 30-passenger. - The configuration selected for this aircraft is similar to current-production commuter type aircraft with the primary exception being a higher cruise speed capability of Mach 0.60 to provide efficient, economical operation at the 1100 km (600 n.mi.) design range. Selection of the Mach 0.60 cruise speed dictates a wing loading of 390.6 kg/m^2 (80 lb/ft^2) for current, lower-speed commuters. One advantage of the higher wing loading is improvement in ride quality during operation in turbulence. A GAW-1 type airfoil with an average thickness ratio of 16 percent is incorporated. The high-aspect-ratio (AR 12)) cantilever wings are mounted above the cabin and require no exterior support struts. The current technology turboprop engines are underslung and are placed at 43 percent half span (0.4 diameter propeller to fuselage clearance) to minimize cabin interior noise. Attainment of the NASA-required cabin interior noise levels of 85 dB OASPL results in incorporation of 431 kg (950 lb) of acoustic treatment.

To meet the balanced field length requirement of 1219 m (4000 ft) at sea level and 32°C (90°F), full-span, full-translation, single-element Fowler flaps and full-span slats are incorporated as depicted in figure 28. These high-lift devices result in a C_{Lmax} of 3.5 at the 42° flap setting used for landing. Two-piece spoilers are included on the wing upper surface to provide roll control.

The fuselage has a minimum of compound curves to reduce manufacturing complexity and costs. The windshield is composed of flat panes rather than a curved, wrap-around type, also to reduce costs. The cabin is pressurized to 34.5 KPa (5 psi) differential.

The nose and main landing gear wheels retract into the fuselage; the nose gear retracts cleanly without protruding fairings, while the main gear requires small fairings to enclose the main support struts. Four abreast seating (7.5 rows) was chosen so that a fuselage stretch could be accommodated at a later time. The aircraft can be stretched to a maximum passenger capacity of 40. A fuselage diameter of 2.90 m (9.5 ft) was chosen to meet aisle and seat width

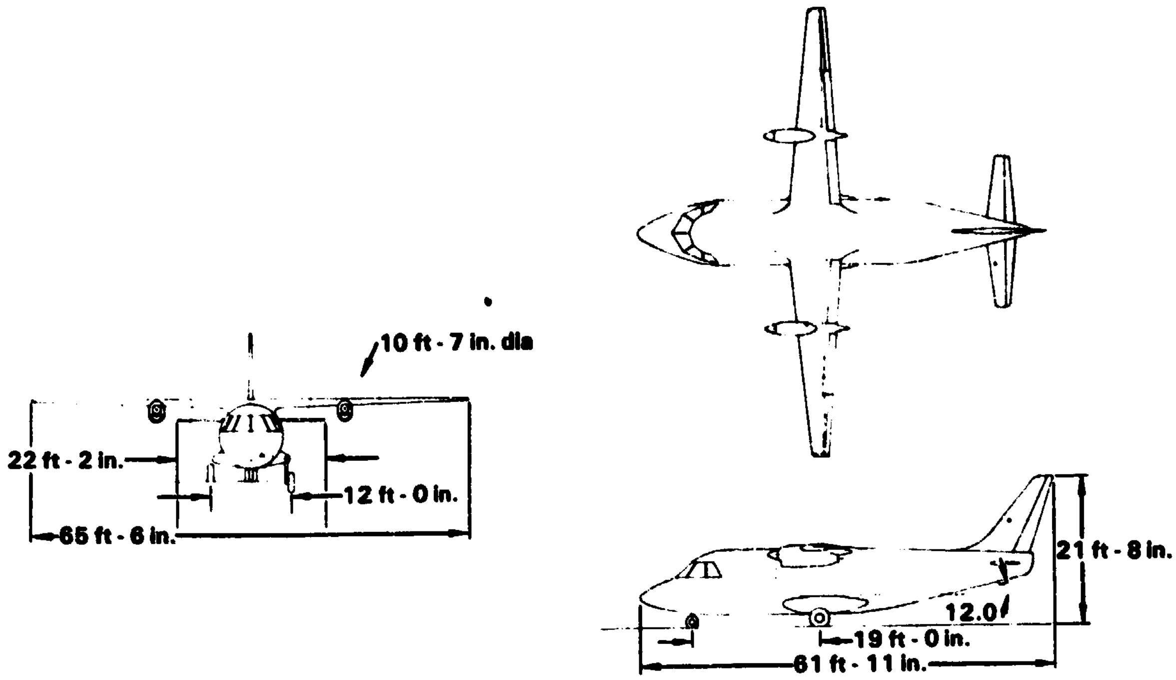


Figure 26. - 30-passenger, short haul.

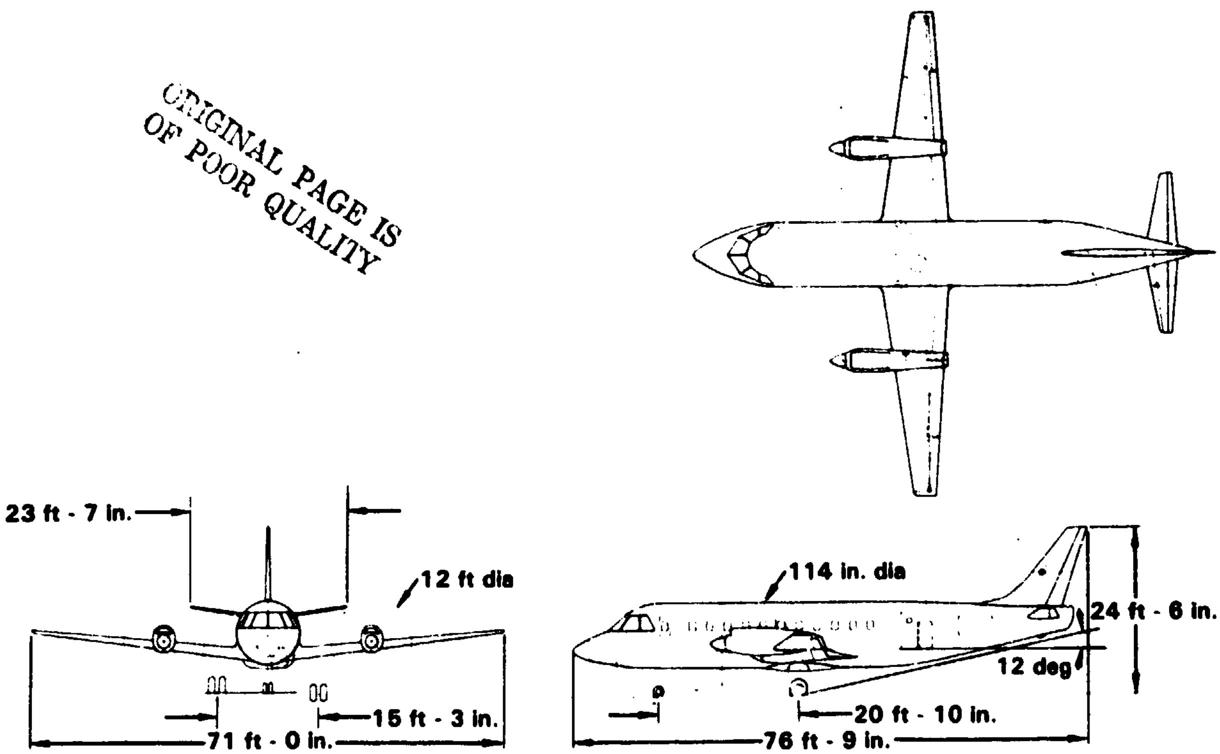


Figure 27. - 50-passenger, short haul.

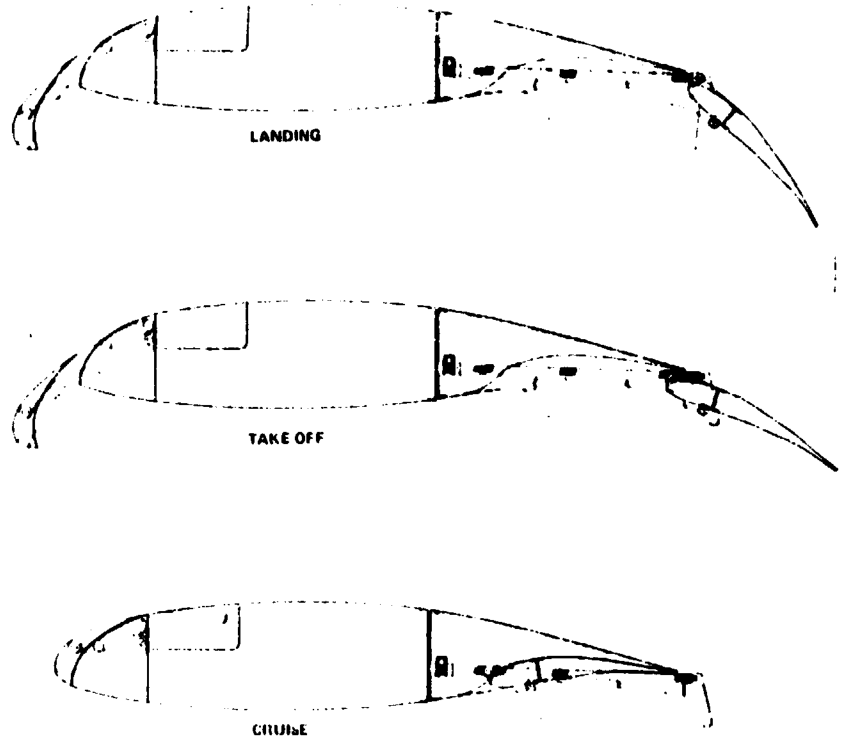


Figure 28. - High lift system.

requirements and to provide 4-abreast seating. Passenger carry-on baggage is stowed in overhead lockers, and checked baggage is stowed in a compartment aft of the cabin which is accessible from an exterior door. A lavatory, beverage service bar, and coat storage comprise the aft end of the cabin. Passenger and crew entry/exit is through the single main door at the rear left-hand side of the cabin. The cabin floor is 1.32 m (4.33 ft) above ground, which permits entry with an airstair door, so no extra ground equipment is necessary for passenger loading. The exterior cargo door permits access from a pickup truckbed. Three emergency passenger exits are provided as per FAR Part 25. Acoustic insulation is included throughout the cabin from floor to ceiling to attenuate propeller tip noise. The treatment thickness is graduated from a maximum, in the zone which extends from immediately in front of the prop disc plane to a few feet aft, to a minimum at the cabin ends. The hydraulic service center and ECS units are located beneath the cabin floor forward of the main landing gear bay.

5.2.2 50-passenger: This aircraft was configured to provide a cruise speed capability of Mach 0.70 for a design range of 1100 km (600 n.mi.). The wing design and high-lift devices are essentially identical to the 30-passenger aircraft except that wing AR is 10 and the wing is mounted under the cabin floor. The engines are over wing mounted to minimize gear length for the required ground clearance.

The fuselage is identical to that of the 30 passenger except that a 4.06-m (13.33 ft) plug was added, and the fuselage/wing junction was changed. Future growth can be obtained by stretching the fuselage for a total capacity of approximately 80 passengers. Two lavatories are placed in the extreme aft end of the cabin along with increased coat storage and beverage bar capacities. The cabin floor height is 2.08 m (6.83 ft) above ground and requires a specially designed airstair for passenger entry/exit. Baggage loading in the aft compartment requires some means of ground equipment to reach the door. Three emergency exits are provided as per FAR Part 25. Acoustic treatment of the fuselage is the same as for the 30-passenger; however, due to the higher propeller tip speed at Mach 0.70, the acoustic weight penalty is increased to 680 kg (1500 lb). Landing gear for this aircraft are fully retractable; the nose gear retracts cleanly into the fuselage, and the main wheels also retract into the fuselage rather than into the engine nacelles. The main gear leg pivots are supported on the rear spar of the wing. The ECS and hydraulic service center are located beneath the floor in front of the front spar.

5.2.3 Flight Controls. - The 30- and 50-passenger, short-haul transports are treated similarly in the flight control area. The engineering philosophy is simplicity. Use of power for primary flight control is avoided with only the rudder for the 50-passenger and the spoilers for 30-passenger and 50-passenger being powered. Even in these cases, reversion to mechanical is provided in case of failure of the powered system.

Two separate hydraulic systems are provided, each powered by one of the two engines. The landing gear is free fall in case of hydraulic failure.

5.2.3.1 Pitch Control: Pitch control is shown schematically in figure 29. No power is provided except for the autopilot servos. Main control is by a dual cable loop operating directly on the elevator. A tab geared to the elevator reduces the hinge moments to approximately 27 N·m (20 lb-ft) for full elevator. A viscous damper is provided to avoid overshoot caused by the geared tab gain.

Trim is provided by separate means to the horizontal stabilizer. This electric trim system serves as a backup to the cable and rod system or backup in case of damage to the elevator. The trim motor is disengaged by a solenoid-operated clutch in case of failure. The autopilot can also be used for primary pitch control in case of failure of the main cable system and the trim system.

The autopilot is mechanically enabled by engaging a spring-loaded detent (figure 29). Thus the autopilot servo is in parallel with the manual control and is operating the crew controls in addition to the elevator and tab. The pilot can overide the autopilot by exerting enough force to make the control arm ride out of the detent. The force required is adjustable from 45 to 222 N (10 to 50 lb) of force on the control column.

5.2.3.2 Roll Control: Roll control (figure 30) is unconventional in that no ailerons are used. Control is by spoilers to allow the use of full span flaps. Spoilers hinge up from the top of the wing with a hinge moment of 68 N·m (50 lb-ft), for the 50 passenger, for full deflection at approach speed. This is too much for manual control so hydraulic boost is provided. However, in case of power failure, the pilot, with 27 N'm (20 lb-ft) of effort, can produce 8 degrees per second of roll to provide safe flight, approach, and landing. If one hydraulic system fails, the other system, valve, and actuator provides control. If this hydraulic system fails, the backup is manual through the cable system. If the manual control fails without hydraulic failure, the autopilot can be used as a backup. If the autopilot fails or the cable system in the wing fails, the trim system can be used. If the trim system fails, roll control sufficient for safe flight and landing can be provided by the rudder system.

The trim system is by electric operation of two small ailerons used for trim only. The reason for this arrangement is that the use of spoilers for trim results in excessive drag. The use of cables or push rods to these ailerons is difficult because the ailerons are mounted on the moving flap. Thus electric actuation is used with synchronization provided electrically.

With the autopilot engaged, the autopilot servo output is applied directly to the dual control valve which causes motion of the mechanical crew controls in parallel with the autopilot. The crew can overide the autopilot by exerting enough force to make the control arm ride out of the detent. The force required is adjustable from 13 to 68 N'm (10 to 50 lb-ft) on the control wheel.

5.2.3.3 Yaw Control: Yaw control is shown schematically in figures 31 and 32. The 30-passenger aircraft is controlled by a manual mechanical system while the 50-passenger requires hydraulic boost. In both cases, an electric trim motor operates a tab for trim and a separate tab is geared to the elevator to reduce hinge moments. A viscous damper is provided to avoid overshoot caused by the geared tab gain.

The 50-passenger can revert to manual control in case of two hydraulic failures. The geared tab reduces the hinge moment to allow a 356 N (80 lb) push on the rudder pedal to give full 30° rudder at approach speed. If the manual cable control fails on either the 30- or 50-passenger, the trim control can provide an independent system for yaw control. If the trim system fails, the spoiler system can supply adequate directional control without the use of rudder. The trim motors have a solenoid-operated release, selected by the pilot, in the case of hard-over failures in the trim system.

5.2.3.4 Autopilot: The autopilot operates in the roll and pitch axes only, no yaw SAS is required. The autopilot in both the 30- and 50-passenger aircraft is the same, similar to Collins Co. AP-106A with FD-112 director system.

The features of the autopilot are: rate control, airspeed compensation, control wheel synchronization, linear VOR coupling, adaptive all-angle capture, and glideslope smoothing. The modes are: attitude hold, heading hold, navigation, approach, back course, altitude hold, airspeed hold, go-around, and pitch hold. The flight director includes an attitude indicator and horizontal situation indicator.

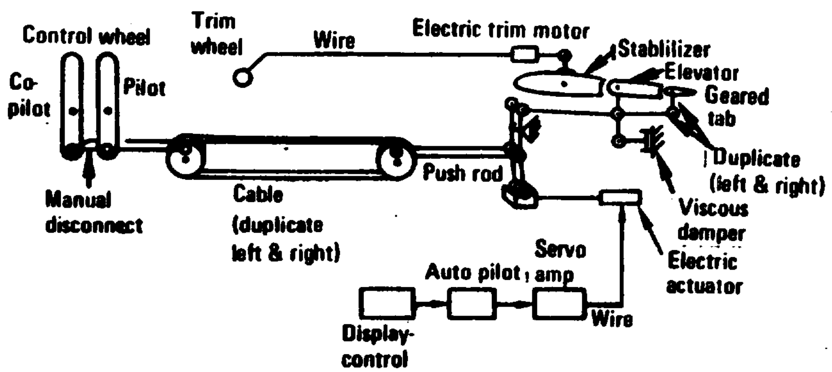


Figure 29. - Pitch control, 30-
and 50-passenger short haul.

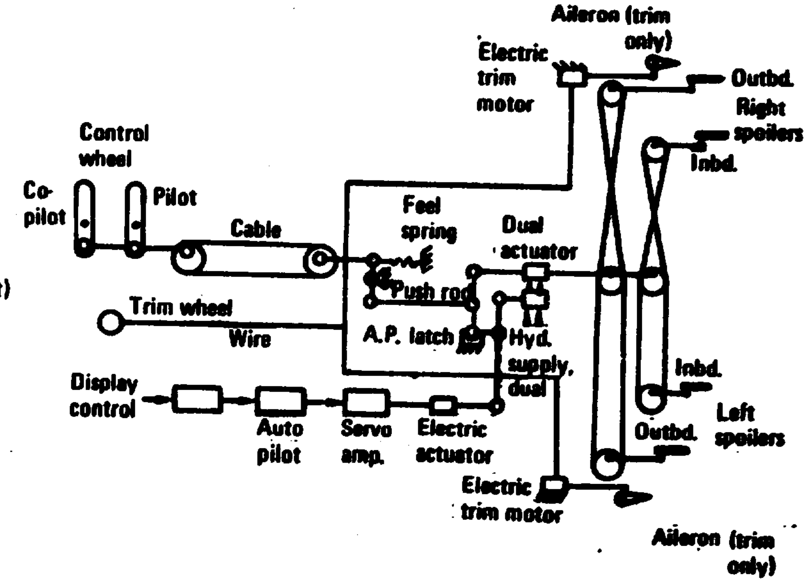


Figure 30. - Roll control, 30-
and 50-passenger short haul.

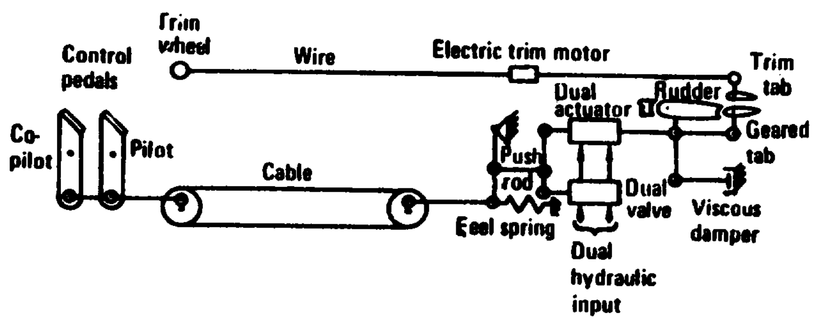


Figure 31. - Yaw control,
30-passenger short haul.

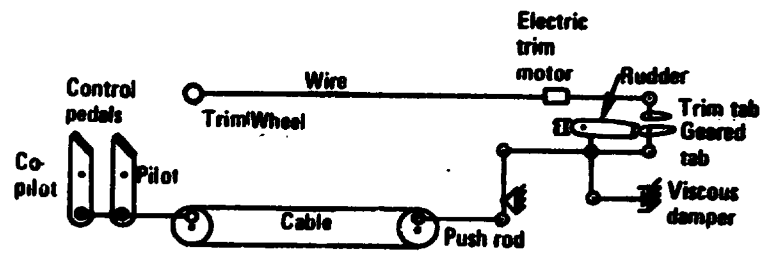


Figure 32. - Yaw control,
50-passenger short haul.

5.2.3.5 Secondary Flight Controls: The secondary flight controls include flaps and slats. The systems are the same on the 30- and 50-passenger. There are 3 slat panels and 3 flap panels on each wing. Control is by a single lever. The first detent (approximately 5° flap) extends the slats fully. Succeeding detents extend the flaps in steps up to 30 degrees. Flaps in each wing are driven by a torque tube operated by a hydraulic motor. Cross-shafting connects the torque tubes in each wing to provide symmetry. In addition, a resolver at each panel detects any asymmetry greater than 2 degrees and shuts down the system. The slat system mechanization and operation is similar to that of the flaps.

5.2.4 Electric System for Short-Haul Transport. - The design of the baseline elecrtric system in the short-haul transport is predicated on the use of two turbo prop or propfan engines that will run at essentially constant speed. As a result, a constant speed drive or a variable speed constant frequency (VSCF) type power system is not necessary since direct-driven generators will provide high-quality constant-frequency ac power for the primary loads such as de-icing, minigalley, heating, lighting, motor loads, and fan loads, etc. Twenty-eight Vdc power will be used to furnish the conventional type loads such as instrumentation, essential/emergency lighting, emergency avionics, and motorized values, actuators, etc.

The primary difference between the baseline SHT and the all-electric SHT is that the baseline electric system is a part of a conventional secondary power system in which hydraulics are retained for the typical actuation function and pneumatics are retained for the cabin air conditioning: pneumatic thrust reversers are not necessary in the baseline airplane since acccelerate-stop requirements will be met by propeller-reversing. The propellers themselves, with the cuffs/spinners, present additional electric load to the electric system in addition to wing de-icing. Isophobic materials, inflatable boots, liquid de-icing are alternative forms of wing ice protection; but electro-thermal (or electro-impulse) de-icing is assessed as more practical and cost effective for the short-haul vehicles. The penalty on the generator-sizing is not considered significant because the cold air with high liquid content mitigates the cooling of the generators.

Engine starting is another important consideration in the short haul transports with the option of using pneumatic, hydraulic, or electric starters. Again, to reduce logistic support problems, and in consideration of the maintenance support aspects of multiple power sources, electric starting is selected for the baseline (and the all-electric) airplanes.

5.2.4.1 System Description: The primary electric system consists of two 30-kva generators in the 30-passenger airplane, and two 50-kva generators in the 50-passenger airplane. These generators provide 3-phase, 200/115 V, 400 Hz nominal constant frequency power, and they are air cooled to avoid the complexity and maintenance support of an oil cooled generator system. A circuit breaker panel/ load center is located in the flight station area, providing flight crew access to all essential load circuit breakers.

The modern/advanced transport aircraft will be able to take advantage of solid-state power controllers (SSPCs), and these will provide the dual function of wire protection and circuit control. SSPC technology in the low-voltage, 28 Vdc is a low technical risk item, but development in the high-voltage, 200 Vac (and 270 Vdc) is still continuing. Solid state electric logic (SOSTEL) is also available to the advanced SHTs and this will replace the need for relay-tree logic, where auxiliary contacts and relay provide the interlock/logic functions.

Multiplexing and advanced digital data processing methods to solve circuit equations appear inappropriate or unwarranted for a cost-effective, short-haul transport. Additionally, the motivation to use multiplexing for the purpose of reducing wire quantity and wire-weight is not significant in these smaller airplanes. However, more sophisticated load management techniques that can minimize the proliferation of busses is desirable and, as proposed in the all-electric aircraft, an advanced low-level-logic load-control technology can be used. This control permits the use of miniature-gage dedicated wiring and it can be interfaced with a simple automatic load management system that will prioritize loads and control their disconnectionn in response to various emergency conditions.

DC power in the short-haul transports is obtained from partial-rectification of the ac power by means of two 150 amp T/R (transformer rectifier units). The output of the two T/R units can be operated in a paralleled or non-parallel mode. The normal mode is for both main dc buses to be tied through a bus-tie relay, but the relay can be opened when required. A 40-ampere hour lead acid battery is used to support the dc buses and to provide emergency power.

Secondary/emergency ac power for engine ignition, transducers and communication avionics, etc., is derived from a 3-phase, 500 Vac static inverter powered from the 28 Vdc battery. In the event of a dual-engine failure, or a compound failure of an engine and generator (which results in a complete loss of primary ac power), all ac and dc loads, not essential to the operation of the airplane, will be automatically disconnected. A manual override capability is possible, but is accomplished at discretion of the pilot.

Starting of the engines is accomplished using a separate dc brush-type 28 Vdc starter. A starter-generator was evaluated for the short-haul transport but was abandoned in favor of the separate-starter system. The factors affecting this trade involved reliability and maintenance support considerations. While saving the need for a separate rectifier system, the brushless starter generators reflected higher maintenance support costs. Typically, a separate dc starter has a mean time before failure (MTBF) of 20,000 hours, compared to 4000 hours for a brush-type starter generator. The typical maintenance support costs for a starter (brushless) ac generator system are assessed as 65 cents/fh compared to over $3/fh for a starter-generator system.

Figure 33 is a schematic of the ac/dc system in the short-haul transport. Operation of the system is automatic. Generator control switches are provided on the pilot's overhead panel and ammeters/indicators/status lamp display the condition of the electric power system. The generator control switches are normally closed and connection of each generator to each ac bus is effected under control of the two supervisory/regulator panels. When the voltage, frequency, phase-sequence are correct, bus contactors BC1 and BC2 close the generators to their respective buses. The bus-tie contactor BT1 is normally opened and is closed (automatically) only on failure of either ac generator. Zone-protection is provided for the generators, and feeders, and any power feeder fault will result in a rapid electrical isolation of the generator in the faulty channel.

When either ac generator is on line, rectifier dc power is immediately availabe to both buses of the dc system. With both generators on, the unregulated rectifiers share the electric load via the load droop characteristic of T/R units. There are no input ac contacts in the rectifier circuits. Table 11 is a brief itemization of the loads in the short haul transport.

5.2.5 Hydraulics. - The baseline SHT is provided with a dual engine driven pump system, which furnishes the main hydraulic power. This system is supported by an ac motor-driven pump unit and an emergency dc pump unit. The system operates as a dual-isolated system with the hydraulic loads balanced across both systems. To take account of engine or engine-pump failures, a power transfer unit is connected between both systems; this allows a limited power transfer to be effective without any interchange of fluids.

In addition to furnishing power to the short-time demands of the main and nose landing gears, doors, nose wheel steering, etc., the hydraulic power is used for the spoilers in the 30- and 50-passenger airplanes and for yaw control in the 50-passenger airplane. See figures 29, 30 and 31. Full-time hydraulics for the FCS is therefore used for some of the hydraulic FCS actuators but manual and/or electric backup is available in the event of an emergency. There are two actuators on each of the outboard spoilers and three actuators on each inboard spoiler. Similarly, high redundancy is provided in the yaw and pitch axis by use of three actuators and four actuators, respectively.

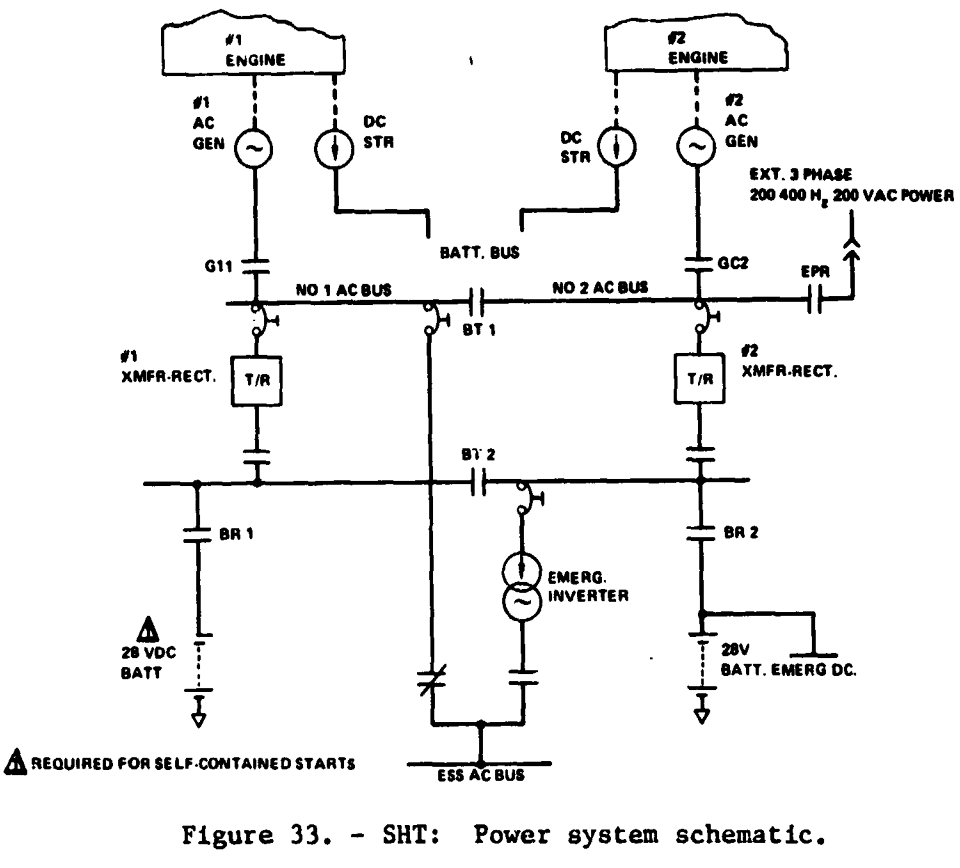


Figure 33. - SHT: Power system schematic.

TABLE 11. - SHORT HAUL TRANSPORT - LOAD SUMMARY

	Power: kVA	
	30 Pax	50 Pax
For Interior Lights	2	2
Exterior Lights (inc. landing/taxi)	1.2	2.5
Service Wing/Nacelle Lights	0.5	0.75
Avionics	5.0	6.5
Icing Protection: Wings	25.0	30.0
Propellers Spinners Cuff	12.5	15.0
Windshield Heating	5.0	7.5
Beverage Service Bar	2.0	2.5
Ventilation Fans	2.0	2.5
Re-cir/H_X	1.5	2.0
Motor-hydraulic pumps	5.0	6.5
Fuel Boost pump	3.0	5.0
Transfer Pump	2.5	2.5
Instrumentation	1.0	1.5
Auxiliary Heat	4.0	5.0
T/R Units	2.5	3.0

To support the aerodynamic-surface redundancy, the hydraulic system schematic shown in figure 34, uses four separate power sources: two separate engine-driven pumps, an ac motor-driven pump and the dc motor-driven pump. As described, the power transfer unit also permits cross-powering the systems, left to right, without exposing either system to a major leakage problem in the other. While not a part of the hydraulic system, but supporting it, electric trim actuators are connected into the outboard ailerons, stabilizer, and rudder of the 30- and 50-passenger airplanes.

Other functions connected to hydraulic power on the SHTs are brakes and miscellaneous actuators for functions such as stairs, doors, and door locks etc. A reservoir connected into each system supplies emergency braking power and the gears are designed free-fall. The nosegear retracts forward and takes advantage of slip stream to assist in the free fall mode: main gears retract inboard.

The SHT baseline does not use a ram-air turbine or any mono-propellant type emergency power system, so any extended emergency such as a loss of both engines, or an engine and pump in an unfavorable combination, is met by the dc-driven emergency pump unit.

5.2.6 SHT Baseline ECS. - In many current aircraft the ECS energy is provided by mid-stage and last-stage bleeds on the engine compressors. Typically, the engine manufacturers allow up to a ten percent bleed, but for the smaller turbo-fan engines this customer-bleed demand may be constrained to only

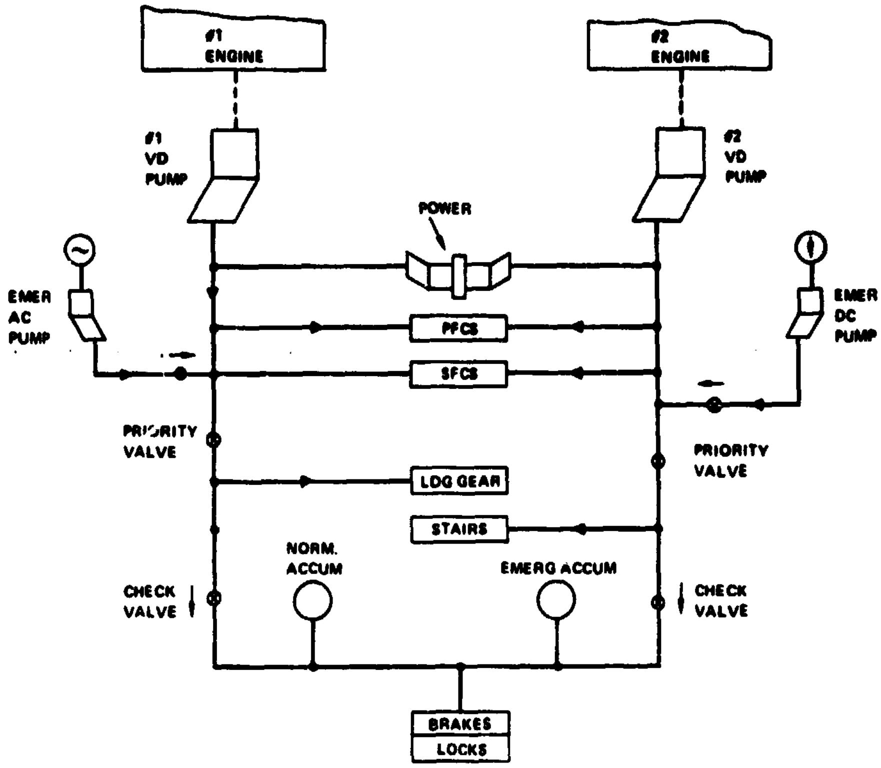


Figure 34. - SHT: Hydraulic schematics.

2 to 4 percent. At the engine power settings associated with idle-descent let-down (from say 25000 ft.), this percent of bleed could be marginal or inadequate for the ECS demand of the short-haul transport. With the adoption of turbo-props for the 30-passenger and 50-passenger Lockheed SHT designs, the bleed air capabilities are even more marginal, and as a result, the following alternative approaches, for furnishing pressurized air, are available:

- Engine driven compressors
- Electric driven compressors

Since the study calls for a trade of a baseline SHT and an all-electric SHT, these were the respective selections for the two airplanes.

Cabin ventilation rates are typically 15 to 17 cfm/passenger, but in the smaller aircraft, with the higher passenger density per unit volume, 20 cfm/passenger is proposed. This results in cabin flow requirements of approximately 45 ppm to 76 ppm. With the trend toward lower-levels of vitiated air, however, 50 percent recirculation and 50 percent fresh air is considered acceptable for the short-haul aircraft. Therefore, the compressor displacement is sized at approximately 22 and 38 ppm for the 30-passenger and 50-passenger airplanes, respectively. The pressure ratio of the compressors is selected to provide a 1828 m (6000 ft) cabin up to 4572 m (15000 ft) and not less than an 2438 m (8000 ft) cabin up to 8202 m (25000 ft). To minimize the weight and volume of the ECS turbo--machinery, two compressors and two ECS packs are proposed. Both ECS packs are ducted into a plenum prior to cabin distribution, and they share the total cabin air conditioning demand. In the event of a loss of either ECS pack, the aircraft will descend to a lower operational altitude.

Figures 35 and 36 are schematics of the ECS system. In the baseline SHT, the two compressors provide heated pressurized air for the simple air-cycle packs, which include heat exchangers, filters, control valving, and water separators. Heating of the cabin is provided (in the baseline and all-electric) from heat-of-compression; however, in the baseline this is only available by running one or more engines (on the ground). Cooling air, in the baseline, is by use of an expansion turbine.

5.2.7 Avionics for Short Haul Transports. - The avionic suites for the 30-passenger and 50-passenger aircraft are identical and the complement of functions is typical of the short-haul and business aircraft of today. The equipment is mounted in the avionics bay and remotely controlled in the cockpit.

Table 12 lists the equipment. The system features dual COMM, VHF NAV, and DME. A weather radar and an integrated COMM/NAV control are provided. The autopilot and flight director system are described in Section 5.2.2 dealing with flight controls.

- VHF COMM: Each of the two tranceivers provide 20 watts of transmitter output and cover 118 to 135.975 MHz in 25 Hz steps.

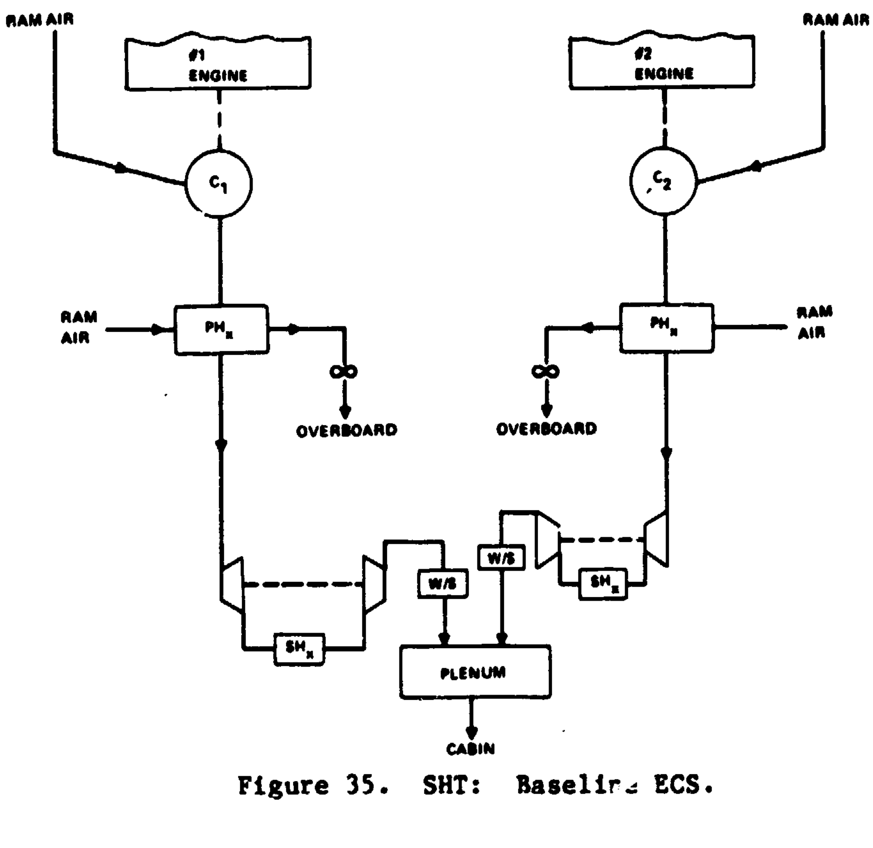


Figure 35. SHT: Baseline ECS.

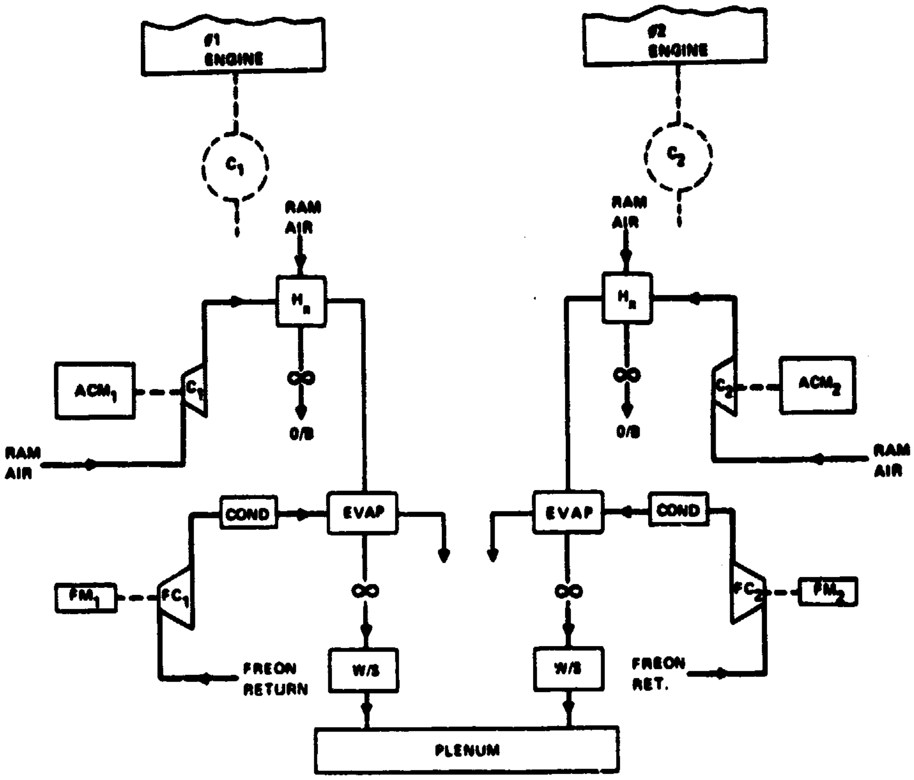


Figure 36. - SHT: All electric ECS.

- VHF NAV: The NAV receivers provide VOR, localizer, glideslope, and marker beacon. 200 VOR, 200 localizer, and 40 glideslope channels are provided. Control and display are provided by the integrated NAV and control system.

- ADF: The receiver is digitally tuned in 0.5 KHz steps through the 190 to 1749.5 KHz range. The sense antenna and RF amplifier are mounted in the loop antenna package.

- DME: The two DME tranceivers provide 0 to 250 n.mi. range on 252 channels. Transmitting is at 300 watts in the range of 1025-1150 MHz. Receiving is in the range of 962-1213 MHz.

- Radar: The weather radar has range scales to 300 n.mi. selectable in 10, 25, 50, 100, 200, and 300 NM maximum ranges. Transmitter is 5 KW with a 5.5 or 1.0 microsecond selectable pulse width. Frequency is 9345 MHz $\pm$ 30 MHz (X band). The 0.3m (12-inch) flat plate antenna is stabilized. The color CRT display area is 0.11 x 0.10m (4-1/2" x 4").

- NAV and COMM Control: This hardware provides area NAV with 10 stored waypoints. It provides tuning and control for all radios and the setting of transponder codes. Up to 10 frequencies can be stored for later use. The remote control units can selectively provide a display of active and preset comm. and nav. frequencies plus the ADF frequency and the transponder code. A flight progress display provides distance to the active way point and either groundspeed or time to the way

TABLE 12. - SHORT HAUL AVIONIC EQUIPMENT

VHF #1, Collins VHF-20A, 20 watts
VHF #2, Collins VHF-20A, 20 watts
VOR-Localizer-Glideslope-Marker, Collins VIR 30
VOR-Localizer-Glideslope-Marker, Collins VIR 30
ADF, 190-1750 KHz Collins ADF-60
ADF Antenna
DME #1, Collins DME 40
DME #2, Collins DME 40
Transponder, Collins TDR-90
Radar, Collins WXR-300
Radar Indicator
Radar Antenna, 12 in.
Audio Control Center, Collins 346B-3
Speakers, 6 at 3 lb.
Cockpit Voice Recorder, Collins AVR-101
Locator, Garrett RESCU/88
Nav. & Comm. Control, Collins NCS-31
Remote Control, Collins CTL-( ) (quantity 7)
Power Supply, 5 volt, Collins 639-U1
Mode Select Panel
Radio Alt., Collins ALT50
Indicator
Antenna (2)
Compass, King KCS 305

point. Accurate ground speed is displayed regardless of whether or not the aircraft is tracking directly toward or away from the station way point.

6. EVALUATION METHODOLOGY

6.1 The ASSET Vehicle Synthesis Model

Aircraft parametric sizing, configuration tradeoff, and performance evaluation studies are performed through the use of the Lockheed-developed Advanced System Synthesis and Evaluation Technique (ASSET) vehicle synthesis model. A schematic presentation of the primary input and output data involved in the ASSET synthesis cycle, which is programmed on an IBM-370 computer is shown on figure 37. The ASSET program integrates input data describing vehicle geometry, aerodynamics, propulsion, structures/materials, weights, and subsystems, and determines candidate vehicles which satisfy given mission and payload requirements. It provides the means to assess the effects of airframe, propulsion, and systems options (thrust weight, wing loading, engine cycle, advanced materials usage, etc.) on the vehicle weight, size, and performance.

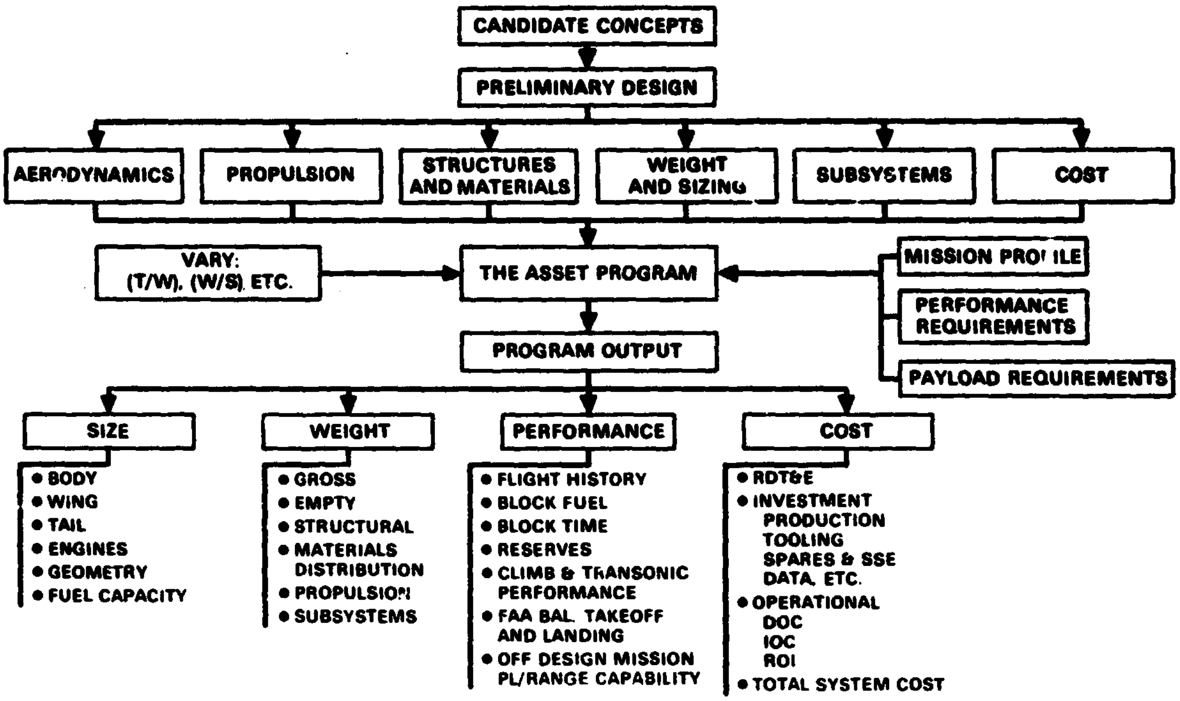


Figure 37. - The asset synthesis cycle.

The main benefits from the employment of this computerized synthesis technique are:

- Once a set of basic input data is assembled for a baseline vehicle, a virtually unlimited number of design options and alternatives can be evaluated with minimum effort, time, and cost.

- Tradeoffs between different technologies are properly related and are evaluated on the basis of their effects on the total system.

- Computer accuracy, though often greater than necessary considering the accuracy of the preliminary design input data, ensures that differences in weight, size, and performance between candidate vehicles are not masked by the noise level of computational techniques.

- Last-minute changes to the design ground rules can be rapidly incorporated into the vehicle synthesis.

- The output from the computer program provides an automatic bookkeeping and documentation instrument.

A generalized schematic illustrating key elements and the flow of information through the ASSET program is shown in figure 38. The three major subprograms of ASSET are sizing, performance, and costing. The sizing program sizes each parametric aircraft to a design mission. The design characteristics and component weights of the sized aircraft are then transferred to: 1) the costing program, which computes aircraft cost on the basis of component weights and materials, engine cycle and size, avionics packages, payload, production and operational schedules, and input cost factors; and 2) the performance program which computes maneuverability, maximum speed, ceiling, landing, and takeoff distances and other performance parameters.

ASSET program output consists of a group weight statement, vehicle geometry description, mission profile summary, a summary of the vehicle's performance evaluation, and RDT&E production and operational cost breakdowns.

6.1.1 Vehicle Sizing. - The sizing subprogram is composed of five routines: sequence, configuration, weight, drag, and mission. In addition, the sizing subprogram uses propulsion data input in the form of thrust and fuel-flow tables and an independent atmosphere subroutine.

The sequence routine groups the sets of independent variables (design options and mission requirements) that are to be varied parametrically. Examples of these variables include (but are not limited to) thrust/weight, wing loading, aspect ratio, wing thickness ratio, wing sweep angle, design load factor, payload, equipment, avionics weights and volumes, materials usage factors, and design mission rquirements, (range, radius, endurance, speed, etc.).

The input parameters from the sequence routine and the configuration and weight inputs are transmitted to the configuration and weight routines. The configuration inputs describe the fuselage geometry (forebody, cockpit, fuel section, engine section, afterbody), the wing geometry, wing fuel-tank volumes, the tail geometry and sizing relationships, engine scaling relationships, and engine nacelle or inlet geometry. The weight input consists of equipment and payload weights, propulsion system weight relationships, loads criteria, component airframe weight coefficients and exponents applicable to conventional constructions, and the materials distribution for each major structural airframe component, and the corresponding weight correction referenced to conventional construction. The configuration routine computes the geometric data for the vehicle components (planform areas, wetted areas, frontal areas, lengths, diameters, chords, reference lengths, volumes, shapes, etc.) required by the weight and drag routines. The weight routine determines the component weight build-up, materials usage for the major airframe elements, and the fuel available. These data are used in the configuration routine. The configuration and weight routines, operating together, determine the geometric and weight characteristics for an airplane having an assumed trial takeoff gross weight. The trial vehicle is geometrically sized to contain the crew, equipment, payload, propulsion system and fuel. The tails are sized to provide specified (input) tail volume coefficients.

The geometric data for the trial aircraft are transmitted to the drag routine. In addition, component zero-lift pressure drag coefficient data (subsonic pressure, transonic compressibility, supersonic wave interference) for the empennage, fuselage, and nacelles are estimated for a baseline aircraft and are input as functions of Mach number.

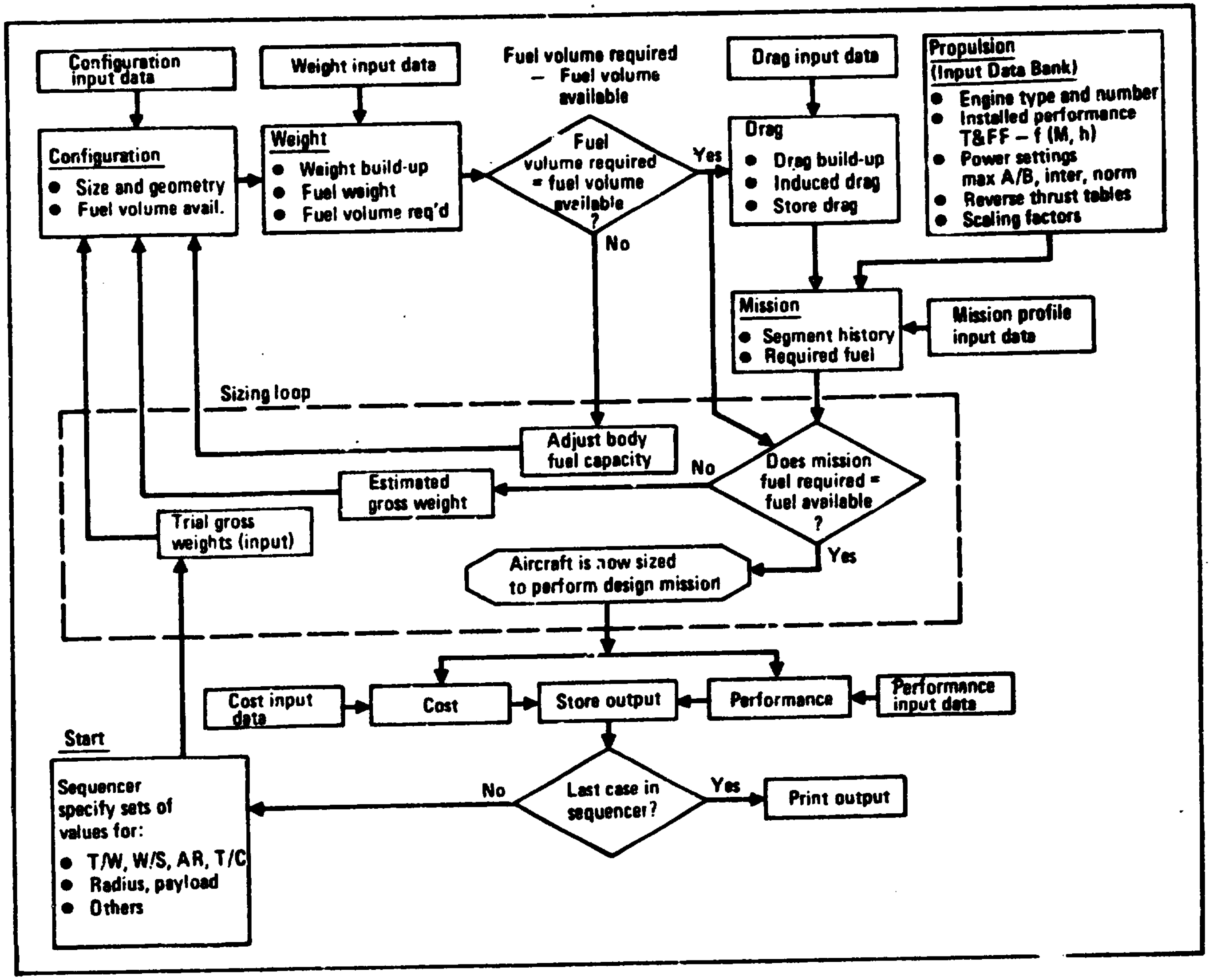


Figure 38. - ASSET program schematic.

Propulsion data for the engine under study are input to the program. Applicable power setting, (takeoff, maximum, intermediate, maximum continuous, etc.) thrust and fuel-flow data are provided as functions of Mach number and altitude. Partial power tables are used to simulate operation at thrust levels required during cruise or loiter. The partial power tables describe fuel flow as a function of thrust level, Mach number, and altitude. Engine scaling factors, determined from the configuration routine, are applied to the propulsion data to determine thrust and fuel flow for the engine size of the aircraft under study for any flight condition.

The atmosphere subroutine, used by the mission routine and the performance subprogram, allows computation of pressure, density, temperature and the speed of sound at any given geometric or pressure altitude. Standard or nonstandard days may be considered. Standard or arbitrary atmosphere models can be used.

The mission routine uses the propulsion thrust and fuel-flow tables, the aerodynamic-drag tables, and the atmosphere subroutine to determine the fuel required to perform the design mission profile. The mission profile is assembled from specified flight segments, such as takeoff, climb, acceleration, cruise, loiter, combat, etc. Simplified two-dimensional point mass flight equations are used in determining the time history of the mission. Simplifying assumptions common to classical aircraft performance analysis, which ignore rotational and normal accelerations, are incorporated into the flight equations.

An iterative convergence technique completes the sizing subprograms. Using this technique, the fuel available from the weight routine and the fuel required determined by the mission routine are compared. If the difference between the available and required fuel is greater than acceptable tolerances, a new trial takeoff gross weight is computed. This iteration continues, passing trial aircraft through the sizing cycle until acceptable agreement is reached between the available and required fuel. The configuration, weight, and aerodynamic data generated for the final aircraft satisfying the mission requirements are saved for use by the performance subprogram.

6.1.2 Performance Evaluation. - The performance subprogram uses the aerodynamic, weight, and propulsion data generated for the synthesized aircraft by the size subprogram, and additional aerodynamic, weight, and propulsion input data required to evaluate any or all of the following performance characteristics:

- Climb characteristics (sea level rate of climb, ceiling)
- Speed (maximum speed at sea level, maximum speed at optimum altitude)
- Maneuverability (steady state maneuvering load factor, specific excess power, time to accelerate, time to decelerate)
- Airport performance (takeoff distance over an obstacle, landing distance over an obstacle, wave-off rate of climb)
- Alternate mission capability (range, radius, endurance, etc., for off-design missions)

The climb characteristics of the synthesized aircraft are assessed at specified vehicle weights for given thrust settings, external store and/or fuel-tank configurations. The maximum rate of climb at sea level is determined at the takeoff weight for a zero-acceleration climb schedule. Ceiling altitudes are determined for specified rate of climb requirements for a series of aircraft weights ranging from the takeoff weight to the zero fuel weight. Service, combat, and cruise ceilings may be determined by specification of the appropriate thrust settings, and rate-of-climb requirement.

Speed characteristics are assessed for specified aircraft weight, thrust settings, and external store and fuel tank configurations. The maximum speed at sea level, the maximum speed at the optimum altitude, and the corresponding optimum altitude are determined.

Maneuverability capabilities are evaluated for specified aircraft weights, external store and fuel tank arrangements, thrust settings, speeds, and altitudes. Steady state load factors are determined for zero specific excess power and maximum lift coefficient flight conditions. Specific excess power is computed for defined load factor conditions. Acceleration and deceleration time histories are determined between given speeds. Drag brakes and/or thrust reversal may be employed during deceleration.

Airport performance is evaluated for standard or nonstandard days. Any airport altitude may be specified. Aerodynamic data representing the maximum lift coefficient and drag polars for the aircraft in the take off and landing configurations are provided by input. The distance required to takeoff over an obstacle is determined for defined thrust settings. Takeoff and transition speeds are specified as percentages of the stall speed. Landing distances over an obstacle may be determined for both flared and unflared approaches. Approach and touchdown speed are specified as percentages of the stall speed. Sinking speeds at the obstacle height and at touchdown are constrained below defined limits. Thrust reversal may be employed during the braking phase. Go-around rate of climb during the landing approach is computed for specified thrust settings. Any number of engines may be inoperative.

6.1.3 Costing. - The costing program computes RDT&E, investment, and operational costs. Both the RDT&E and production (flyaway) aircraft costs are broken down by airframe, engines, avionics, and armament. Airframe costs are further broken down into engineering, tooling, manufacturing, quality control, and material costs. The various cost elements are computed on the basis of cost estimating relationships (CER) which are established by analysis of historical data of applicable aircraft programs, Lockheed's R&D and production experience, and subcontractor/supplier quotations. Cost input consists of dollars-per-hour (labor cost) and dollars-per-pound (material cost) factors by aircraft structural element and material, labor rates, production rates and schedule, learning curves, subsystem, engine and avionics cost factors, and operational (fuel, maintenance, etc.) considerations. The model permits parametric costing as function of thrust, inert weight elements/and advanced material usage.

6.1.4 System Design. - The ASSET program was applied to the AE/ET study as shown in figure 39. The inputs were equipment weight, equipment cost, development cost, maintenance cost, bleed air requirement, shaft power extraction, ram air requirement, and aero drag. Since the configurations were variations from a baseline aircraft already resident in ASSET memory, only changes (deltas) in the aforementioned parameters were added to or subtracted from the baseline system parameters.

6.2 Figures of Merit

This section deals with the description of the quantifiable economic figures of merit and their use in detemining the net value of technology. The output of the economic subroutine in the ASSET program provides the economic indices associated with all aspects of the aircraft to develop, manufacture, place in service, and operate. These costs are combined in such a way as to provide several economic figures of merit, and determine the net value of technology. A definition of the figures of merit considered for this analysis is provided in table 13.

The figures of merit primarily used in this study are Net Value of Technology and Direct Operating Cost. The net value of technology has to do with what effect the technology has on the characteristics and performance of the aircraft and the ultimate impact of these changes on the cost and economics.

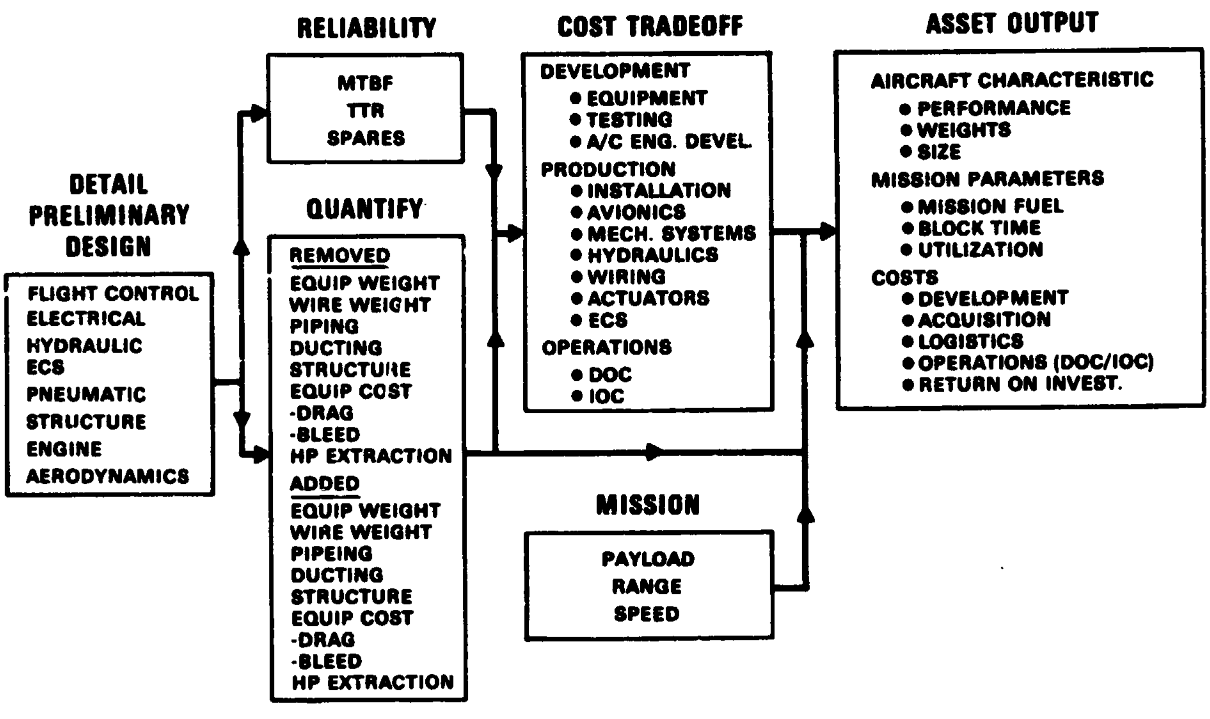


Figure 39. - Study flow.

TABLE 13. - DEFINITIONS OF FIGURE OF MERIT

	DEFINITION	REMARKS
NET VALUE OF TECHNOLOGY	DIFFERENCE BETWEEN COST OF TECHNOLOGY AND COST SAVING RESULTING FROM IT	LIFETIME COST IMPACT
DOC	DIRECT OPERATING COST: INCLUDING FLYING OPERATIONS, MAINTENANCE, AND DEPRECIATION	REFLECTS AIRCRAFT TECHNOLOGY ADVANCES — EASILY TRANSLATED TO PROFITS
ROI	NET INCOME/BOOK VALUE OF INVESTMENT	A MEASURED RETURN TO THE USER (PERCENT)
PAYOFF TIME	THE TIME FOR SAVINGS INCURRED TO EQUAL COST	A MEASURE OF MERIT BY LENGTH OF PAYOFF TIME
IOC	INDIRECT OPERATING COST: OVERHEAD COSTS ASSOCIATED WITH SYSTEMS OPERATION	NOT SENSITIVE TO ADVANCES IN AIRCRAFT TECHNOLOGY
LIFE CYCLE COSTS	THE COST TO DEVELOP, PROCURE AND OPERATE OVER THE USEFUL LIFE OF THE AIRCRAFT	MILITARY SYSTEMS COSTS IN COMMERCIAL TERMS IS EQUAL TO THE SUM OF THE DOC, IOC, INTEREST
BENEFIT/COST RATIO	BENEFITS IN DOLLARS DIVIDED BY COST	LOSES MEANING IF COST IS LESS THAN SYSTEM REPLACED

The economic impact is measured as differences in cost to a baseline aircraft that is void of the advanced technologies. The schematic of the process involved in arriving at the net value of technology is illustrated by figure 40.

Direct and indirect operating cost (DOC and IOC) include all of the aircraft and system expense elements. For clarification, the elements of both are shown below and illustrated in figure 41.

DOC	IOC
Flight Crew	System Expense
Fuel and Oil	Local Expense
Insurance	Aircraft Control
Depreciation	Food and Beverage
Maintenance	Passenger Handling
	Cargo Handling
	Other Passenger Expense
	Other Cargo Expense
	General and Administration

The summation of the DOC, IOC over the life of the aircraft (16 years) would constitute the lift cycle cost for the aircraft. The DOC reflects any changes in cost or performance and is sensitive to advanced technology changes if they impact on cost or performance. The IOC comprises expenses related to the ground system and is generally not influenced by the advanced technologies related to

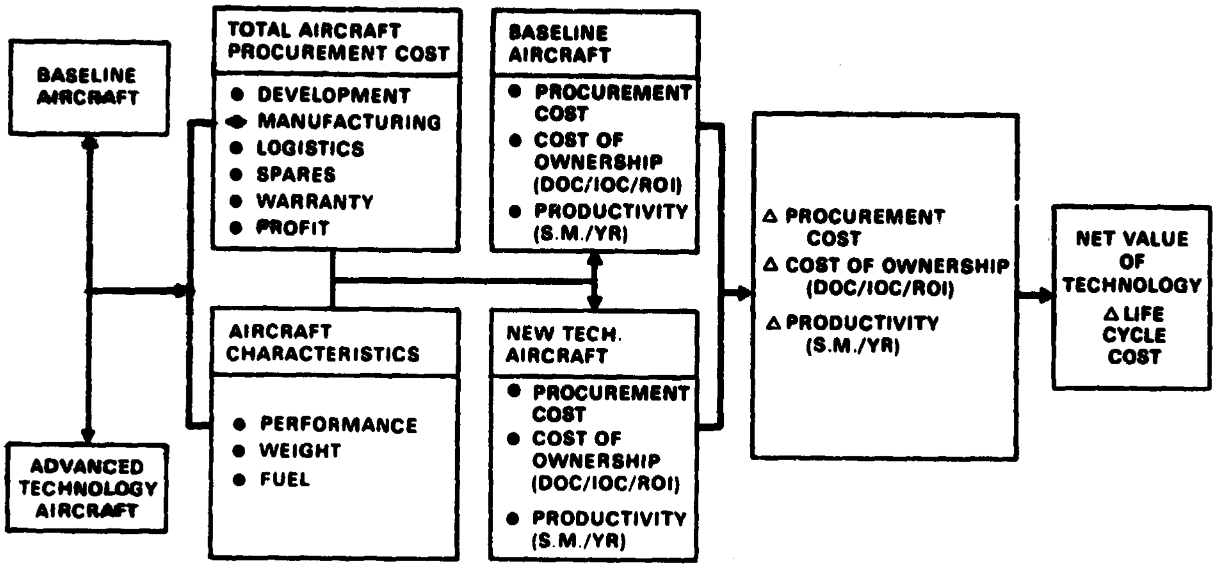


Figure 40. - Net value of technology.

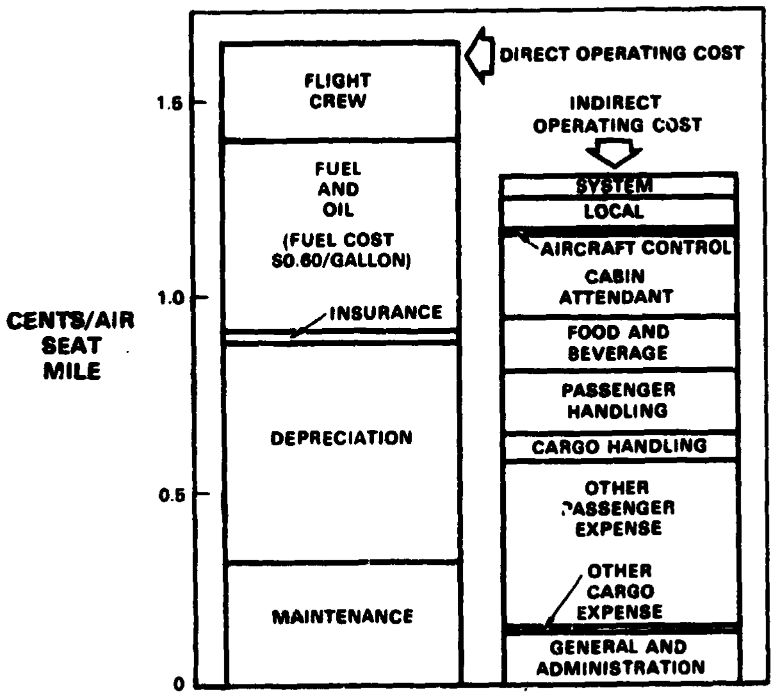


Figure 41. - Direct and indirect operating costs, large domestic transport.

the aircraft unless there is a significant impact on the number of passenger miles flown. The largest item of IOC elements is for passenger handling, and since there is no change in this, the IOC remains relatively constant. Cash flow measures the ability of the system to generate cash for facility expansion or additional investment for new aircraft.

The return on investment (ROI) measures the profitability of a business in relationship to the amount of capital being placed at risk. The ROI, as determined for these aircraft, would appear high in relationship to the ROIs as reported by airline operators. This is due to the fact that the ROI is calculated for one route segment of 3000 n.mi. with no tag-end short hops and is not diluted by the nonprofitable route that exist in a real airline route structure. This ROI is calculated to determine relative values where all aspects of the system may be considered for a single route segment out of the total structure. The ROI is an economic measure and does not take into account the qualitative benefits of the advanced technology.

Payoff time is another economic figure of merit that is useful in determining the net value of technology. The payoff time is determined by equating the cost of incorporating the advanced technology into the aircraft (development and procurement cost) with the saving per year in operations cost times the number of years required to offset that cost. The payoff time for the AE/ET aircraft is zero as the cost of incorporating the technology is less than incorporating the current systems into the conventional aircraft. The reason for this is covered in detail in Section 7.4.

The various figures of merit are included to reflect the sensitivity of the cost to the various changes in the aircraft equipment, and resultant weight changes. The RDT&E, and investment cost show the amount of front-end cost to establish the program. The operations cost (DOC/IOC) and ROI bring all of the costs together to provide an economic figure of merit from a systems point of view. The estimated values for these figures of merit are presented in Section 7.4.

7. TRADEOFFS

The tradeoffs were performed in incremental additive steps:

- Conventional vs. FBW
- FBW vs. FBW + multiplex
- FBW + Multiplex vs. laser gyro
- Laser gyro vs. integrated avionics
- Integrated avionics vs. the all-electric airplane
- All-electric airplane vs. fiber optics.

In each case, each new technology was traded off against a configuration that includes all the previously traded off technologies. This was done for the ATA and the short-haul transports, SH-50 and SH-30. The short-haul transports were not evaluated with the laser gyro system because such transports would not normally include an inertial system, thus there is no tradeoff. An additional technology, electric load management, was at first considered as a tradeoff. It was found, however, that addition of further load management to reduce the size of the generating and distribution system was not cost effective.

7.1 ATA Candidate System Descriptions

The advanced transport aircraft (ATA), Section 5.1, is a 500-passenger transport aircraft. The baseline aircraft has three fan jet engines and uses systems technology similar to the L-1011. The following candidate technologies were compared in additive steps, starting with the baseline aircraft.

7.1.1 Fly-By-Wire (FBW). - The ATA flight control system, which is typical of present-generation aircraft, uses 1173 pounds of mechanical cables, rods, cranks, quadrants, springs, and couplers. A look at the flight control schematic drawings, figures 7 and 9, reveal that this is a very complicated mechanical system. It includes sophisticated mechanisms to allow mixing and nonlinear proportional control of the various surfaces. These functions are a natural for electronic control, especially digital, but the single item that has kept the system mechanical is the requirement for safety. Reliance on electronics for flight critical controls is becoming more acceptable and advances in large-scale integration (LSI) of semiconductor circuitry has made large amounts of redundancy feasible. The resultant advances in system and software architecture will soon make it feasible to design electronic systems which are as reliable as the mechanical system and as immune to external hazards. A cautious approach will be required with extensive laboratory and flight testing, however. It must also be an evolutionary approach which does not give up the mechanical backup until full-time electronic flight controls have demonstrated reliability in millions of hours of commercial transport flight and until users are convinced that the electronics will not fail.

New transports with supercritical airfoils will yield substantial cruise efficiency improvements. These aircraft must use relaxed stability and thus active controls in order to fully exploit the supercritical airfoil technology. The resulting aft cg location will require full-time artificial stabilization and control force shaping. The conventional mechanical systems with electronic augmentation can only meet these requirements with large penalties in complexity, weight, cost, and safety. In fact, for fairly unstable airframes it is questionable if a mechanical system could effectively take over control following a total electronic failure.

Even present technology aircraft will benefit from FBW from weight savings and/or decreased maintenance costs. The tradeoff of this section considers a large ATA aircraft using present technology flight controls and a moderately aft cg and trades off a replacement FBW system using digital computers, electro-hydraulic valves and hydraulic power actuators. It will define payoffs that result from the control systems improvements and from aerodynamic payoffs resulting from new wing technology.

Figure 42 illustrates the payoffs associated with FBW. The system improvements in cost, weight, and maintenance were defined through careful analysis in this study. Payoffs associated with supercritical wing technology were determined based on the results of one wing configuration that has been tested at Lockheed. Multimode spoiler usage is discussed.

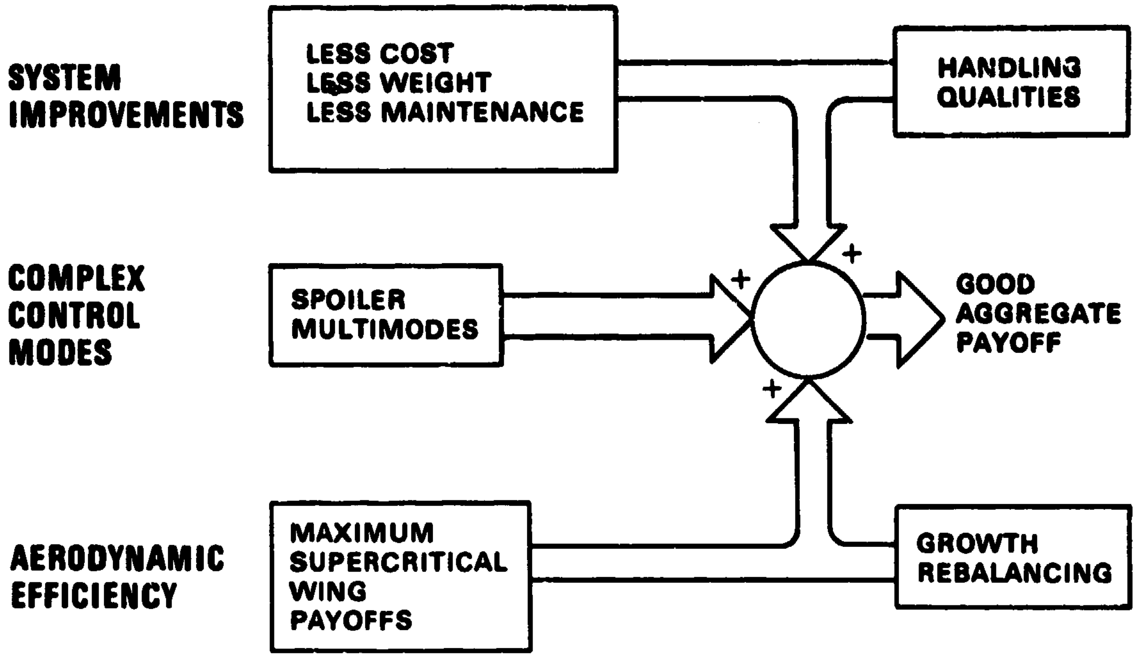


Figure 42. - Transport fly-by-wire payoff.

7.1.1.1 Fly-by-wire design criteria: The following criteria were followed in the design of the FBW configuration.

There shall be no single failure points in the flight control system that are flight critical. The flight control electronics shall be quadruply redundant. No more than two of the four parallel channels of sensors, electronics, or other flight control equipment shall be housed together. Consideration shall be given to the use of analytic redundancy to enhance operation following sensor failures. A direct electronic link (DEL) mode shall be available in case of total failure of feedback sensors. Control shall be by centerstick rather than sidearm or control wheel.

The probability of catastrophic failure of the flight control system shall not exceed 1×10^{-9} failures per flight. The probability of failure of the stability augmentation shall not exceed 1×10^{-7} failures per hour.

Built-in test equipment shall detect 100 percent of first and second parallel electronic flight control failures. In the event of third parallel failures undetected by on-line monitoring, the system shall revert to a fail safe configuration. This requirement applies to the fly-by-wire control system including the auto-land system. Preflight checkout shall be automatic and shall check out all flight control equipment and auxiliary systems.

Asymmetry detection shall be provided. Electrohydraulic actuators shall be used to communicate electronic signals to the power actuators in the initial tradeoff. As part of the all electric airplane tradeoff, electromechanical actuators shall be substituted for the electrohydraulic command and primary actuators.

The flight control system shall be designed in accordance with the following FAA documents.

FAR Part 25, plus all current Amendments	Airworthiness Standards: Transport Category Airplanes (FAA)
FAA AC 20-57A	Automatic Landing Systems
FAA AC 25.1329-1A	Automatic Pilot Systems Approval
FAA AC 120-28B	Criteria for Approval of Category IIA Landing Weather Minima
FAA AC 120-29	Criteria for Approving Category I and Category II Landing Minima for FAR 121 Operators

7.1.1.2 FBW configuration: Based on experience with redundant flight control systems and preliminary effort in reliability detection, it was felt that a quadruplex system could be made to give sufficient reliability by a combination of built-in test, on-line monitoring, and parallel voting. The selected configuration is shown in figure 43. The four digital flight control computers each calculate a control signal for each surface independently. Each computer receives the signal from each of the others, rejects out-of-tolerance signals, and takes the median value as an output. Thus, each computer outputs the same value avoiding force fights at the actuators. A computer shut down, either manually or automatically as directed by the monitoring system, will not result in an actuator being deactivated. Outputs of all computers are cross-strapped to all flight control actuators so that three of the four flight control actuators can fail and still leave all flight control surfaces active.

The combining of multiple inputs at an actuator can be handled in different ways. Mechanical force summing, mechanical position summing, electric summing, magnetic summing, and combinations of these could be used. The methods chosen for the ATA FBW configuration were mechanical summing at the servo valves as in the baseline system. For the added electrohydraulic valves, magnetic summing is used for the spoilers and force summing for the other control surfaces.

Consistent with the goal of using 1980s technology, Honeywell HDP-5301 Flight Control Computers were selected. These computers perform all computations and logic digitally; however, each has a considerable number of analog devices for communicating with the sensors and actuators, all of which require analog and discrete interfaces. Sensors of the flight control system comprise cockpit stick and pedal sensors to communicate crew commands and rate, attitude, and acceleration sensors to feed back aircraft states. Failure of all state sensors will result in a direct electronic link configuration for continued flight under degraded control.

The secondary actuators for all surfaces except the spoilers are similar to the shuttle elevon servo shown in figure 44. The features of this servo, as applied to ATA, are as follows:

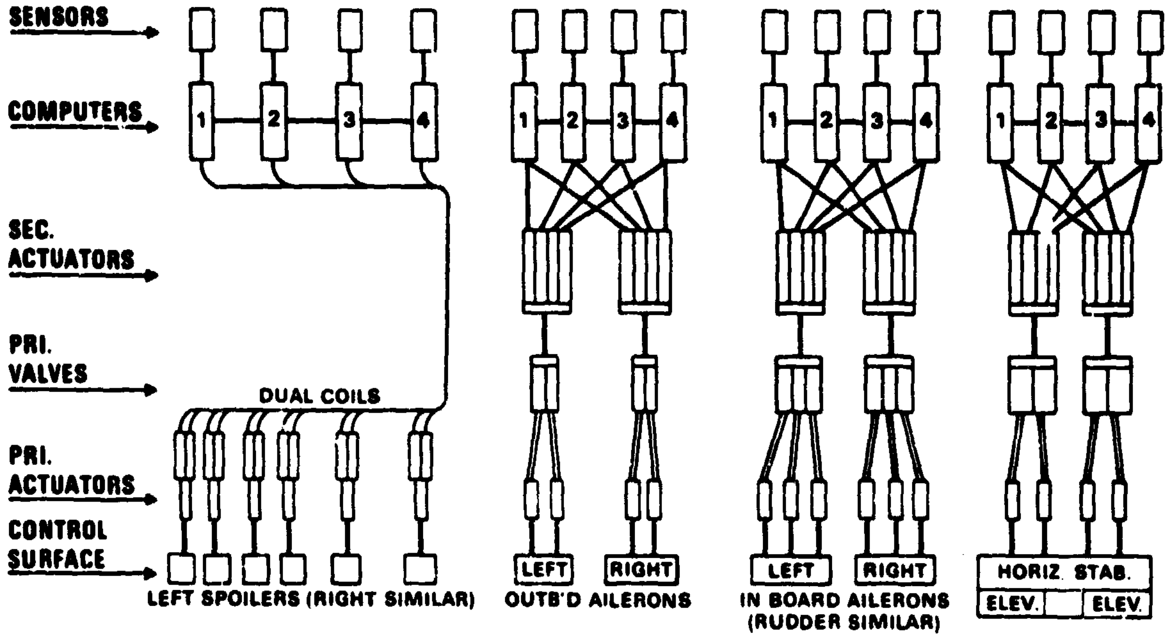


Figure 43. - Fly-by-wire diagram.

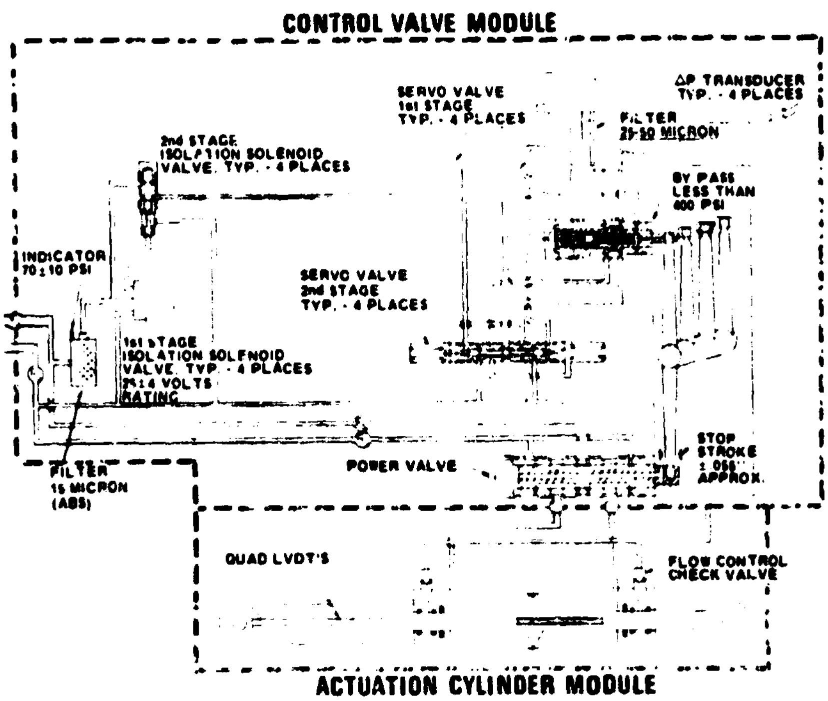


Figure 44. - Shuttle elevon servo.

- Four-channel electric command (two fail/operate)
- Force summing
- Synchronized by lowering pressure gain
- Redundant hydraulics
- Cross-channel monitoring

The spoilers, because of a high degree of redundancy, use actuators having dual servo valves operating on one primary ram. However, each servo valve has two separated coils. Thus, there are four electronic inputs to each spoiler, with each computer driving into one servo valve coil for magnetic force summing.

The primary valves and actuators, as stated previously, are identical to the baseline system. As in the baseline system there are no single failure points. The control wiring is conventional, unshielded, twisted. The valve and LVDT coils are center tapped for failure monitoring. For each of the four channels there are three wires for the coil, two for LVDT excitation, three for position, three for rate, two for pressure differential, and two for hydraulic shutoff.

7.1.1.3 Evaluation methods: The flight control system weight was calculated by subtracting the weight of cables, rods, bellcranks, bungies, quadrants, electro-hydraulic servos, computers, and wire from the baseline and adding the weight of computers, wire, feel servos, secondary actuators, and electro-hydraulic valves for the FBW system. The weights deleted were obtained from detailed L-1011 weight statements scaled up to the ATA configuration (see Section 7.3). The weight and cost of new computers and sensors were obtained from Honeywell Avionics Division. The weight of valves and actuators was obtained from Hydraulic Research Co. Cost and reliability data were compiled for all components. These data were entered into the ASSET program and results presented in Section 7.3.

The evaluation of fly-by-wire was performed in two steps. First the payoffs which accrued to the ATA from flight control system improvements alone were evaluated. Next, the payoffs resultant from the incorporation of an unstable aft cg location to optimize the supercritical technology performance were evaluated. This latter payoff was performed to show how an additional 3 percent fuel savings made possible by the artificial stabilization provided by fly-by-wire contributed an even greater payoff than the flight control payoffs alone. Figure 45 illustrates the 3-percent increment obtained by moving the cg range of the supercritical wing aft so that the most aft location is 10 percent statically unstable. All payoffs should be considered in reaching a decision of whether or not to apply FBW. Considerable benefit derives from the application of fly-by-wire spoilers because of the versatility of these surfaces. Some functions which can be performed by the spoilers are: roll control, speed braking, ground braking, approach direct lift control, profile descent direct lift control, maneuver direct lift control, vortex alleviation, and emergency pitch control. An electronic means of coordinating these multiple control modes is the only logical approach.

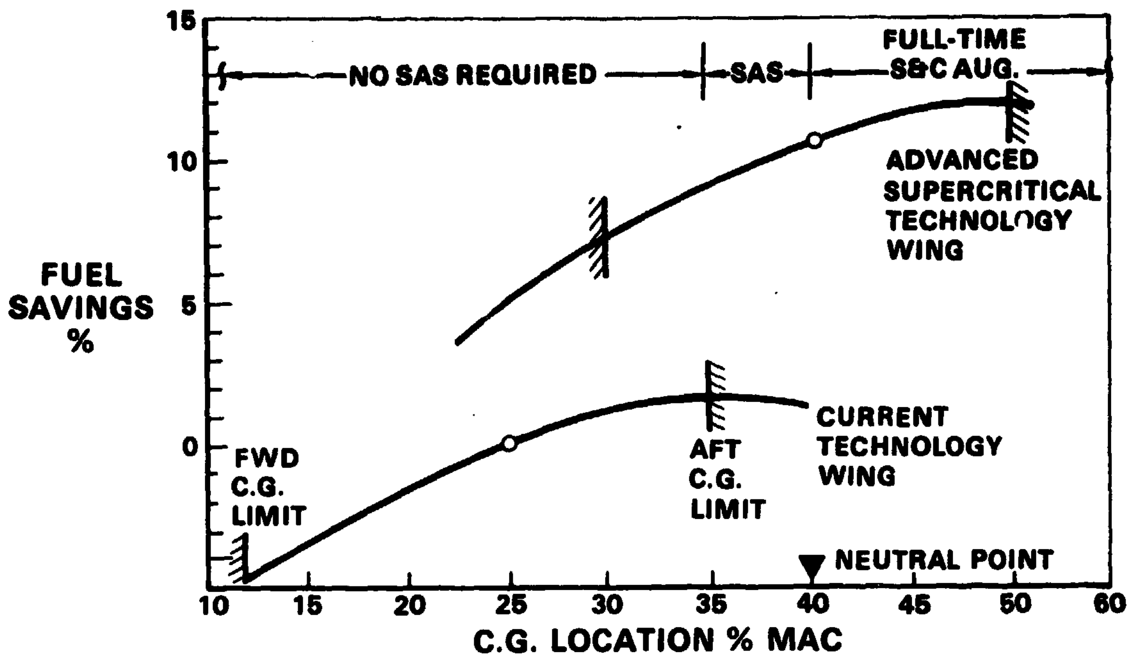


Figure 45. - Wing technology - augmentation requirements.

7.1.2 Multiplexing. - The multiplexing tradeoff is concerned with only the flight control system and the associated flight management, autopilot, navigation, and display systems. Later in the tradeoff sequence, when considering the all-electric aircraft, additonal multiplexing is introduced, (see Section 7.1.5).

In most transport aircraft, including the ATA, the electronics bay is located close to the flight station for the purpose of reducing wire run length. The ATA electronic bay is located directly below the flight station thus the maximum wire run is approximately 5 m (15 ft) and the average wire run within the electronics bay/cockpit area is 2 m (six ft). Thus the weight saving is negligible in this area and the equipment designer can make the data transfer choice based upon equipment parameters rather than aircraft impact. He may chose parallel transfer, serial transfer or analog formats, based upon feasibility, reliability, cost, complexity, and weight of the subsystem. It is assumed in this tradeoff that the subsystem designer has made these tradeoffs, that ARINC 700 series avionics has been chosen, and that the tradeoff involves the data transmission to and from peripheral equipment where long wire runs and wire weights are involved. Figures 46, 47, and 48 show how the data transfer evolves from mechanical transmission in the conventional flight controls, to the electrical transmission in FBW to the multiplexed system considered in this tradeoff. Three sets of four-channel multiplex-demultiplex (MDM) units are located near each wing root and near the tail, central to the actuators and associated sensors. The number and locations of MDM units is in itself a subtradeoff. More MDMs mean more MDM weight but less wire weight. The area MUX scheme chosen is consistent with a near term approach. All MDMs are located in the benign fuselage environment.

C-2

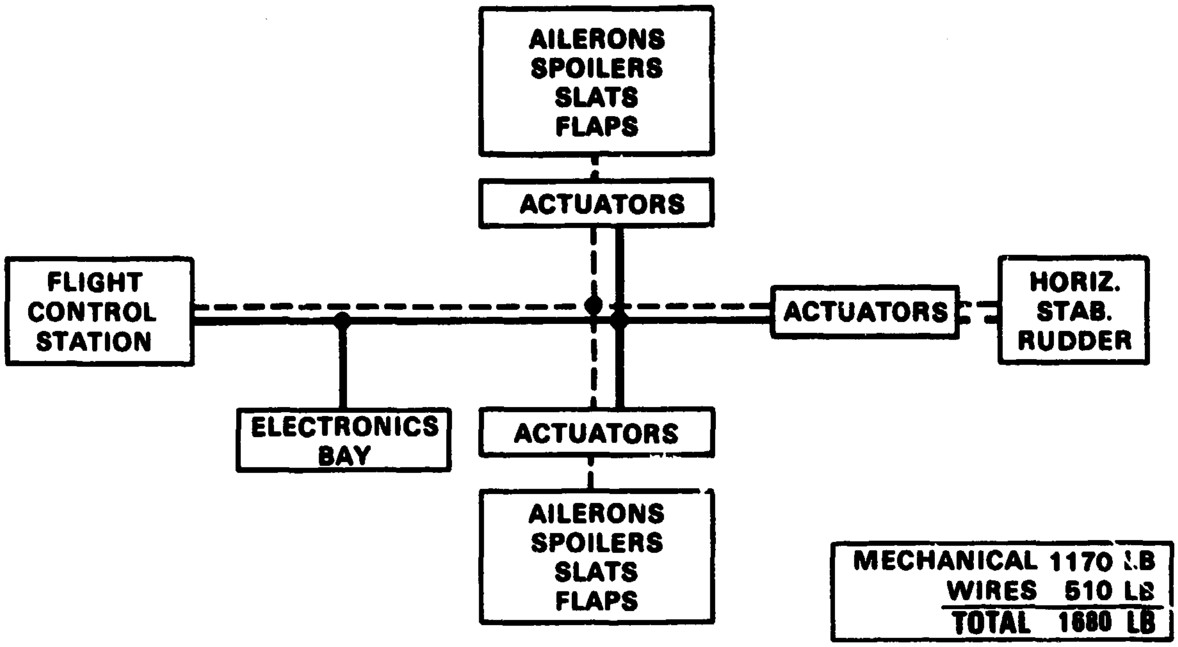


Figure 46. - Conventional data transmission.

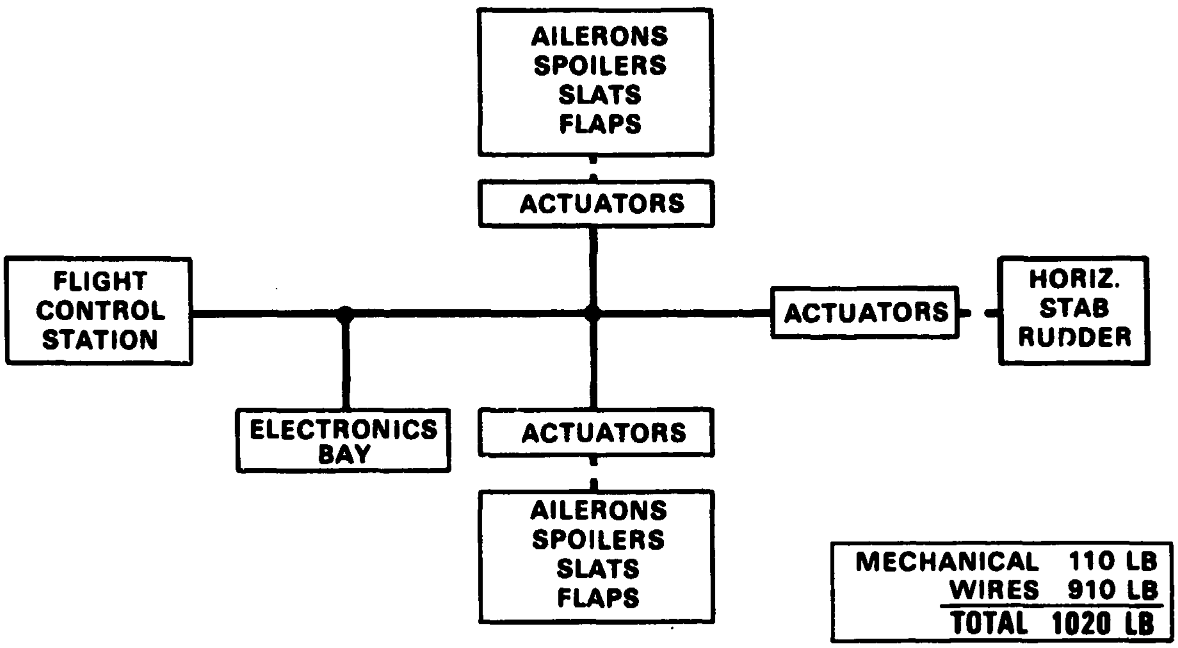


Figure 47. - Fly-by-wire data transmission.

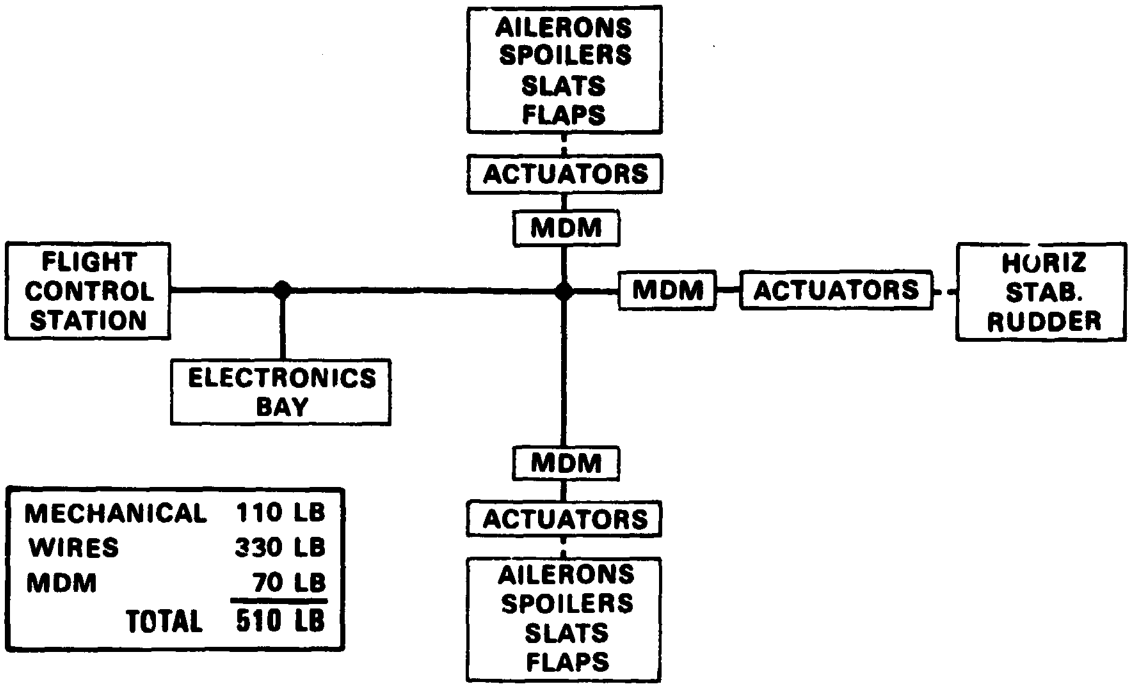


Figure 48. - Mux data transmission.

Table 14 shows the types of bus considered. ARINC 429 HS was chosen as being most applicable in the near term (1980-1990); however, there is approximately 150 kg (330 lb) of MUX wire for the FBW flight controls and 200 kg (450 lb) of wire for MUX in the all-electric aircraft. Some of this weight could be saved by using a high-speed, two-way bus such as MIL STD 1553A or the S-3A 13 Mbps digital bus which has operated satisfactorily for many years. However, the decision was made that for the near term (1980-1990), a high speed two-way bus was too risky for a commercial transport application because a remote terminal can refuse to get off the line. Such a system could, however, be used in the near term as an evolutionary step in noncritical areas, possibly with fiber optics.

TABLE 14. - DATA BUS CHARACTERISTICS

Data Bus Type	Bit Rate	Format	Data Flow
ARINC 429 low speed	13 k	RTZ Bipolar	One Way
ARINC 429 high speed	100 k	RTZ Bipolar	One Way
ARINC 453 VHS	1 Meg	Manchester	One Way
MIL-STD-1553B	1 Meg	Manchester	Two Way
S-3	6 Meg	Manchester	Two Way

Advances in other technology areas; aerodynamics, electrical systems, remote terminals and fiber optics could make the advanced bus systems more advantageous in the years beyond 1990. This is because the first two technologies mentioned will increase the data rate to be handled, remote terminals that can tolerate high ground soak temperatures will be mature and fiber optics will make high speed buses more interference free.

Multiplexing is present in all of the avionics configurations considered for the AE/ET study. In all cases, the ARINC 429 Digital Information Transfer System Standards have been followed. Digital data busses for inter system communications are required to conform to ARINC 429 standards by the air transport industry. An ARINC 429 bus has the following characteristics:

- Each bus is a broadcast bus. Each bus will emanate from a particular avionics system element having information to transmit. The data is transmitted from an output port over a single twisted and shielded pair of wires to all other system elements having need of that information. Bidirectional data flow on a given twisted and shielded pair of wires is not permitted.
- Word formats are specified. Each word is 32 bits in length. Included in the format is a label, data in either binary or binary coded decimal form, a parity bit, source/destination identifier, and sign/status matrix
- Communication is open loop in that no form of acknowledgement or handshake is specified to verify receipt of a message
- Data rates are 12K or 100K bits per second
- Minimum update rates are specified for each parameter

The bussing conforms to the following rules.

- Where dual redundancy is employed, bussing is provided as though one set of devices was dedicated to the captain's system and the other to the first officer's system. The captain and first officer's systems are relatively independent.
- Triplex sensors distribute their data with one sensor dedicated to each of the dual using units and the third sensor transmitting to both users.
- Quad sensors are provided only for the quad computing required for the primary flight control function (PFCC).
- The primary flight control computers are provided with serial data exchange busses so that the four computers can interchange input, ouput and status signals. The data exchange busses do not conform to ARINC 429 since they do not transmit data outside the primary flight control system.

- The automatic flight control computers (autopilot) are provided with serial data exchange busses between the computers so that input, output, and status signals may be exchanged. The data exchange busses do not conform to ARINC 429 since they are intrasystem busses.

7.1.3 Ring Laser Gyro (RLG). - The substitution of a strap-down RLG for the conventional gimballed mechanical inertial navigation system (INS) and for the rate gyro of the flight control system was investigated. The use of this technology for commercial aircraft is now accepted, with Honeywell RLG systems planned for the B-757 and B-767. These first-generation systems are approximately the same weight and accuracy as existing mechanical gyro systems, but of lower cost and better reliability.

The RLG detects and measures angular rates by measuring the frequency difference between two contra-rotating laser beams. The two laser beams circulate in the triangular cavity simultaneously. Mirrors are used to reflect each beam around an enclosed area. When the system is stationary in inertial space, the path lengths are the same and corresponding phase peaks of light arrive at the detector simultaneously. When the housing is rotated in space, the two paths are different in length and the two-phase peaks arrive at a different time giving a cancellation of light at the detector. A constant rotation gives a constant difference in frequency, constant phase shift and a uniformly periodic varying of light intensity at the detector. In fact, each pulse of light (coincidence of phase peaks) represents an angular distance traversed. Thus a count of the pulses is a measure of the angle referenced to the angle at the start of count.

The strap-down feature makes the RLG ideally suited to flight control applications since the direct output of gyros and accelerometers are in body coordinates. Mechanical strap down systems have been difficult to implement because of the small dynamic range of the gyros. The RLG, however, is inherently of large dynamic range; it has low power consumption, high reliablity, self-calibration capability and quick warmup.

The accuracy of one nautical mile drift per hour typical of present commercial INS is easily obtained by the RLG but present RLG technology ties accuracy to the length of optical path and thus to size and weight. Therefore, at present the RLG is not competitive with high accuracy systems such as Honeywell Co.'s SPN-GEANs with 0.1 NM/H nominal accuracy. This is just the beginning of RLG technology, however, and future systems should show significant improvements in weight, size, reliability, and accuracy.

Figure 49 shows the commercial RLG-IRS as proposed for the B-767. Figure 50 shows life cycle costs as projected by Honeywell Co. for lots of 336 and 1736 systems. As shown, the development costs are higher for the RLG than the conventional mechanical gimballed system, but reduced acquisition and support costs easily give the RLG the advantage in overall costs.

In the tradeoff, four RLGs were substituted for three conventional INS, the AHRS, and the separate body mounted gyros and accelerometers used for flight control. This resulted in a small weight advantage of 18 kg (40 lb) for the RLG. Advantages to the commercial user are mainly from reduced acquisition cost and maintenance.

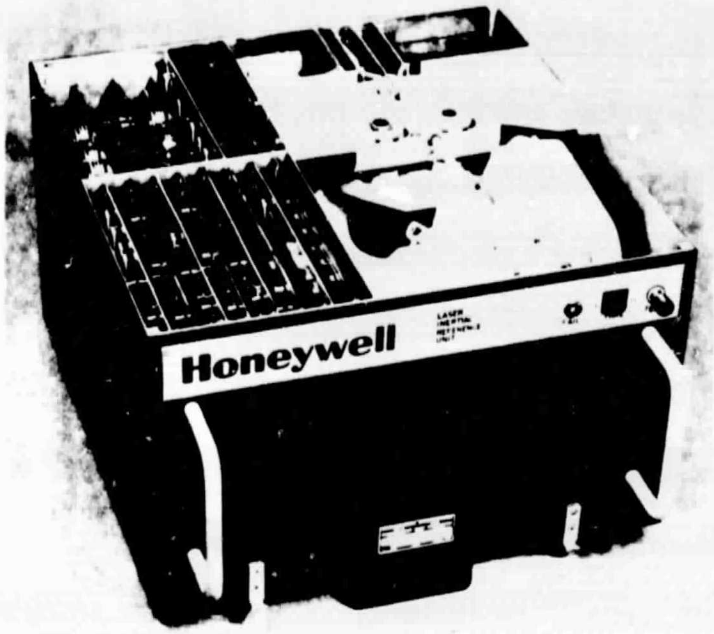


Figure 49. - Laser inertial reference unit.

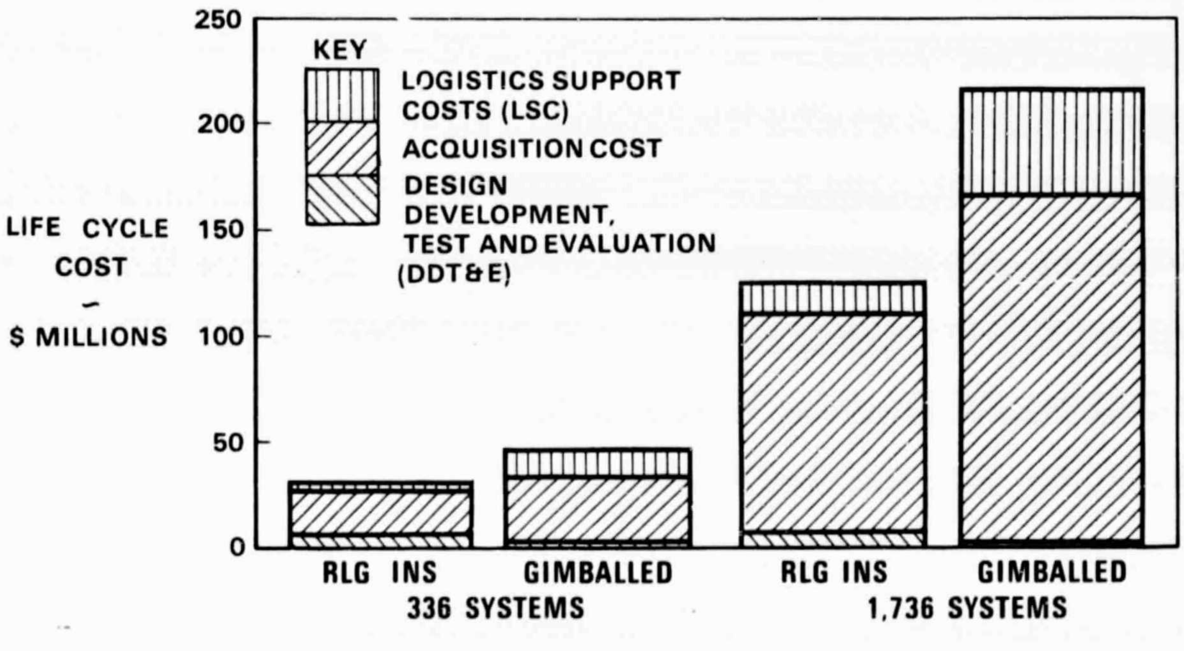


Figure 50. - RLG INS and gimballed system LCC comparison.

The characteristics of the RLG INS vs. a typical gimballed INS are as follows:

	Gimballed	RLG
Nominal Accuracy, NM/H	1	1
Drift, Deg/Hr	0.001	0.01
Weight	20 kg (45 lb)	20 kg (45 lb)
Power, watts	225	110
Size, box type	ATR-1	ATR-1
Reliability, hours MTBF	800	2300
Electronic parts	2800	1900

7.1.4 Integrated Avionics. - This section discusses the configuration selected for the tradeoff against the conventional ARINC 700 methodology. The strategy used was as follows.

- Consolidate functions to save cost, weight
- Near term approach to integration
- ARINC 700 compatible
- Consider flight controls with:
  - Flight Management
  - Nav. System
  - Air Data System
  - Displays
- 40 lb. limit/box
- Combine functions having same redundancy

7.1.4.1 Configuration: This section presents the rationale for the functional integration that was performed to realize configuration 5, Avionics Integration. The avionics integration configuration has combined functions so that the flight management and thrust management functions are performed by one computer and so that the primary and automatic flight control and air data functions are performed by a second computer.

The primary and automatic flight control computers differ from the remainder of the avionics computers in that each computer of the flight control set is synchronized with its redundant counterpart. The other avionics computers are assynchronous with one another. Serial data exchange busses are also used in the flight control system to allow input and output data to be exchanged for monitoring purposes and allow identical computations to be performed in each channel. This make up of the flight control system is a favored implementation which allows flight safety to be ensured with a high degree of confidence.

The primary and automatic flight control functions were combined into a single computer because they shared a need for synchronous operation, data exchange, and redundancy management features. A single set of data exchange busses suffice for both functions. The rather involved synchronization provisions (macro sync) need not be duplicated. Perhaps a negative outcome of the combination is that the redundancy of the AFCC computations is increased beyond that needed.

The digital air data computer function was also combined with the flight control computer function. This was done because the redundancy requirement is the same as the PFCC, the air data signals are required for both automatic and primary flight control, and the air data computing load is low.

The thrust management and flight mangement functions were combined because they are related functions and the redundancy level of each is the same (dual). The Inertial Reference System was considered for integration with other functions. This was rejected because the weight of the sensor/computer unit was marginally high 19.96 kg (44 lb). No addition was felt tolerable.

Figures 51 and 52 show the subsystem before and after integration. Note that only the flight controls and associated autopilot, navigation, and display subsystems were considered in the tradeoff.

Figure 53 shows the advanced displays and controls on the instrument panel.

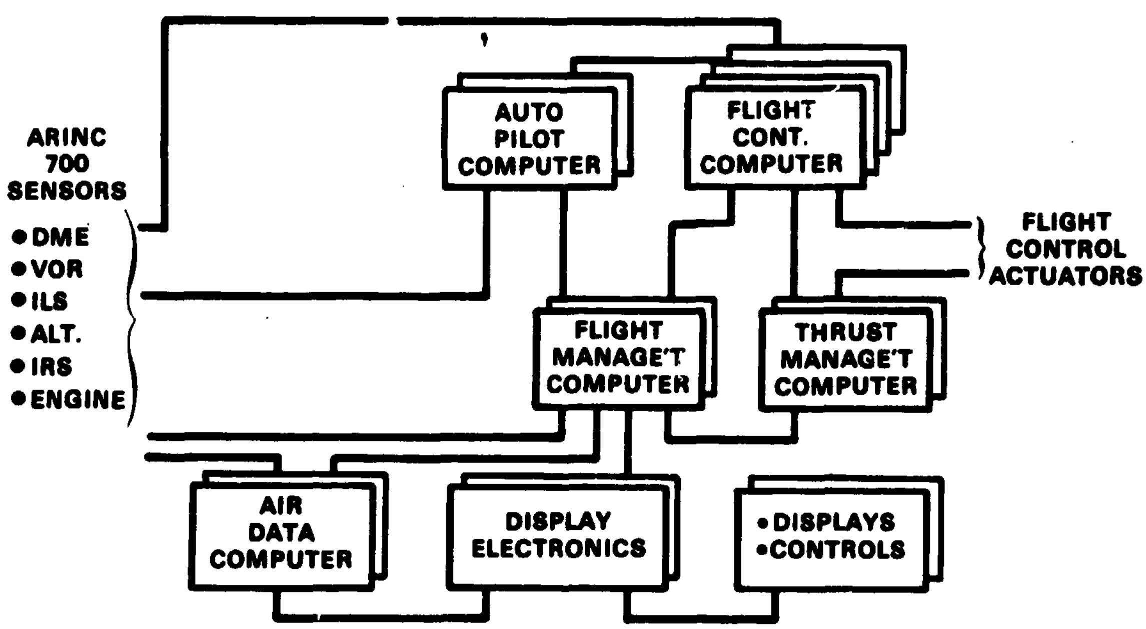


Figure 51. - Conventional avionics.

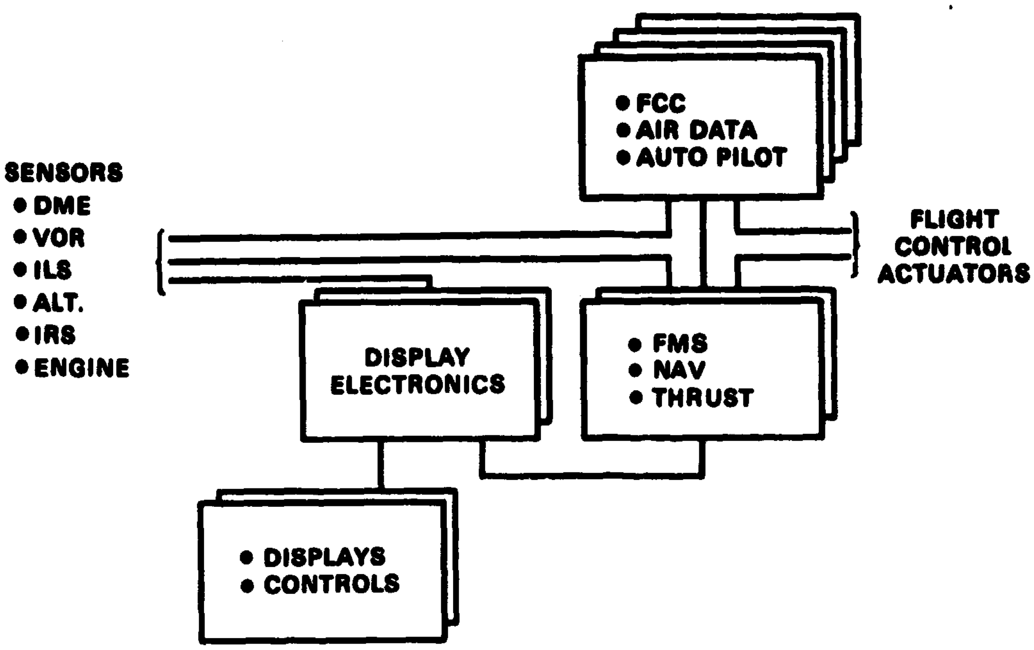
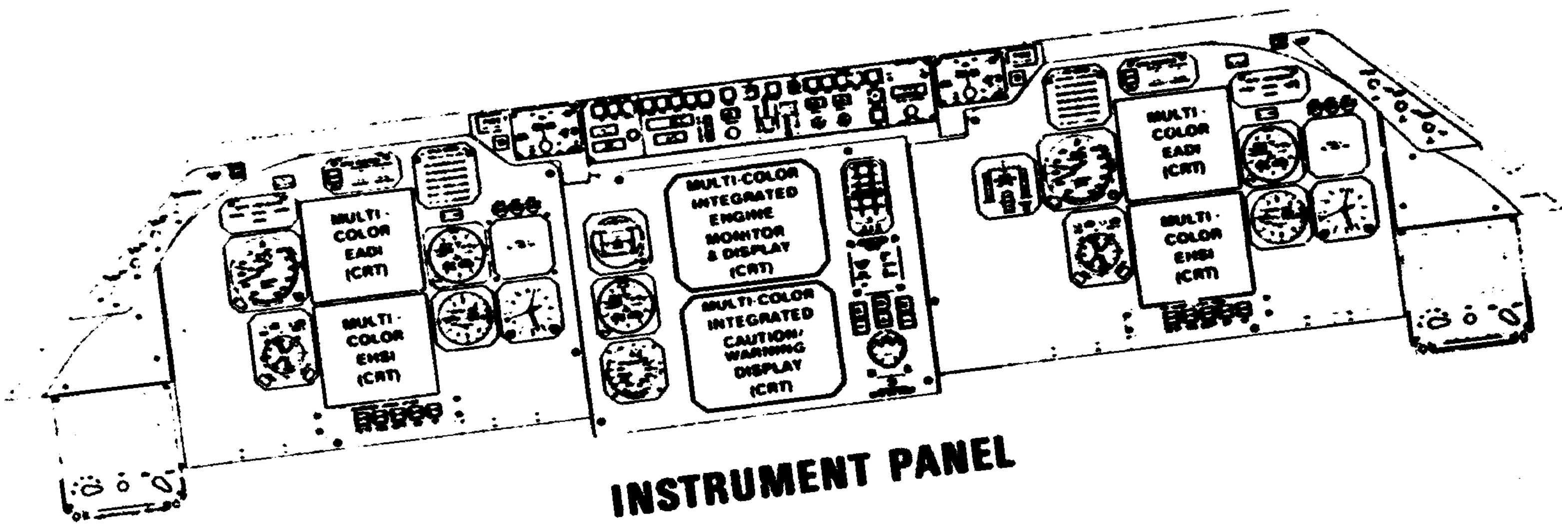


Figure 52. - Integrated avionics, ATA.

7.1.5 All-Electric Aircraft. - The purpose of this section is to describe not only the special type of power generation system selected for the all-electric ATA, but also the elements or subsystems of the secondary power system (SPS) that are impacted by the use of electric power, as the only energy source in the vehicle. Both NASA and Lockheed projected several advantages, in the use of all-electric power, but the results of the study have shown that the projections have been surpassed by a wide margin.

The Lockheed ASSET program was used to perform the tradeoffs and to establish the delta differences in weight, cost, fuel impact, changes in aircraft/engine performance and overall operating costs, etc. All data were cycled for impact on aircraft TOGW and other effects. These data are quantified in this report, but in general terms the all-electric ATA was shown to offer the following advantages:

- A major component and system weight saving
- A major reduction in design, development, test and installation costs
- A significant reduction in complexity of the SPS installation
- A significant reduction in mission block fuel.



INSTRUMENT PANEL

In the elimination of the "residual" pneumatics and hydraulics, as defined in NASA's RFP, it was necessary to consider the services and functions that would be affected. These services and functions are listed in table 15. Also, it was necessary to compare the make-up, or configuration, of an all-electric SPS, compared to the conventional SPS as used in many current wide-body jets. Table 16 shows the number of power elements in the L-1011-100 (which were also used in the design of the SPS in the baseline ATA) and compares them to the equivalent number in the all-electric ATA. This chart shows the major reduction of power components of the all-electric vis-a-vis the conventional (9 versus 21).

Table 17 is a tabulation of the projected advantages and features of an all-electric airplane and Figure 54 is a flow chart that traces the projected payoffs of the all-electric airplane. To validate these prospective advantages, all pertinent data were put into the ASSET program and were cycled for the overall impact on the vehicle, in terms of its TOGW, its operating costs, development costs, and other data. Delta fuel-changes were calculated on the basis of changes in SFC, due to different power extraction methods for the SPS, and these were cycled back into mission fuel change, impact on fuel tankage, and aircraft weight/size changes, etc.

TABLE 15. - SECONDARY POWER SYSTEM: FUNCTIONS AND SERVICES, ATA

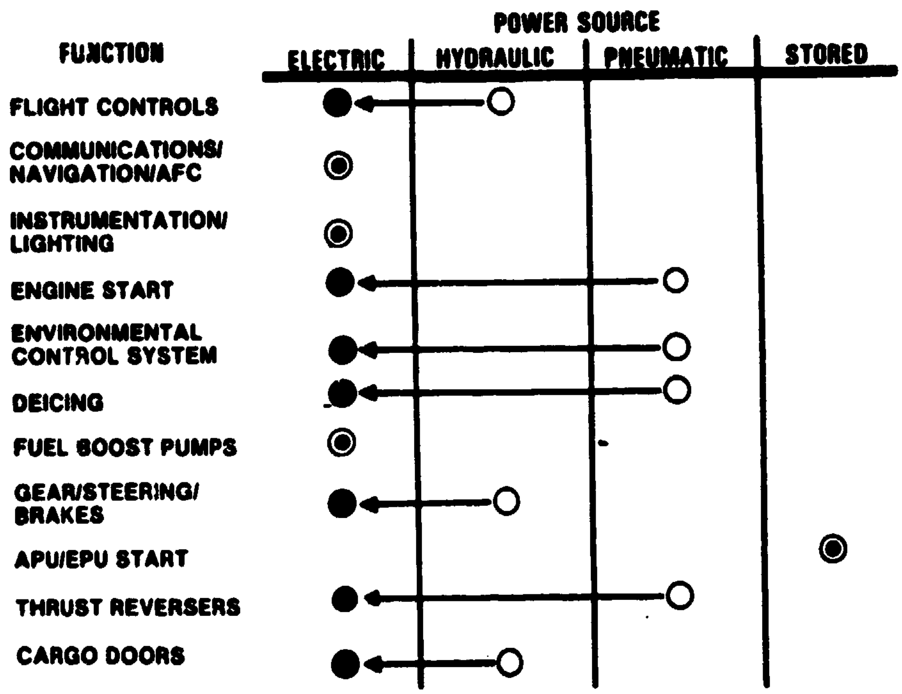


TABLE 16. - SECONDARY POWER SOURCES

		CONVEN-TIONAL	ALL ELECTRIC
HYDRAULIC PUMPS	ENGINE	4	0
	AIR TURBINE	2	0
	ELECTRIC	2	0
	RAM AIR TURBINE	1	0
	POWER XFER UNITS	2	0
ELECTRIC GENERATORS	ENGINE	3	6
	APU	1	1
	BATTERIES/INVERTERS	2	2
PNEUMATIC	ENGINE BLEED	3	0
	APU COMPRESSOR	1	0
	TOTAL	21	9
	COMMONALITY	10	3

TABLE 17. - ALL-ELECTRIC AIRPLANE

- ALL SECONDARY POWER SUPPLIED ELECTRICALLY
- ELIMINATES
  - ✓HYDRAULICS
  - ✓ENGINE BLEED
  - ✓PNEUMATICS
  - ✓SEPARATE START SYSTEM
  - ✓COMPLEX MECHANICAL FLIGHT CONTROL DEVICES
- REDUCES
  - ✓ACCESSORY POWER PROVISIONS
  - ✓THRUST LOSSES
  - ✓SFC PENALTIES
  - ✓ENGINE WEIGHT
  - ✓SECONDARY POWER SYSTEM CAPACITY/WEIGHT
  - ✓COMPLEXITY SPS INSTALLATION
- IMPROVES
  - ✓LOGISTICS
  - ✓MAINTENANCE – SYS C/O W/O ENGINE

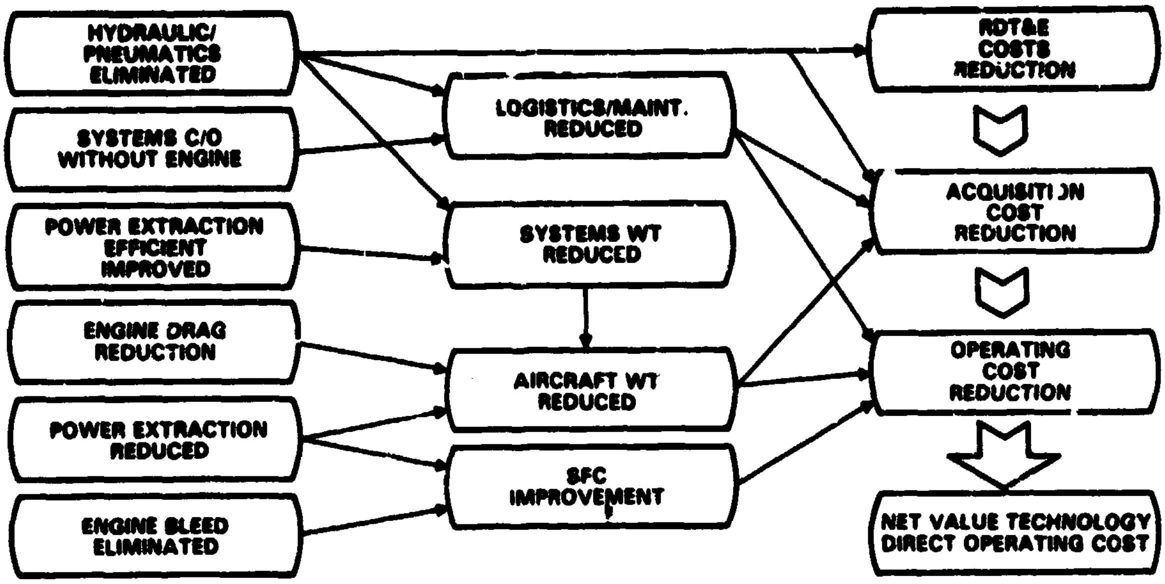


Figure 54. - All-electric payoff

A key factor in this regard is the sensitivity of the high compression ratio/high bypass ratio engines (projected for future energy-efficient aircraft) to bleed air extraction, versus mechanical power extraction. The following tabulates data submitted by Pratt and Whitney relative to their Energy Efficient Engines (E^3) NASA contracts.

Engine: P&W STF 505-M7C
Thrust 8540P SFC = 0.562

Condition: 35K/0.8M/Max. Cruise.

Engine Sensitivity:	Thrust loss	+ SFC
Bleed	3.4%/pps	1.24%
HPX	0.8%/100hpx	0.4%/100hpx

The above penalties reflect the sensitivities for constant-rating (CR) and these increase somewhat for constant thrust (CT) rating. A comparison showing the SFC changes for the CT condition can be seen in figure 55, which are engine performance curves reelating to the General Electric E3 engine. These curves show the fuel impact differences only. They are as follows:

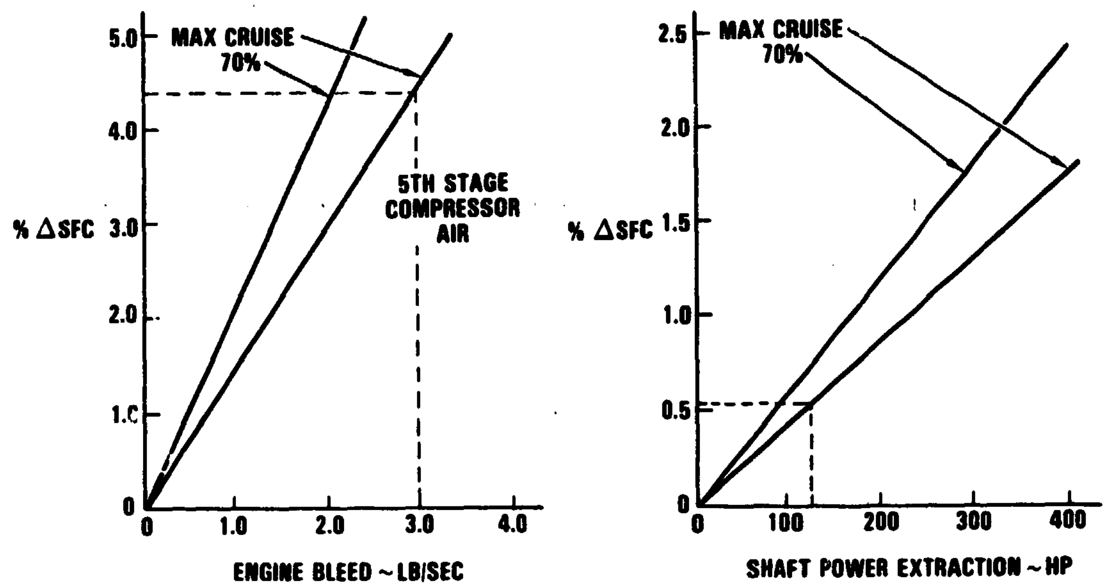


Figure 55. - Bleed and shaft power extraction effects on SFC 35K/0.8M/std day, constant thrust.

Bleed SFC = + 1.5%/pps
Horsepower SFC = + 0.4%/100hpx

It is evident from the above that going from a CR to a CT results in + SFC difference of 0.26 percent per pps of bleed. There appears to be minimal, or no change, for the horsepower extraction.

The other benefits accruing to the propulsion system by the elimination of the engine bleed demands are the physical aspects. There is a 2.7 percent reduction in engine weight, a 1.3 percent reduction in engine diameter, and a 3.7 percent reduction in drag. Figure 22 shows the amount of high-pressure ducting valves, etc., that can be removed from the L-1011-100 type power plant, while figure 56 shows the ducting that can be removed from pylons, wings and fuselage. The weight of this ducting amounts to some 2540 pounds.

Finally, to give a graphic illustration of the impact of bleed power extraction versus mechanical power extraction, figure 57 illustrates the total thrust loss and horsepower losses under the following criteria:

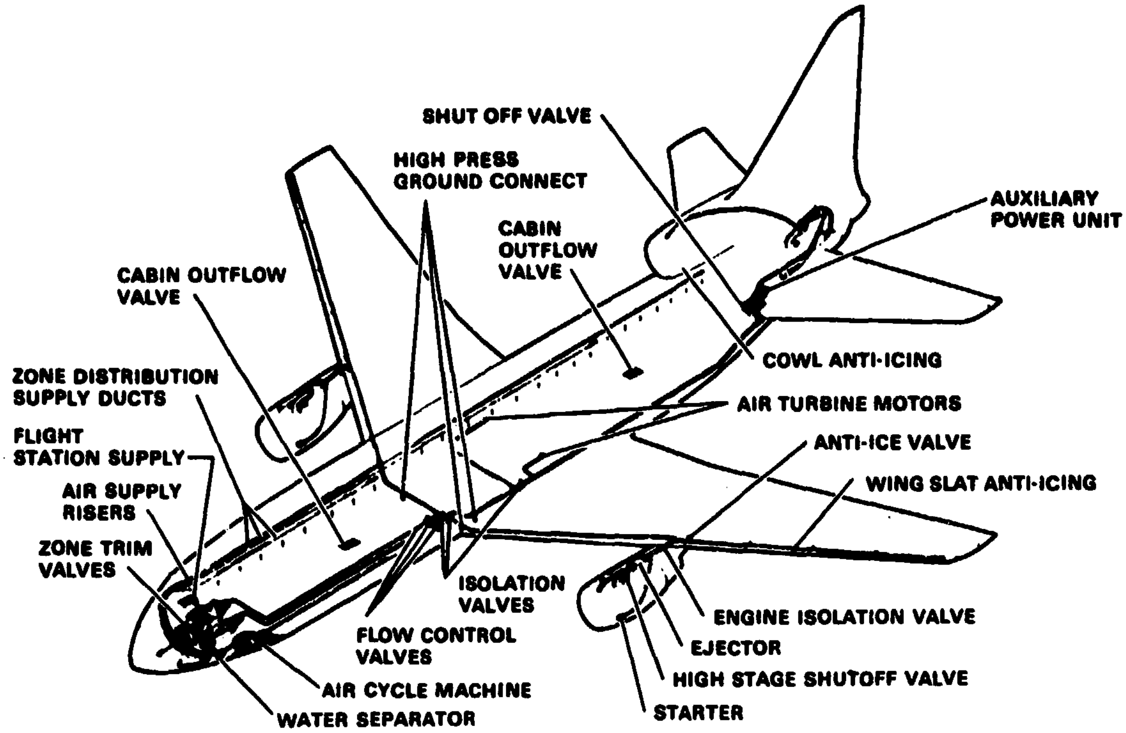


Figure 56. - Pneumatics system, ATA.

	Baseline ATA	All Electric
Bleed	3pps/engine	none
HPX	123/engine	250 hpx/engine

These data show that the 3pps bleed/engine costs result in a total thrust loss of 2613.24 pounds to the propulsion system. This is equivalent, at 600 mph, to a penalty extraction figure of 4181 hp. In comparison, the mechanical power extraction of 123 hpx/engine results in a total thrust loss of 252 pounds, or only 403 hp at 600 mph.

Finally, the bottom line with respect to the bleed air elimination is the impact on mission fuel. The ASSET program was given the thrust/fuel extraction sensitivities of the engines, and block fuel requirements for a mission were computed on the basis of the above SPS demands. Typically, for the 35K/0.8M max cruise, the following shows the percentage + SFC between the two systems.

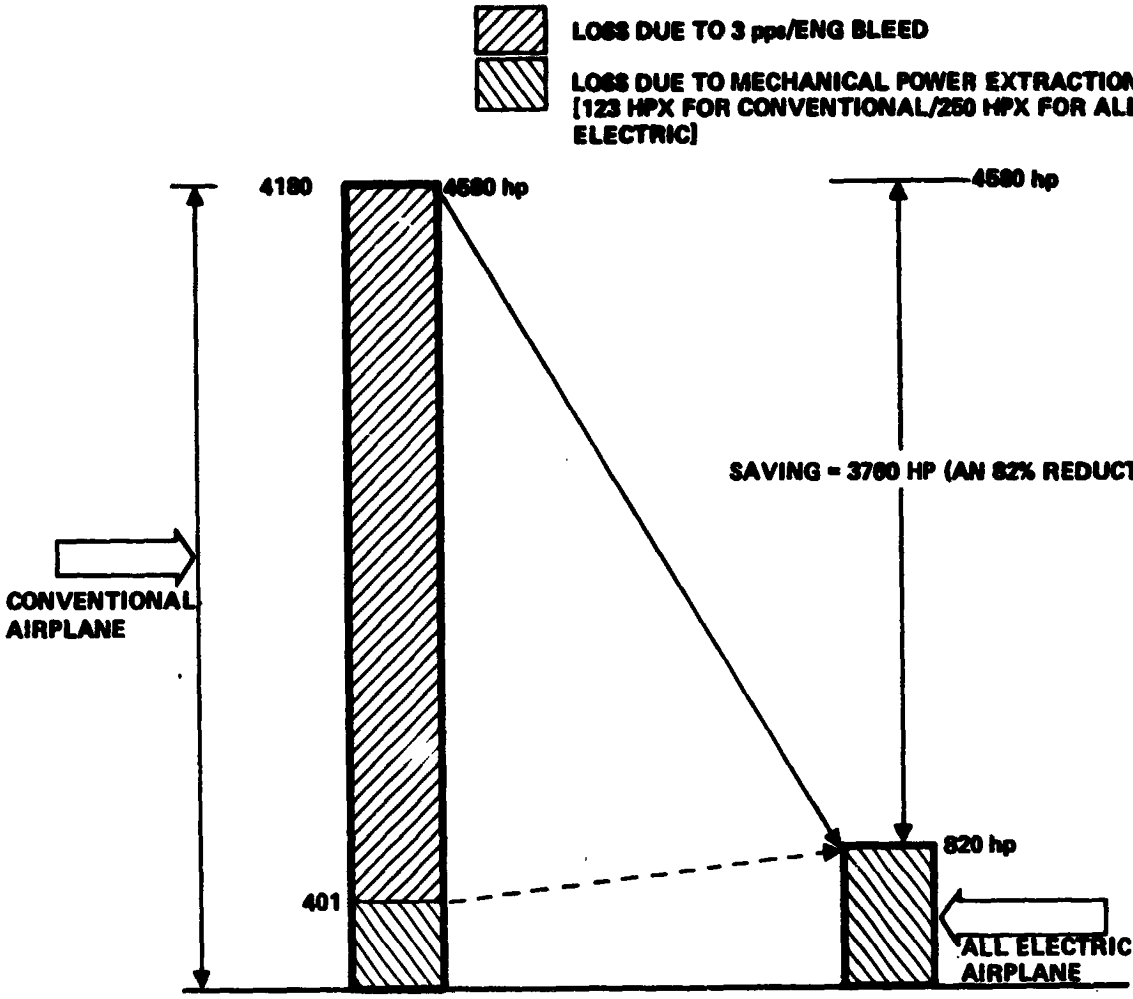


Figure 57. Engine Horsepower-Loss Due To Power Extraction Method

	+ SFC	
	Baseline	AEA
Bleed 3pps/eng	4.5%	-
HPX (123 hp)	0.492%	-
HPX (250 hp)	-	1.0
	4.992%	1.0%

The above shows a 4 percent SFC penalty for the baseline ATA. These fuel penalties are assessed in terms of weight and are included in the summary on weight, given at the end of this section.

For the elimination of bleed air from the all-electric ATA, the following systems were candidates for electric power conversion.

- ECS
- Wing/surface anti-icing
- Floor heating/defogging
- Thrust reversers
- Pneumatic engine starting

These systems are discussed in varying detail in the following sections of this report.

7.1.5.2 ECS: The environmental control system is, manifestly, the major user of bleed air from the engines. A direct correlation of horsepower equivalence of a pound of bleed air, and a mechanical extraction of say 100 hp is difficult, because the bleed is strongly affected by the engine power settings, altitude changes, etc. However, it is evident that the air bleed, even from the fifth stage of the compressor, is at a temperature and pressure very much higher than that required by the ECS. Typically, the temperature of the bleed air can be 400 to 500°F and pressures can be up to 60 psia. The ECS requires, say, a maximum cabin pressure differential of 8.4 psi (equivalent to a cabin pressure of 10.92 psia at 42,000 feet) and a cabin temperature of +75°F. Therefore, pressure throttling/regulating plus heat exchanges are required to condition the bleed air supplied to the cabin. In the all-electric ATA, the T across the motor-driven compressor is of the order of only 220°F, and the discharge pressure is a function of the ambient pressure. The all-electric ECS therefore requires smaller heat-exchanger areas and/or less ram air (to be taken on board).

The AirResearch Company, Torrance, California, conducted the evaluation and design of the all-electric ECS and this was completed in accordance with Lockheed-California Company specifications. However, the key feature of the ECS was that the design was to be optimized at the 35K/0.8M maximum-cruise condition. All other flight modes were to be considered the off-design points. The system is therefore designed to yield maximum efficiency at the 0.8 mach no. cruise condition. Appendix B contains an AiResearch tabulation of the heating and cooling loads over the flight envelope of the ATA.

Based on a maximum ventilation rate of 1.2 ppm/pax and a 50 percent recirculation rate, the system is designed to furnish approximately 300 ppm of fresh air and 300 ppm of recirculated air. Three ECS packs are used to furnish the required heating, cooling, and pressurization needs of the airplane. Figures 58, 59 and 60 comprise data from the L-1011-100, which was scaled up by AirResearch to the ATA-sized airplane. Ambient humidity was taken as 130 gr/lb and the metabolic rates were taken for 476 passengers and 24 crew/attendants. Ram air was assumed for the heat sink, with louvered shutters on the heat exchangers to modulate the amount of cooling air flow.

Figure 61 is a schematic of the all-electric ECS as proposed by AirResearch. The source of pressurized air for each ECS pack is the M1/C1 motor-compressor unit. The motor is a two-speed, 3-phase, 400 V/800 Hz machine which permits the compressor to be driven at 48,000 rpm at cruise altitude, and at 24,000 rpm at low altitudes. The lower motor speed, along with inlet guide vane (IGV) control, avoids overloading of the motor at the lower atitudes, where the ambient-pressure and density of the air are high. Air from the C1 passes through the HX1 (heat exchanger) and then through the evaporator into the cabin. Heat is removed at HX1 by ram air, (or fan-induced air, on the ground) and, if necessary, by vaporization of freon passing through the evaporator, HX2.

For cabin-heating, HX2 cooling is inhibited and auxilliary-heat, for air temperature pull-up, is obtained via electric duct-heaters. The motor-driven fan, M3/F1, returns approximately 50 percent of the cabin inflow back through the inlet to the evaporator. The expansion valve controls the rate of freon evaporation and therefore the cooling capacity. The freon compressor, like the air compressor, incorporates inlet guide vanes to permit a lower degree of cooling during light loads. Freon gas is returned under suction of the freon-compressor, C2, where it is compressed and then, on its output side, condensed to a fluid via HX3. This is a typical reverse Rankine cycle system using an R114 refrigerant. The M5 fan forces outside air through the condenser on the ground, while ram air is used in flight.

Each motor compressor is designed to supply 86 ppm at a pressure ratio of 3.32:1. The motor which weighs 78 pounds, is 9 inches in diameter and 14 inches long: the motor is freon-cooled. Each ECS pack weighs 988 pounds. The total weight of the three ECS packs is 2964 pounds. The baseline ATA system weighs 7682 pounds and the all-electric ECS 6177 pounds, so this results in a 1505 pound weight saving for the all-electric airplane. Appendix B includes a breakdown of ECS component weights by AiResearch.

It is to be noted that since each compressor motor requires 100 kVA, a minimum generator capacity of 150 kVA was necessary for the all-electric ATA. By the use of onboard inverters it is possible to operate the generators as synchronous motors to permit engine starting, and so eliminate the pneumatic start system in the baseline ATA.

7.1.5.3 Flight Controls: The flight control system, was one of the primary activities in this study. Typical of many current wide-body jets, the flight control link in the L-1011 is mechanical, using redundant steel cable lines between the flight station and the hydraulic servo-valve assemblies. Physical operation of all primary and secondary control surfaces is by means of a highly redundant, high-pressure (3000 psi) hydraulic system.

The trade-offs, conducted during the study, were in two phases: (1) replacement of the mechanical control with fly-by-wire, FBW, and (2) interface the FBW with a power-by-wire, PBW. The first phase involved the interposition of secondary actuators, which converted electrical input data into mechanical

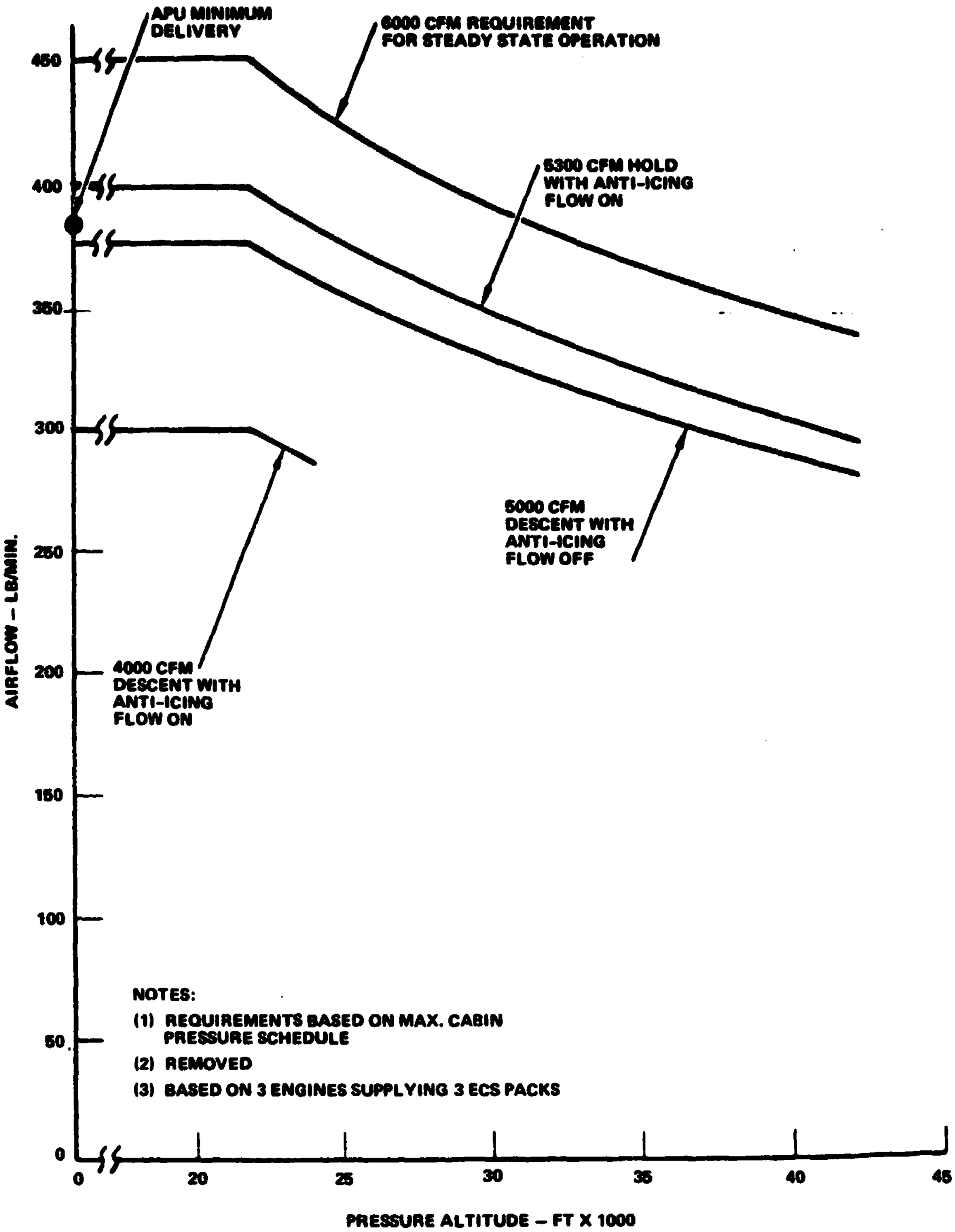


Figure 58. - L-1011 cabin airflow versus altitude.

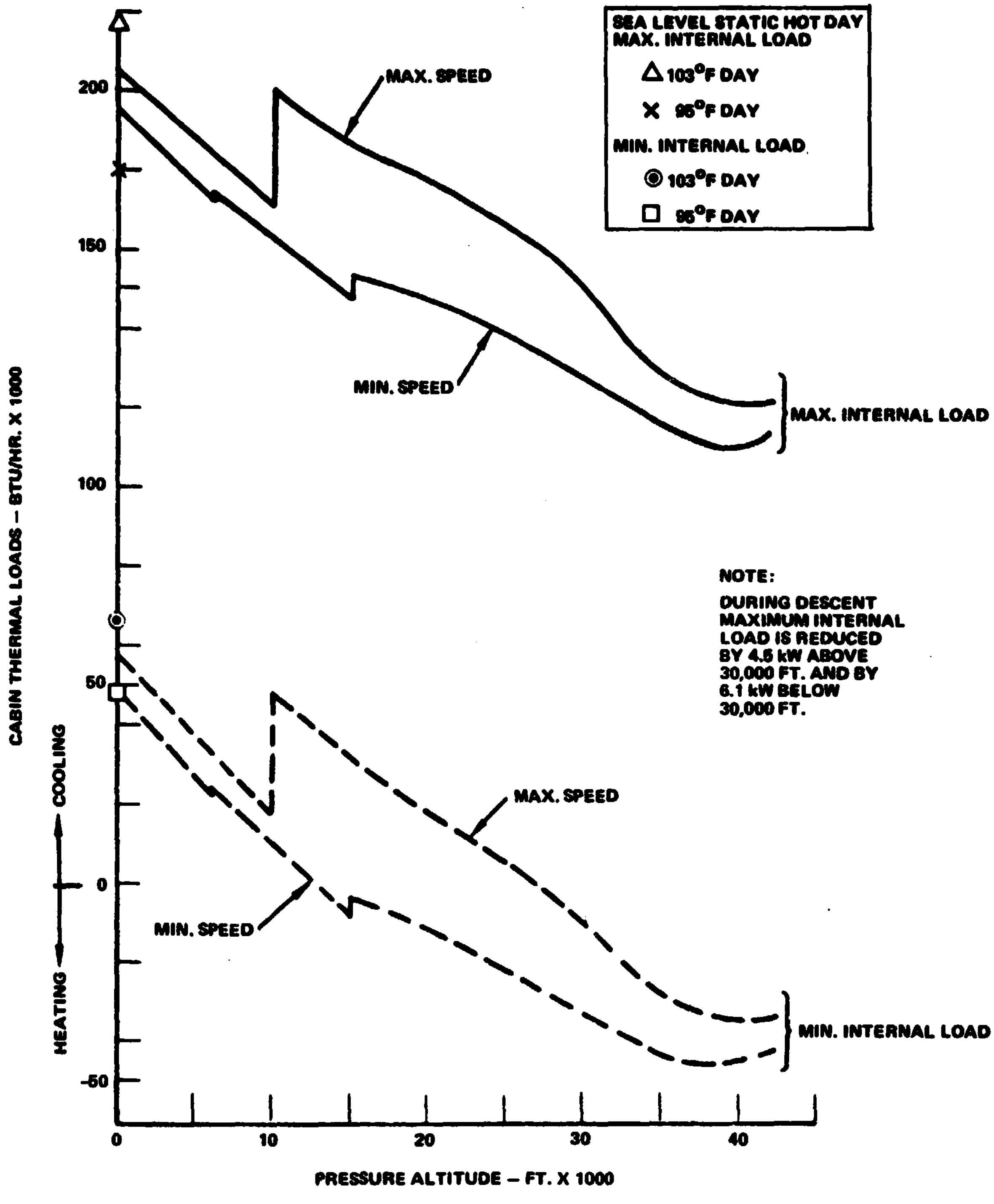


Figure 59. - L-1011 cabin thermal load versus altitude (hot day).

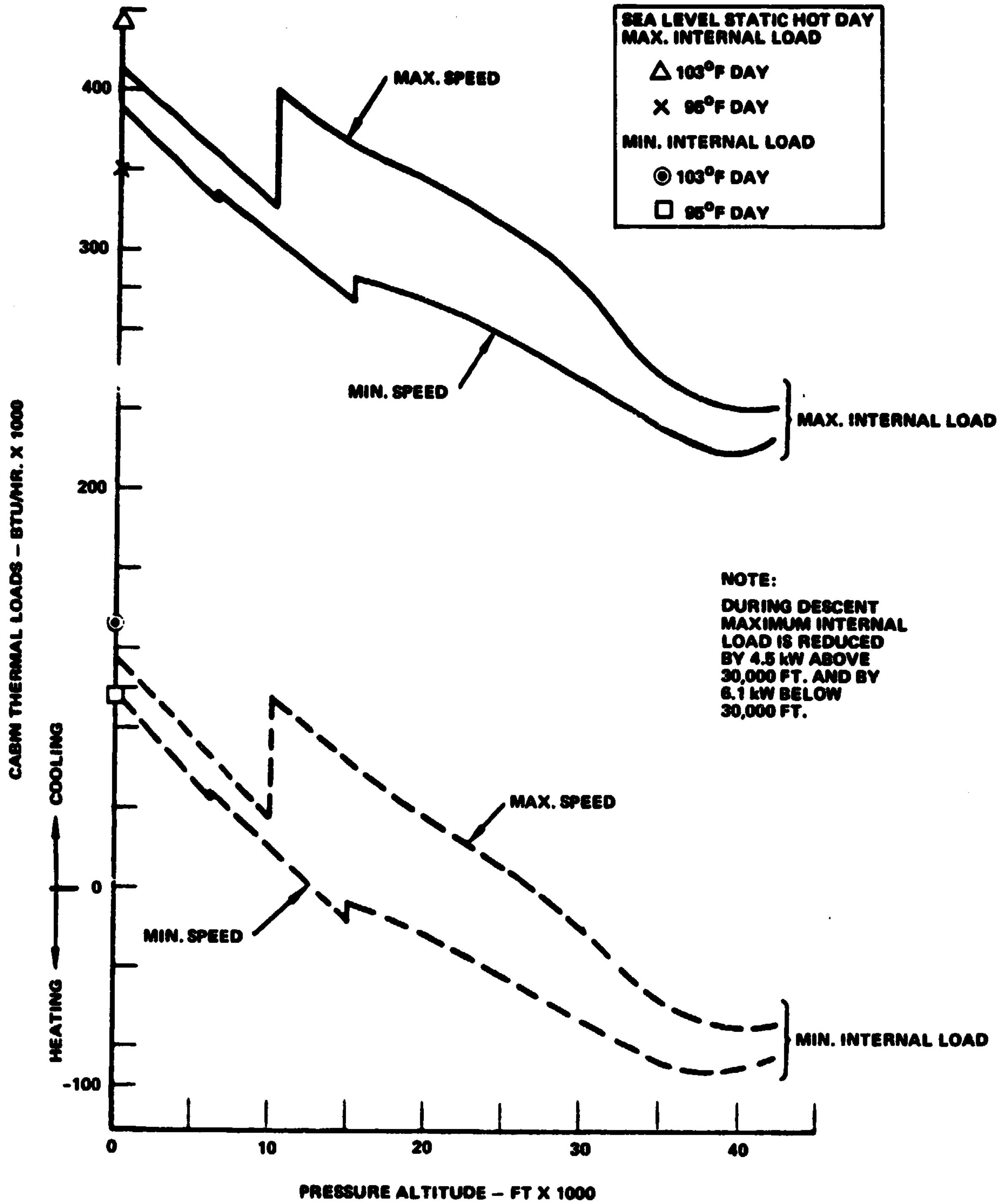


Figure 60. - ATA ECS requirements.

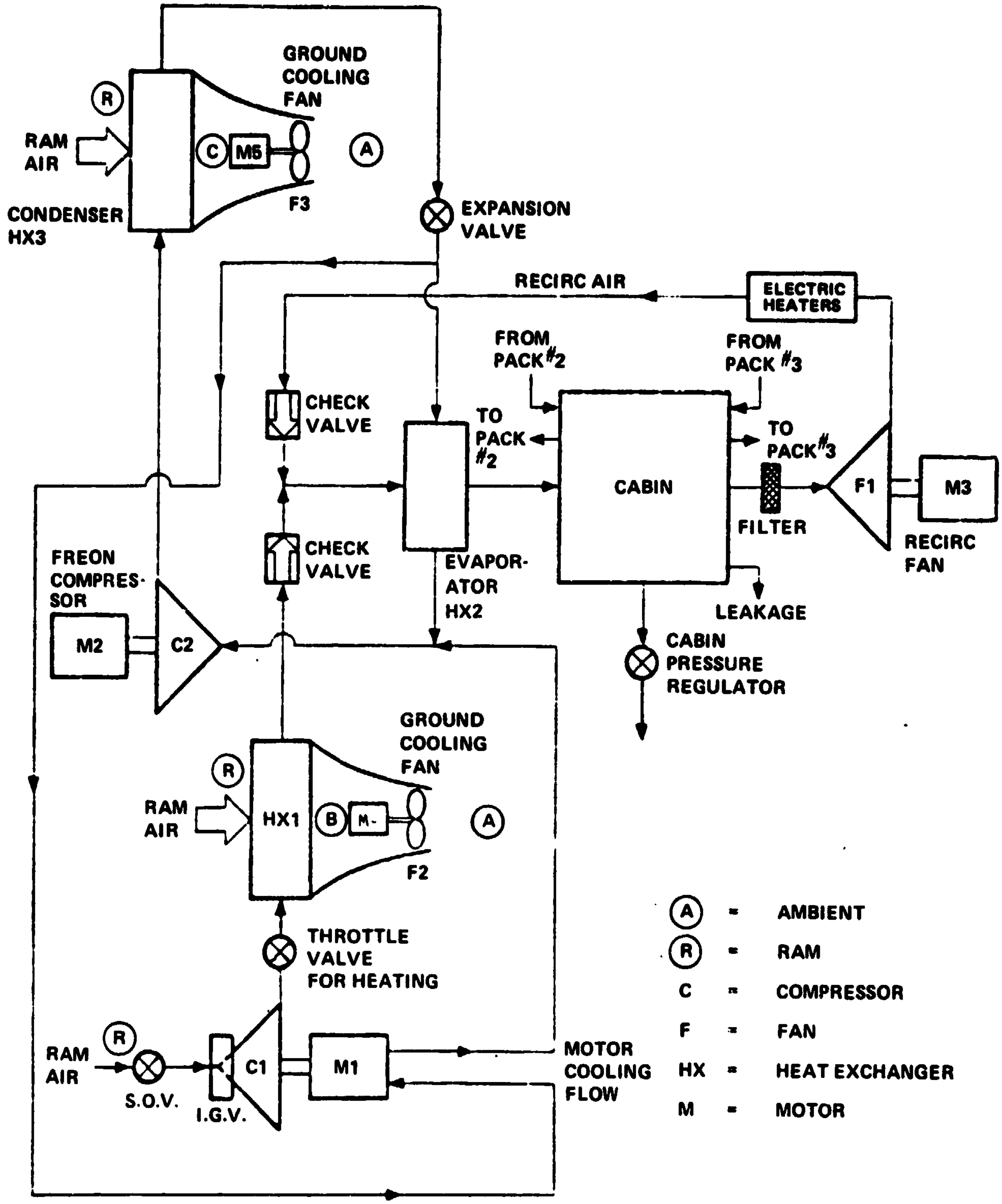


Figure 61. - Electric ECS schematic.

output for the hydraulic servos. This system was shown in Figure 43. With the FBW/PBW approach, the secondary actuators were eliminated and the electrical data inputs (from the flight station) were interfaced directly with the multiple-redundant electric/electronic flight-control system. In the implementation of either Phase I or Phase II it is evident that there is a major simplification of the installation by the elimination of the complex control runs, shown in figure 9.

The primary tasks associated with the all-electric FCS were the design of the flight control computer and the digital avionics system by Honeywell, and the design of the EMA (electromechanical actuators) for the primary and secondary flight control system, by AirResearch. Figure 4 is a three view of the L-1011; this typifies the configuration for the baseline ATA, except that surface areas and hinge moments are changed. The surfaces in the all-electric ATA are activated by power-hinge actuators, using 270 Vdc samarium-cobalt drive-motors. These motors required that a multiple-redundant 270 Vdc system be developed from the primary ac system.

The samarium-cobalt actuators have the basic advantages of rugged design; they have no rotor losses; and their intrinsically high torque/inertia ratio gives them the ability to meet the frequency response characteristics of the flight control system. Figure 62 is an outline drawing of the actuator designs, provided by AiResearch during the study. Appendix B contains outline drawings and tables of physical and performance parameters for the rotary actuators.

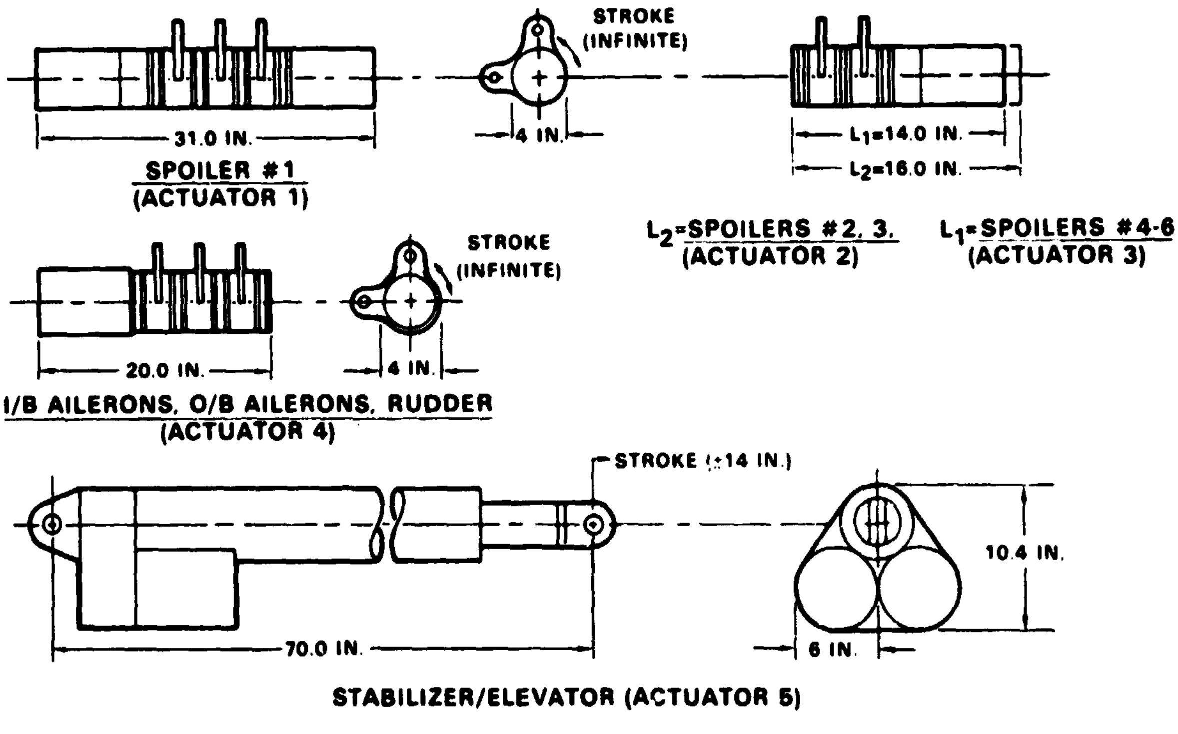


Figure 62. - Actuator outlines for primary flight control surfaces (ATA): commonality.

As a basic design requirement, the configuration of the all-electric FCS followed the basic multiple-redundancy criteria of the L-1011-100. These are as follows:

	Redundancy Level			
	4	3	2	1
Horizontal stabilizer	X	-	-	-
Rudder	-	X	-	-
I/B ailerons	-	X	-	-
O/B ailerons	-	-	X	-
Spoilers 1 thru 6	-	-	-	X

The above redundancy, in the all-electric airplane, is satisfied by using the same number of EM actuators on each of the control surfaces as there are hydraulic actuaors, and using redundant, isolated electric-feeders to the actuators. To this extent, the all-electric FCS is configured in the same fashion as the mechanical-hydraulic FCS. In the case of the secondary flight control surfaces (the leading edge slats and the TE flaps), ac induction motors replace the hydraulic motors on the power driven units (PDUs).

Power for the primary flight control systems is obtained from the 3-phase, 400 Hz, 200 Vac static power converters and the 270 Vdc system (developed by rectification of the 3-phase, 800 Hz, 400 Vac primary ac system). The primary FCS actuators use samarium-cobalt motors, driving hinge-line actuators. The actuators operate in a proportional-control servo-loop, using positional and velocity feedback. Figure 63 is a block diagram schematic of the control loop. Power (switching) electronics (designed by AiResearch) furnish power to the actuators and these static power units are controlled by Honeywell's quad-redundant digital-electronic control system.

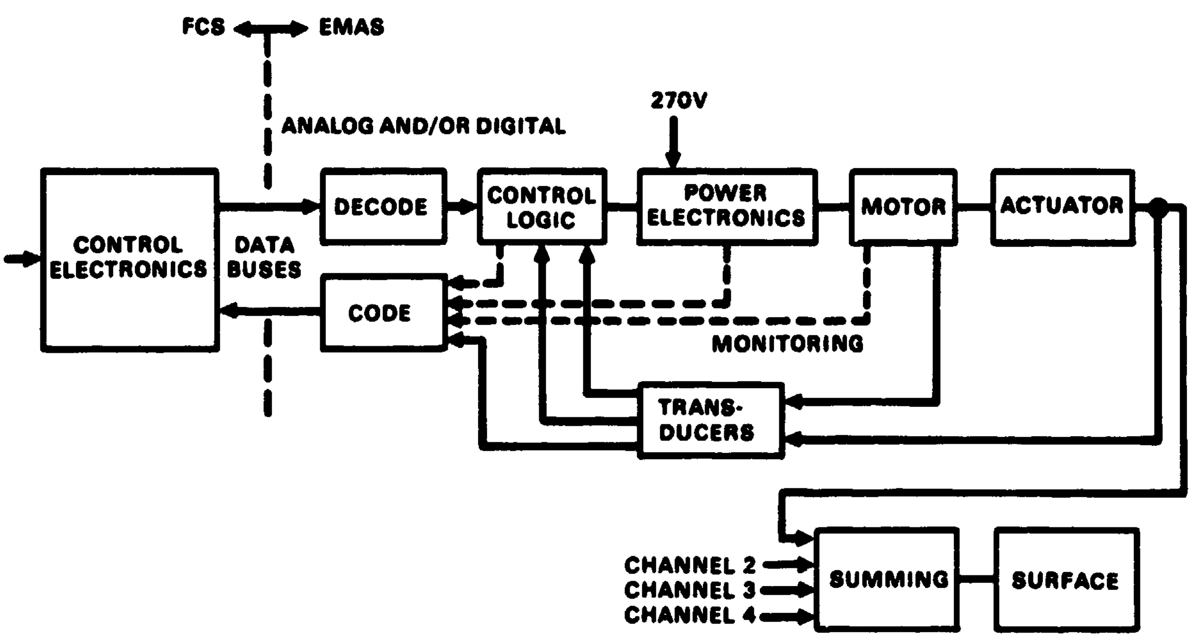


Figure 63. - Typical FCS actuator control.

As projected for hinge-line actuation systems, the all-electric FCS represented a major simplification of the FCS installation, since it eliminated all the high-pressure hydraulic lines in the wings and fuselage. The power-electronics box for each actuator is located in close proximity to its actuator and this minimizes prospective EMI problems. In the case of the I/B ailerons, the O/B ailerons, and the spoilers, the power-electronics and the actuators are mounted directly to the rear spar beam. The rudder and stabilizer actuators and power-electronics boxes are mounted to heavy local structure. This heavy structure (like the spar beam) is used as a conductive heat-sink for the actuators and electronic system components. Figures 64, 65, and 66 are schematics of the primary FCS actuator installation in the ATA. These schematics were generated by Lockheed computer-graphics equipment.

The ASSET program was used to develop the data relative to the baseline FCS, the FBW/hydraulic FCS and the all-electric FCS. While a weight saving of 924 pounds is shown for the all-electric FCS, vis-a-vis the baseline, the significant advantages of the all-electric FCS reside in the elimination of the highly complex mechanical control system. This system involves a major design/development activity which incurs high nonrecurring costs, and physical installation/rigging/adjustment problems. Likewise, testing of a mechanical/hydraulic FCS requires the design, development and fabrication of a sophisticated/costly vehicle system simulator (VSS). This mock-up must be an accurate (physical) facsimile of the aircraft, in which all distances are simulated, and all mechanical control runs, bell cranks, beams, pulleys, etc. are faithfully reproduced.

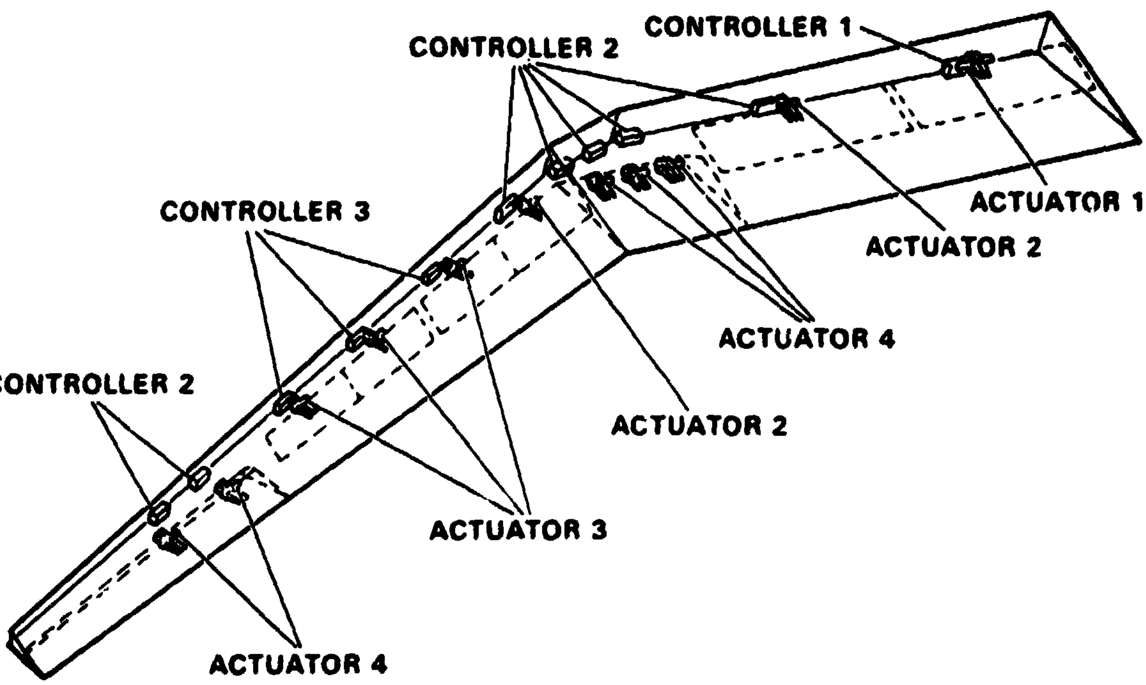


Figure 64. - Electric actuator/controller installation: ATA wing.

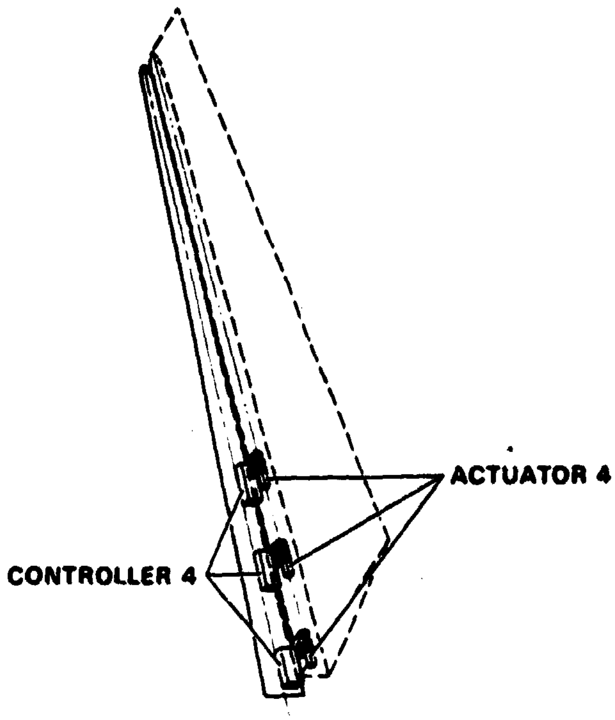


Figure 65. - Electric actuator/controller installation: ATA rudder.

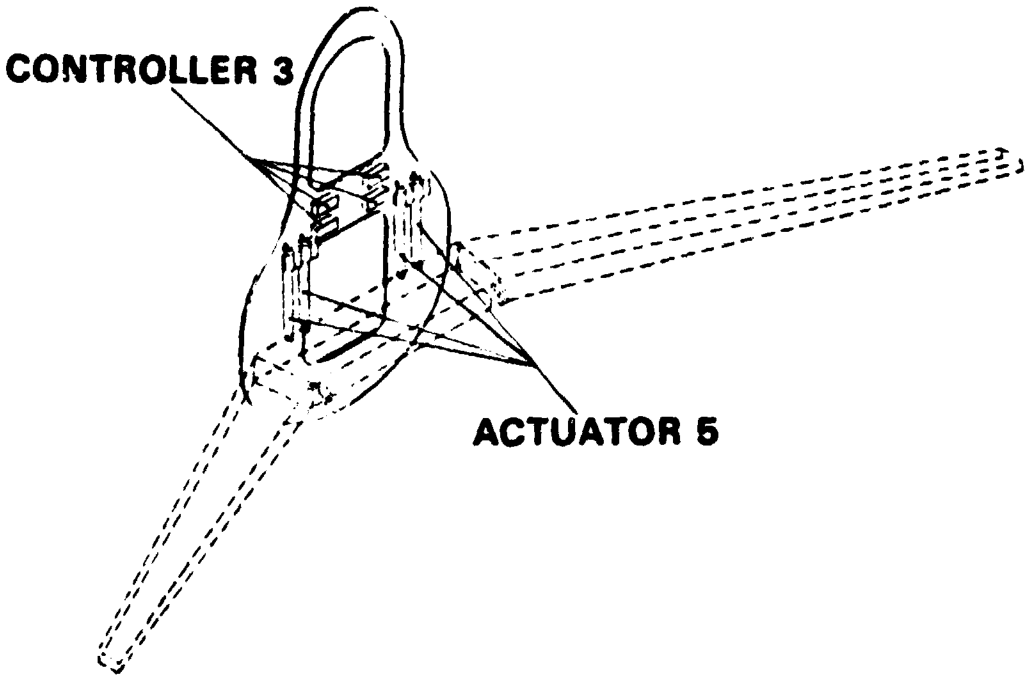


Figure 66. - Electric actuator/controller installation: ATA horizontal stabilizer.

In contrast to the baseline FCS, the all-electric FCS requires no complex VSS, since electric cables are not inhibited by the physical constraints of a mechanical/hydraulic system. These differences explain the lower cost reflected in the installation and testing the all-electric FCS.

The other primary advantage projected for the all-electric FCS is the increased viability offered by this system. Changing transfer-functions and adding new aerodynamic control laws are more easily accomplished with the all-electric FCS. It is evident also that the projected increased role of fully-modulating spoilers, and other high lift devices, can be accomplished in a much more facile manner electrically, than using mechanical torque-tubes or mechanical control cables.

All costs associated with the baseline, and all-electric FCS, were developed along with other outputs from the ASSET program. As a typical output, it was estimated that the testing of the all-electric FCS would cost approximately $12 to $15 million less than a conventional FCS system. There were also major savings in design hours of an all-electric FCS, since "software-design" replaces the detailed/protracted design of a mechanical control system. This saving was estimated at $17.6 million. The cost savings, resulting from the elimination of the hydraulic system, were also taken into account, since a primary role of the hydraulic system is to support the FCS. The hydraulic system is another custom-designed installation which, like the mechanical control system, requires an accurate sophisticated mock-up. Elimination of the cost of this mock-up was included in the tradeoff of the FCS.

7.1.5.4. Hydraulic system: In almost all aircraft today, the hydraulic system is the major power system in the airplane in that it powers the FCS, the secondary flight control surfaces, landing gear systems, and other services. Conventionally, as in the L-1011-100, it is a 3000 psi system, derived from engine-driven pumps and motor-driven pumps. All hydraulic power sources typically feed into a hydraulic load-center, from which power is then distributed in a radial fashion to the wings, wheel wells, empenage, etc. By virtue of the redundancy of the power sources, and the spatial separation given to the routing of the hydraulic lines, the hydraulic system has been shown to be a highly reliable power system in the L-1011 and other modern aircraft. It was this high reliability criterion that had to be (and is) matched by the all-electric power system.

The design of a reliable EM actuation system (and an equally-reliable digital-electronic control system), were the primary efforts of the study, since this made it possible to consider the elimination of the hydraulic system not only for the FCS, but for the other functions, such as landing gear actuation, nose-wheel steering, cargo door actuation, etc.; it was decided that these latter functions be accomplished using open-loop controlled rotary and linear actuators.

Most of the non-FCS actuators were designed to use simple, rugged squirrel-cage induction motors, while for a simple position-servo, such as required for nose-wheel steering, a simple dc brush-type motor type was selected. Figure 67 shows outline drawings of the non-FCS actuators that were designed by AiResearch, under the NASA contract. Appendix B includes physical and performance characteristics of the landing gear actuators.

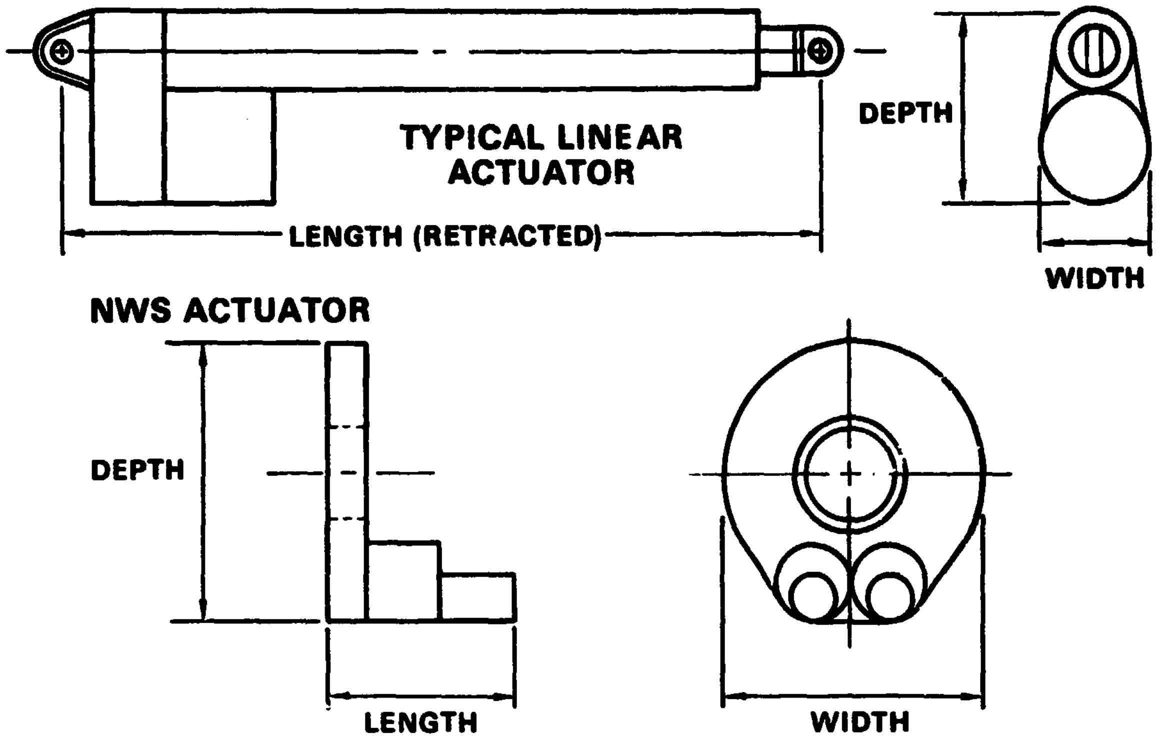


Figure 67. - EMAS secondary FCS and Non-FCS actuators.

It is concluded from this study that there appeared to be no major development problems in the successful development of EM actuators for all the FCS and non-FCS functions. Therefore, as anticipated by NASA, it is feasible to consider the elimination of the hydraulic system and this has been a major premise of this report. It can be seen that the installation benefits, associated with the elimination of the FCS mechanical control system, accrue to the aircraft when the hydraulic system is eliminated. It is a sophisticated system, which has had a highly intense design/development cycle and it has required the use of customized mock-ups, to reproduce the installation of all tubing and components in their proper relationship. These sophisticated mock-ups were necessary to validate the performance of the system under all normal and abnormal conditions.

Labor costs involved with the installation of the hydraulic system are higher because of the complexity of the installation. Lines must be custom-routed and high-quality production control techniques must be used to ensure reliable interfaces between the many welded and non welded joint assemblies. Special gas-welding techniques (with inert gas protection) are used, along with swaged-type fittings. Throughout, special care to avoid leakage and prevent contamination, must be exercised to achieve trouble free installation. The hydraulic system is also a relatively high-maintenance support system and this reflects into the direct operating costs of the airplane.

Figure 20 shows the hydraulic load center in the L-1011-100 airplane. This photo exemplifies the complex custom-nature of the hydraulic installation, and it gives a perspective as to the volume of the underfloor fuselage-area involved with the hydraulic load center. In the all-electric airplane, this valuable real-estate could be released for baggage, fuel, or other utilitarian purposes.

The ASSET program again was used to trade all relative aspects of the baseline hydraulic system, and these were compared with the replacement elements of the all-electric airplane. A weight saving of approximately 2700 pounds was projected for the electric system. In addition to weight, the ASSET program showed the labor/installation costs that were eliminated by the deletion of the hydraulic system from the all-electric airplane. These are recurring costs, which reflect in reduced acquisition for the airplane. These and other cost aspects are shown in the later section of this report.

7.1.5.5. Icing protection: The present use of engine bleed air for wing/engine anti-icing, floor/wall heating, and other functions (such as thrust reversers) is another consideration that impacts on the all-electric airplane. To meet the objective of au all-electric SPS it is necessary that these and other functions by powered electronically.

Engine deicing, historically, has come under the purview of the engine supplier, who has usually selected hot bleed air to protect the engine lips and the compresser stages against ice accretion. Also, it is possible that, since a continuation of this policy would still keep the ducts within the confines of the power-plants, hot-air deicing of the engines might still be a tenable premise. Spraymat-type anti-icing, however, could be considered since this appears more adaptive to the double curvature sections of the engine inlet system. Electric deicing approaches are not acceptable inside the engine.

Wing anti-icing/deicing is another matter. Here, a continuation of hot bleed air deicing would result in high temperature high pressure ducting being brought outside of the power-plants into the wing area; this being undesireable, electric deicing is proposed in the all-electric ATA.

Figure 68 is a schematic of the hot bleed air system, used for the six leading edge slat surfaces in the L-1011. As shown, bleed air is introduced into the slats (on the inboard side) via a telescopic duct. The hot air is then distributed in the double-wall wing design of the slats, and flexible duct joints are employed to allow for transverse airflow between the panelss.

Figure 69 shows the alternative of using electro-thermal deicing for the slats. In this system, the leading edge slats are made up of an aluminum deice boot, which is actually the structural leadiing-edge panel of each slat panel. Stamped, or chemically etched, stainless-steel heater elements are sandwiched between an outer and inner layer of electrical insulation; the thickness of the outer insulation, is thin enough to allow good heat-transfer to the outer skin surface. Primary ac power would be used for the deice boots and, as shown in Figure 69, this power could be introduced into each panel via a flat-cable deployed from a flat-cable cassette located in the fixed wing section behind each panel.

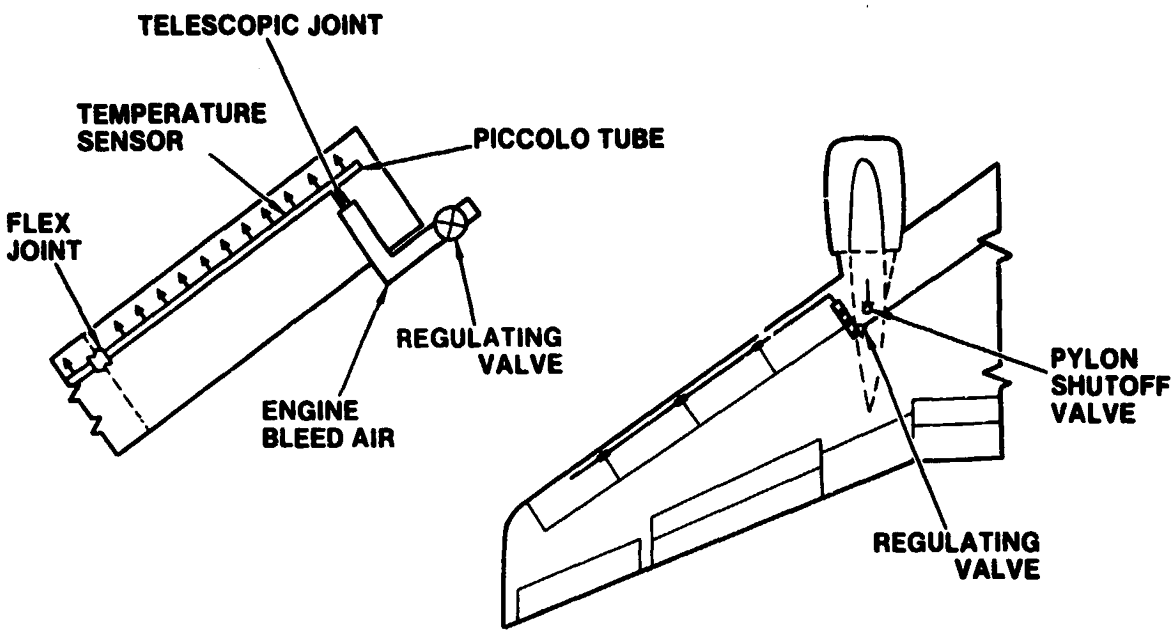


Figure 68. - Conventional wing slat de-icing.

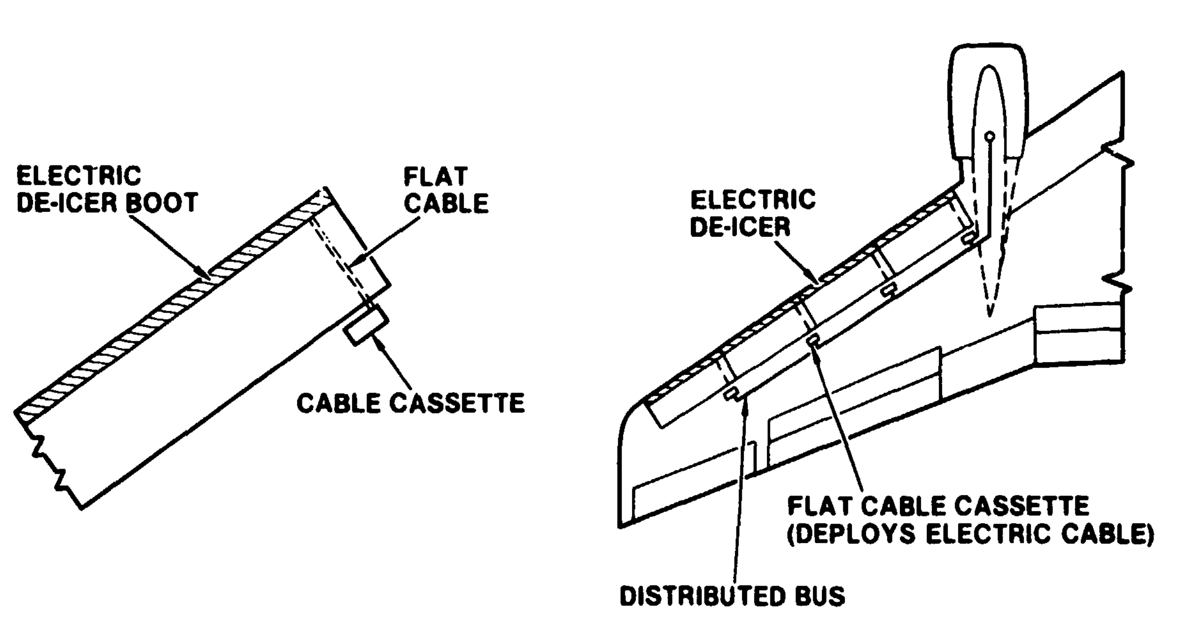


Figure 69. - All-electric slat de-icing.

7.1.5.6 Electric system design: As stated in the beginning of this section, a special type of power generation system was required for the all-electric ATA. In these comments it was pointed out that the taking-over of all loads, normally powered by the hydraulic and bleed air systems, automatically dictated a very large size generator. All-electric aircraft, in the future, could therefore require generators in the 300 to 500 kva capacity (and higher). Fortunately, because of the development of high temperature insulation materials, highly-permeable magnetic-irons and the utilization of very high rotor speeds, these generators are relatively small in physical size and weight.

The 6-pole, 3-phase, 800-Hz, 400-Vac, 150-kVA generator designed by AirResearch, to CALAC design requirements, weighs only 96 pounds and its dimensions are 12 inches long/9 inches diameter. There are two such generators per engine, giving a 300-kVA capacity per engine; this capacity is adequate to supply the power requirements of the all-electric airplane and, at the same, time furnish the power for engine starting.

Engine starting: In the starting mode, both synchronous generators on each engine are operated as synchronous motors, made possible by the use of a programmed voltage and frequency power supply, derived from either of two onboard static power converters. In the all-electric ATA, the two starting inverters use static-power switching-electronics to provide the special variable voltage/variable frequency power supply for the starter generators. Each inverter may be powered from the onboard APU, or from external power. Because of the weight of the inverters, the all-electric start did not show a major weight saving, but it provides for an overall simplification of the start system and it eliminates the need for air compressors on the APU.

Figure 70 is a schematic of the electric start system, which shows the simplicity of this system, compared to figure 71. This latter figure shows the pneumatic start system which was used in the L-1011 and the baseline ATA systems. It can be seen from figure 71 schematic that there are many regulator valves/shut-off valves/check-valves, etc., and the overall complexity is such that it is not a low maintenance-support system.

Power generation system: Six 3-phase, 800 Hz, 400-Vac (two per engine), 150-kVA generators furnish the primary electric power in the all-electric ATA. These are oil-cooled samarium-cobalt generators, which run at speeds of 8000 to 16,000 rpm, over the 2:1 speed range of the engines. Because of the simplicity (and low heat-rejection) of the generators, the oil-cooling supply is shared with the engine oil cooling system. This approach avoids the need to provide pressure-pumps, scavenge-pumps, or dedicated heat exchangers for the electric power system.

Since the generators are direct-driven, their voltage (and frequency) is directly-proportional to engine speed. A power take-off (PTO) shaft is used to drive each pair of generators, and the PTO gear-ratio is such that the generators generate 800-Hz 400-Vac power at the 92 percent engine-cruise speed. Maximum use is made of the basic electric-power, while special conditioned power is used for the FCS actuators and the airplane's avionic system; 28 Vdc power (obtained by transformer rectification) is used as one of the conventional power supplies in the airplane. These special supplies are summarized as follows.

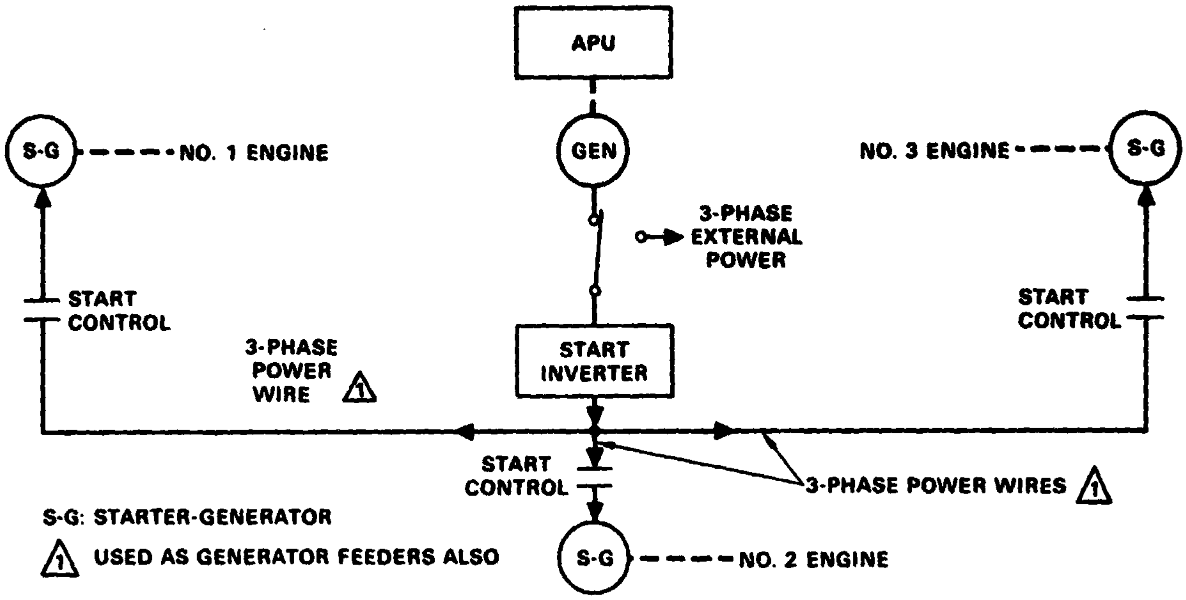


Figure 70. - ATA: all-electric start system.

- 270 Vdc: Used for the FCS and the constant frequency power units (CFPU). Six 28 kw phase-controlled rectifiers (one per generator) provide 270 Vdc over the 2:1 speed range.

- 3-phase, 400-Hz, 200 Vac: Four 15/20 kVA static power inverters provide conventional 200v 400Hz ac power for the avionics and other conventional 400 Hz ac loads.

- 28 Vdc: Three 28 V 200 A T/R (transformer-rectifier) units furnish power to the typical 28 Vdc loads: relays, solenoids, shut-off valves, rotary/linear actuators, relays, indicators/instruments etc.

- 400-Vac, 800-Hz power: This is the primary ac power used for loads such as

  - ECS
  - Heating and lighting
  - Floor/wall heating
  - Galley loads
  - Anti-icing/deicing
  - AC induction motors

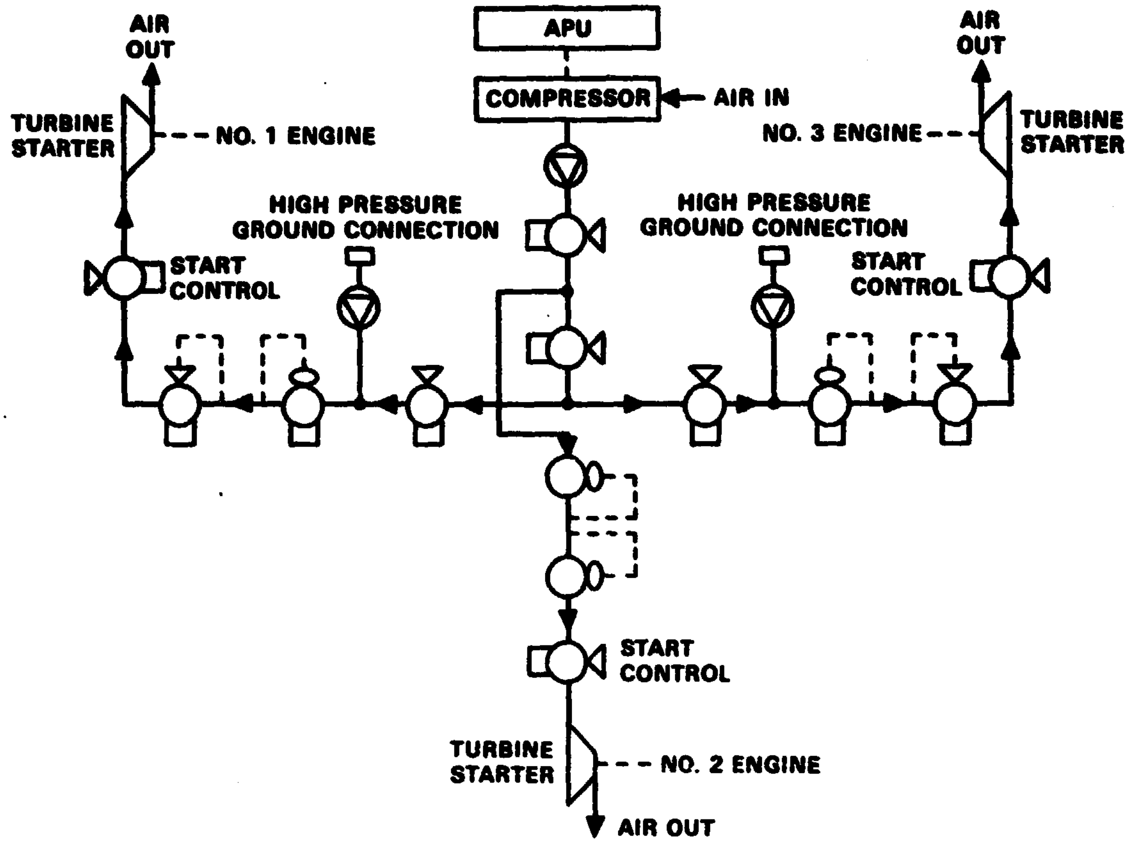


Figure 71. - ATA baseline: pneumatic start system.

Figure 72 is a schematic showing the all-electric ATA system and other power generation alternatives. This schematic shows that conventional power systems using CDSs, involve hydro-mechanical drives, rated at 200 to 300 hp each; drives of this capacity have disadvantages of weight and heat rejection. The schematic depicting the 270 Vdc system involves generators, rated at 300 kVA (instead of 150 kVA), and large power inverters are required to supply any motors, such as the large ECS motors, etc. A conventional VSCF type system, on the other hand, would require six cycloconverters (of capacity equal to the generators) and, again, the generators would be the equivalent to 300 kva (instead of 150 kVA).

In contrast to the above, the generators in the all-electric ATA system are optimally-sized and the large ECS compressors can be driven directly by simple, rugged, squirrel-cage induction-motors (without the use of any converters). Figure 73 shows the performance characteristics of ac induction motors, when the voltage is held constant, and when the voltage varies with frequency. It is to be noted that the constant voltage system not only oversizes the motors (in a ratio of 2:1), but the additional inherent torque of the motor at low frequencies cannot be absorbed by the load (the ECS compressor). It is therefore a significant (electrical) overdesign, compared to the constant E/F ratio power system, where the voltage varies with frequency.

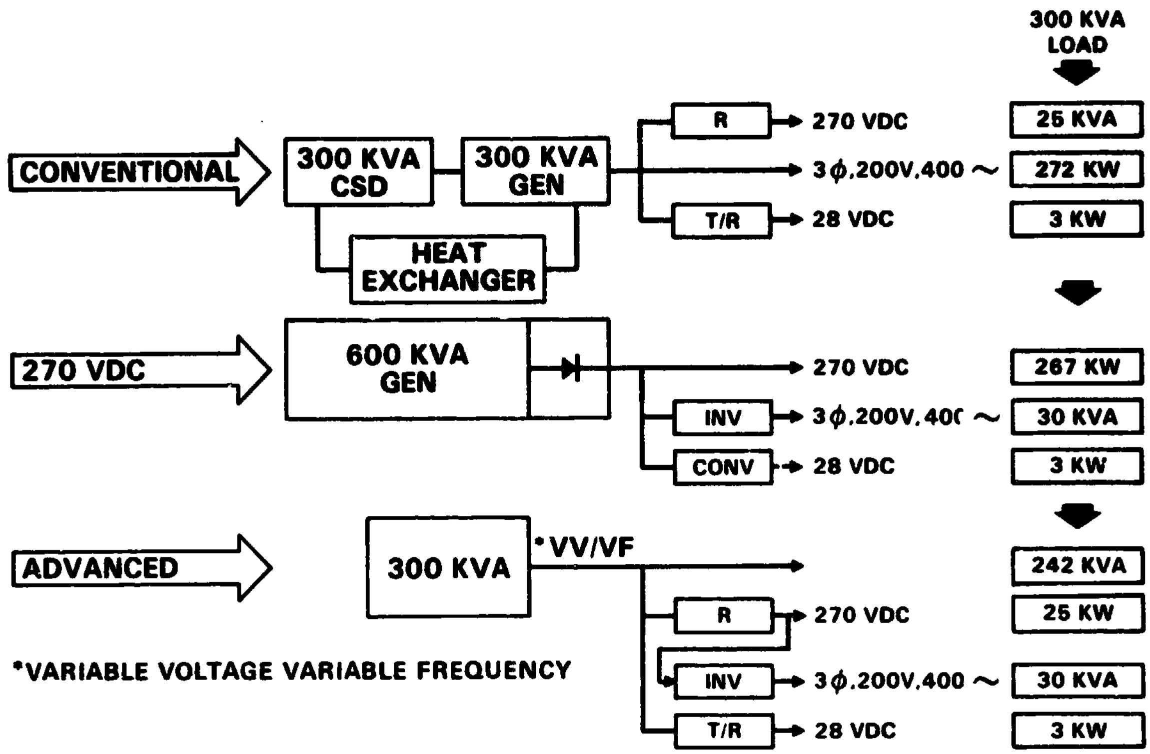


Figure 72. - Candidate electric systems.

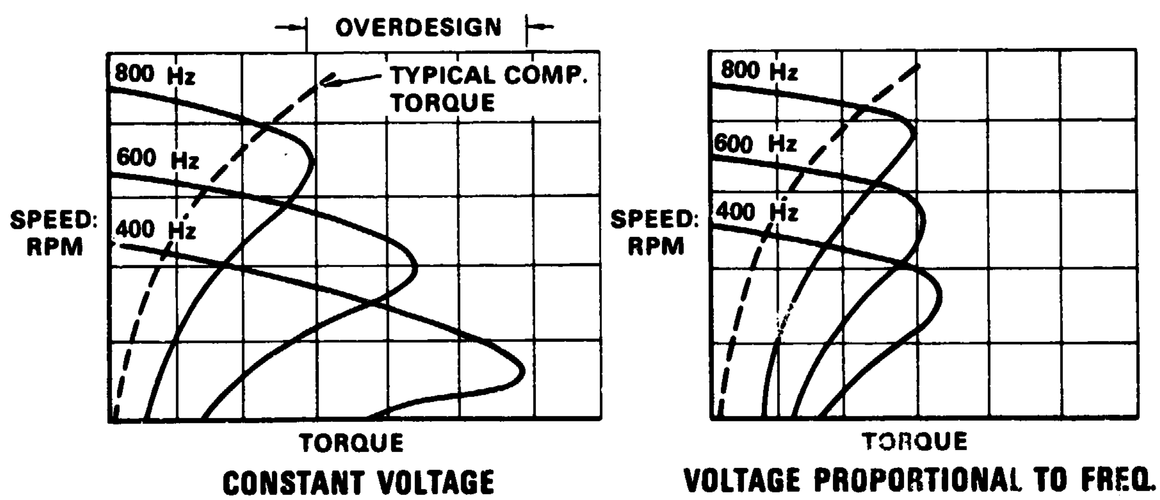


Figure 73. - Induction motor performance.

Power distribution: One of the legacies of the all-electric airplane is that there will be more loads in the wings, wheel-wells, empenage. Therefore, to maximize the use of a digital data bus, or low level logic control system, the power buses must be in close proximity to the loads. In this regard, the conventional radial-distribution system, as shown in figure 74, is inferior to a "distributed-power-bus" system, as shown in figure 75. The figure 75 schematic is the basic configuration of the all-electric ATA and it follows the redundancy criteria of the baseline ATA system; i.e.,

- Quad redundancy in the fuselage to supply the stabilizer/rudder system
  - o Triple redundancy in inboard wings (for I/B ailerons, spoilers, etc.)
  - o Dual redundancy in outboard wings (for O/B ailerons, spoilers, etc.)

In keeping with good installation practice, spatial separation is given to the power feeders, in such a way that cables (in the wings) are routed along the front and rear spars, while the cables in the fuselage are routed along the left and right walls. A (non-conventional) high-impedance grounded neutral system will also be used with the generators, so that line-to-ground faults will not cause high-rupturing fault-currents. Other unique protection features are also proposed for the generators and power distribution system in the all-electric ATA.

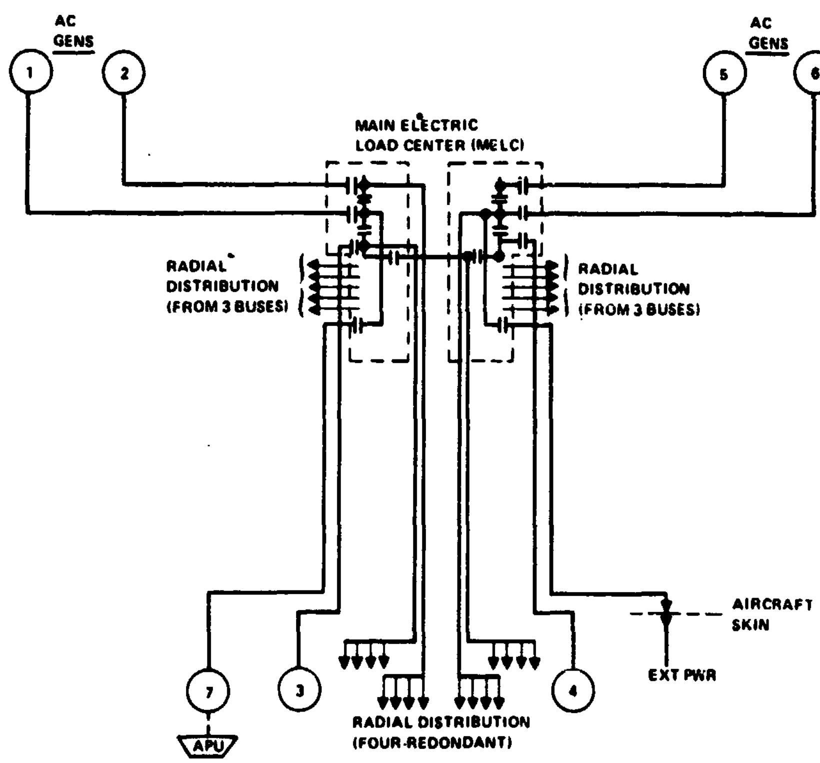


Figure 74. - All-electric airplane: conventional (radial) power distribution system.

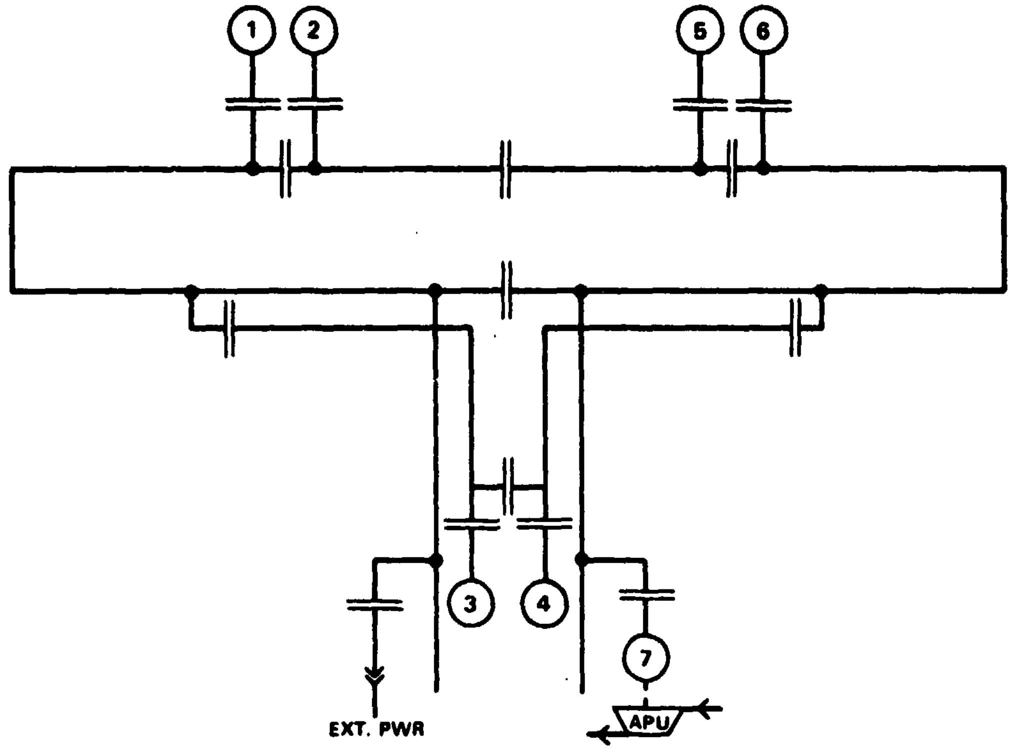


Figure 75. - All electric ATA: distributed bus system.

7.1.5.7 All-Electric System - Summary: The NASA work-statement required the study to evaluate the feasibility of eliminating "residual" hydraulics and "residual" pneumatics from the ATA. This study has shown that it is indeed possible to eliminate these major subsystems, but it is done at the expense of a large capacity generating system. This is not considered to be a major problem but it would be difficult to implement if conventional-type power systems were used (because of the high weight, high cost, and complexity). In addition, the conventional system would suffer from high heat-rejection problems. There is no panacea for any aircraft power system, which has to operate over the variable speed range of engines, but the system selected for the all-electric ATA enjoys an essential simplicity and reliability that commends it to the requirements of the long-range and the short-haul transports.

The advantages of the all-electric ATA have exceeded the optimistic projections made at the beginning of the study. The most significant improvements came from the saving in block fuel, from the elimination of bleed air, and in turn, the elimination of heavy, costly ducting in the engines, pylons and wings (a weight saving of 2538 pounds). The elimination of bleed air also had salutory effects on the engine design itself in that it slightly reduced the engine core size and saved approximately 1000 pounds for the three engines. For the 500-passenger ATA with a 5-hour, 3000-mile mission, the projected block fuel saving (projected by the ASSET program) was 5378 pounds.

The fuel/engine weight savings also added to weight savings, generated in the systems and components area. The ECS, which is a major system (in terms of its design and installation complexity) was significantly reduced in complexity by the adoption of an all-electric ECS, using motor driven compressors and a vapor-cycle cooling system. The weight of the all-electric ECS was shown to be approximately 1500 pounds lighter than the baseline ATA ECS.

Figure 76 is a bar chart, which shows graphically, the major weight savings of the all-electric ATA, vis-a-vis the baseline ATA. The 23,500 pound difference is impressive and much higher than expected.

Weight is always a key parameter in aircraft designs but, today, the concern is shifting to an even greater concern for fuel, since the escalating cost of fuel and its availability threatens the economic viability of the aerospace industry. It is in this context that the all-electric aircraft falls into the role of an energy-efficient transport, which commends it for serious consideration as a transport for operation in the mid 80's and beyond. Maintenance costs, direct operating costs and acquisition costs are the other salutary results of the all-electric ATA supply. Here again, the Lockheed ASSET program revealed impressive differences in favor of all-electric ATA. Figure 77 is a bar chart showing the design, development and test cost savings of the all-electric ATA vs the baseline. The prospective $2.8 billion saving for 300 aircraft over 16 years examplifies the impressive technology value of the all-electric ATA.

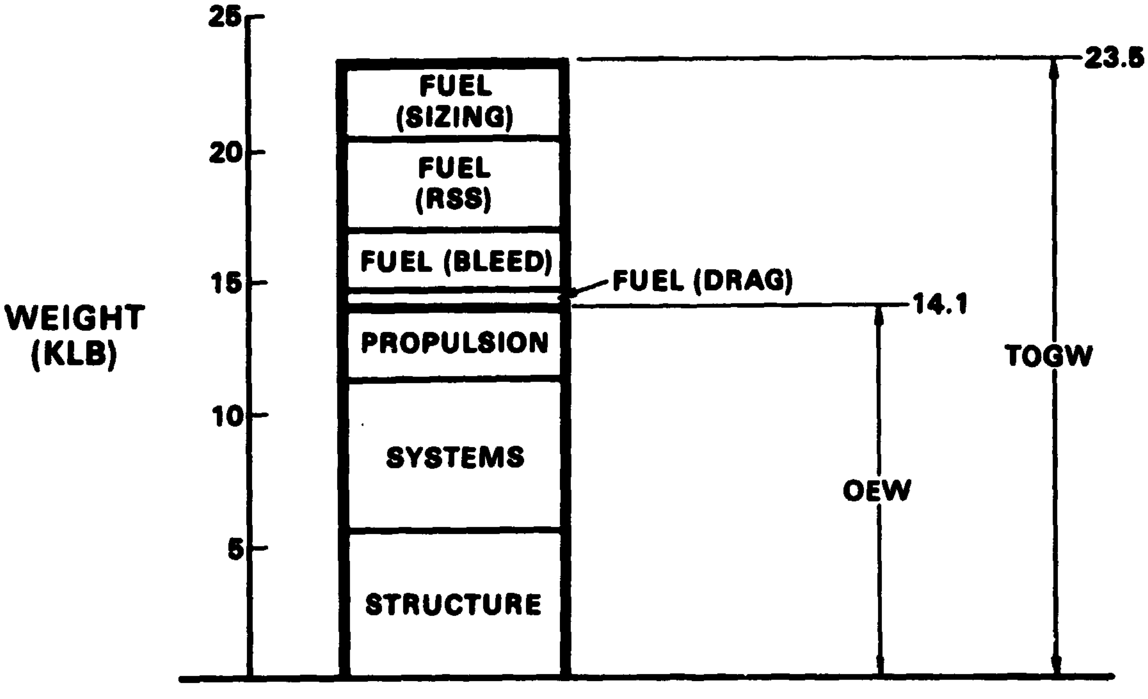


Figure 76. - Weight savings - all-electric airplane.

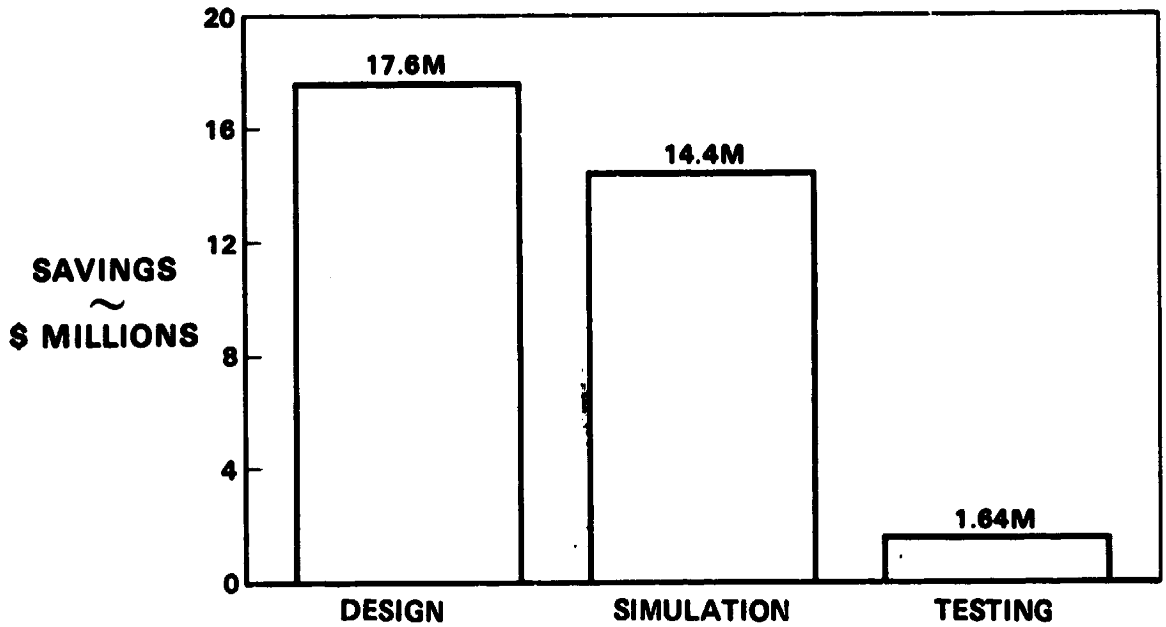


Figure 77. - Development cost savings.

7.1.6 Fiber Optics. - Examination of the fiber optics tradeoff parameters showed that the performance of fiber optics was not required and that weight and cost savings were negligible. Therefore, the fiber optics configuration was not processed through the ASSET program. Future aircraft, beyond 1990, might benefit from fiber optics.

The cost effectiveness of fiber optics is dependent upon the multiplexing scheme selected. With an ARINC 429, 100 kbps bus, a low frequency, one-way system, the full advantages of fiber optics cannot be realized. The fiber optics must compete on a conductor for conductor basis and cannot take advantage of the inherently large bandwidth. When the weight of couplers, terminating electronic equipment and mechanical strenth, is added there is no weight advantage. For example, a four-conductor, 24-AWG aircraft cable (500 lb tensile strength) weighs 12.7 kg/km whereas a four-conductor heavy duty (200 lb tensile strength) fiber optic cable weighs 19.6 kg/km.

There is approximately 150 kg (330 lb) of MUX wire for the FBW flight control and 200 kg (450 lb) of wire for MUX in the all electric airplane. Some of this weight could be saved by using a high-speed, two-way bus such as MIL STD 1553A or the S-3A 13 mbps digital bus which has operated satisfactorily for many years. It is estimated that eight such busses would handle the multiplexed traffic on the ATA. This would be 5 kg for the fiber optics and 50 kg for couplers and taps. This would be a savings of 350 kg (770 lb). However, the decision was made that for the near term (1980-1990) a high-speed, two-way bus was too risky for a commercial transport. Such a system could be used as an evolutionary step in noncritical appplications. We should note that the foregoing savings are not attributable to fiber optics but to high speed multiplexing. This multiplexing could be done with wire (as on the S-3A) but the problems with EMI and impedance matching throw the tradeoff toward fiber optics.

Fiber optics did not prove economically advantageous for the near-term fly-by-wire system. As a means of preventing damage from lightning-induced currents, it does not appear to have a large payoff near term because it could only be applied to MUX conductors in the fuselage, which are comparatively well protected deep inside the wide body cross section. Far-term aircraft might have greater need of the EMI protection that fiber optics can provide because, assuming full MUX (no MDM) and composite skins, the MUX link would be considerably more vulnerable.

The disruption of wired multiplex buss by lightning is a problem of unknown magnitude at this time. For metal-skinned aircraft, this problem has not been serious. It will cause dropouts; i.e., momentary loss of communications, but not catastrophic loss of the system. Composite skins must be protected by conductive additives otherwise they will be destroyed by lightning. It is felt that if the composite skin has a high enough conductivity to protect it structurally, then electronic circuits can be adequately protected by conventional methods such as filtering and nonlinear conductive devices. This, however, must be proven by extensive testing. If such protection for wired busses becomes difficult, then fiber optics will be more attractive and possibly mandatory.

7.2 Short Haul Candidate Descriptions

7.2.1 Fly-By-Wire (FBW). - The baseline short haul aircraft has a cg at up to 30 percent of mean aerodynamic chord, which gives a static margin that allows the aircraft to be flown manually without stability augmentation. However, advanced short-haul aircraft envisioned in the NASA Ames/Lockheed short-haul study, NASA Contract No. NAS2-10264, provide increased fuel economy by using a very relaxed static stability with negative static stability of 40 percent. Under these conditions full-time artificial stabilization and control force shaping will be required. For the short haul, more so than for the ATA, FBW must be combined with new technology aerodynamics and aircraft design to obtain a payoff.

Recent short-haul studies do not consider advanced aerodynamics and aft cg balancing necessary for the near term. FBW weight differences in this study are due to removing the mechanical controls. Because the FBW system for short haul must offer the same safety as for the larger ATA, its FBW system was designed with the same four-channel configuration as the ATA.

The short-haul aircraft have spoilers instead of ailerons; therefore the control diagram would be similar to that for the ATA (figure 45), except that those controls titled spoilers would be omitted and those titled ailerons would be retitled spoilers. This would give the short-haul aircraft the same stability and control redundancy as the ATA. Accordingly, there would be two actuators each for the two outboard spoilers, three actuators each for the two inboard spoilers, three actuators for the rudder, and four actuators for the elevator. The electrohydraulic valves, secondary actuators, primary valves, and primary actuators would be of the same type as the ATA but sized for the smaller flows.

7.2.2 Multiplexing. - Multiplexing for the short haul aircraft shows little payoff in terms of weight and cost. This is because the aircraft do not have long wire runs, or complex avionic requirements and because, as discussed for FBW, the aerodynamics do not require sophisticated command and stability augmentation. For the 1990s and beyond there might be a payoff for multiplexing in terms of reduced wire weight.

As discussed for ATA, multiplexing may be used in many cases for purposes other than reducing wire weight. It may make interfacing easier, more reliable, or less complex. In these cases, the designer would make the decision based upon subsystem parameters rather than by selecting a single integrated multiplexing scheme for the entire aircraft.

7.2.3 Ring Laser Gyro (RLG). - There is no inertial navigator required or desired for the baseline short-haul aircraft; therefore there can be no benefit from changing to an RLG. Thus no tradeoff was run through the ASSET program for RLG. It is possible that in the future (after 1990) RLG technology would advance to a point where RLGs would be competitive with conventional rate gyros and verticle gyros for stability and control sensors and for attitude and heading reference systems for instrument flight. This application is not analogous to that of the inertial quality systems evaluated in the present tradeoff.

7.2.4 Integrated Avionics. - The complexity of avionics required for short haul aircraft is not great and thus integration of avionics does not show a large payoff. Also contributing to this situation is that the baseline equipment is well integrated already. The industry has taken advantage of the large strides already made in the large transport avionics field to produce low-cost, well-integrated subsystems for the small aircraft.

As the sophistication of short haul avionics increase in the 1990s, integrated avionics will show more of an advantage. This is pictured as an evolutionary carryover from the more sophisticated large aircraft systems, however.

7.2.5 <u>All-Electric Aircraft and Load Management</u>. - The primary difference between the all-electric SHT and the baseline SHT is that the all-electric airplane uses an electric ECS system in lieu of an aircycle system powered by engine driven compressors 1, see figure 36.

For reasons of simplified logistic support, and more viability for the short-haul transports, it is recommended that 28 Vdc engine-starting be employed for both types of airplane and that they also use electric anti-icing/de-icing, in lieu of inflatable boots, or engine bleed air. The commitment of the SHT to turboprop and prop fans itself places somewhat critical constraints on the ability to use bleed air. Therefore, engine-driven compressors (EDCs) or motor driven compressors (MDCs) are the only alternative means of generating the pressurized air required for the ECS. It is a premise of the SHT that the ECS is to provide cabin air-conditioning comfort levels (up to altitude of 25000 ft) equal to the 727,737 type transports. A description of the nonelectric and the electric ECS is given later in this section.

The primary impact of the change from EDCs to MDCs, and the change from a mechanical/hydraulic FCS to an all-electric FCS can be summarized as follows:

- The capacity of the ac generator on each engine is increased to 40 and 75 kVA for the 30, 50 PAX SHT configuration.
- A 270 Vdc system is obtained by rectification of the primary 3-phase, 400-Hz, 200-Vac power.
- Pneumatic ducts are eliminated from power plants and wings.
- Hydraulic pumps and hydraulic lines are eliminated from airplane.
- Electric actuators are used for the primary FCS, the trim surfaces, secondary surfaces and for landing gear, doors, etc.

The FCS will be a FBW/PBW (fly-by-wire/power-by-wire) system, which uses electric data control of electric powered-hinge actuators. These actuators are brushless dc motors, using samarium-cobalt (permanent magnet) motors. The hinge-line actuators and the electronic digital control system are similar to the design configurations of the all-electric ATA. Backup and emergency power for the FCS is provided by a ram air turbine driven generator and a 270 Vdc battery-pack. This latter battery power supply will tie into two FCS channels, via isolation diodes. A 28 Vdc inverter will provide the emergency 3-phase, 400-Hz, 200-Vac power for engine ignition/engine flight instruments, etc.

Other aspects of the all-electric SHT will follow the design configuration of the baseline SHT. The system will make the maximum use of modern load management technology and solid-state power controllers (SSPCs). The military's and NASA's research and development programs on solid-state electric logic (SOSTEL) advanced power generation systems and advanced power/load management will influence the design and implementation of the SHT electric systems. Similarly, advantage will be taken of Lockheed's own extensive in-house programs

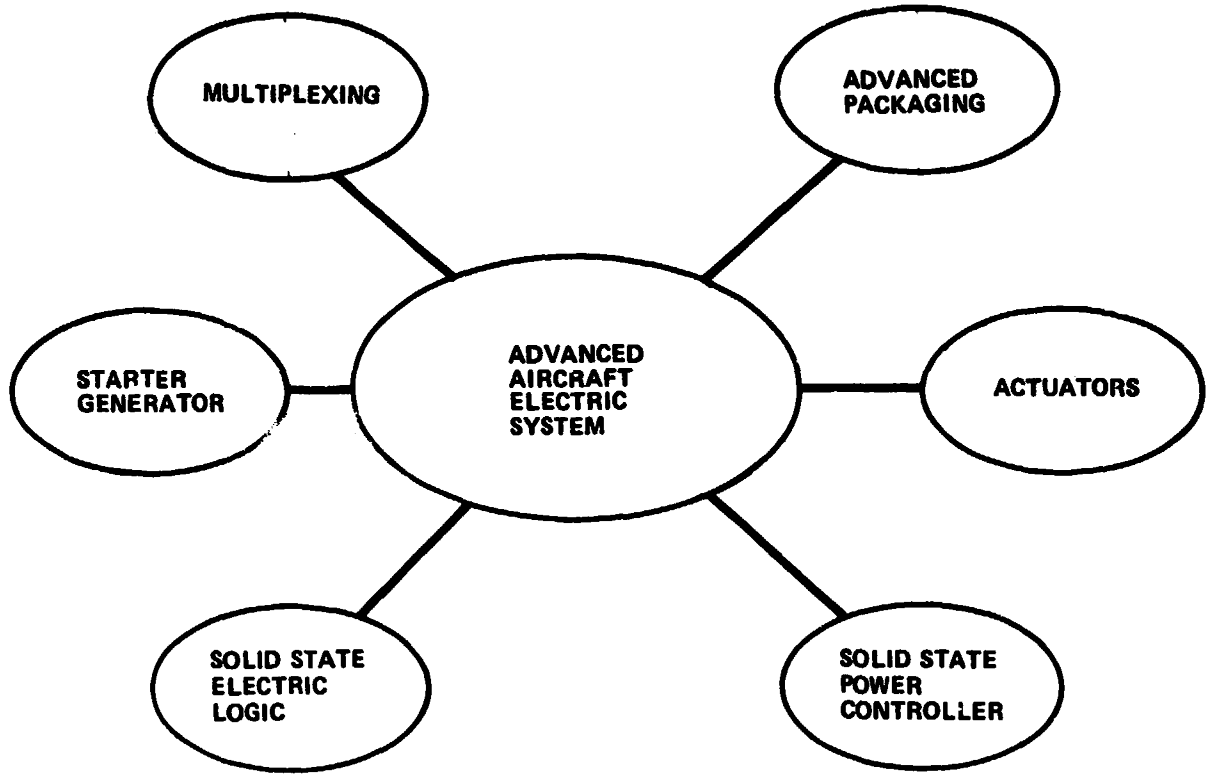


Figure 78. - Elements of AAES.

on advanced aircraft electric systems (AAES). Elements of this latter program are very appropriate to the short-haul transports. Figure 78 is a schematic representation of the AAES.

The referenced figure defines many elements of the AAES, some of which will not be applicable, or advantageous, to the SHT. Multiplexing, for instance, has a primary role in reducing wire quantity and wire weight in many aircraft. This, however, is not a central factor in the SHTs. Also, over-sophistication of the SHT will impact unfavorably on the logistic and maintenance support aspects of these vehicles. Typically, such aircraft will have very short turn-around time and will use personnel who do not have high technical skill levels. The SHTs are utilitarian aircraft and as such need to have simple, reliable systems that can be easily maintained by moderately-skilled service personnel. To this extent, the elimination of the hydraulic system, which is a high maintenace support system, and the bleed air driven EC systems, makes the all-electric secondary power system attractive for the SHTs, as well as the larger ATA.

7.2.6 Fiber Optics. - As for the ATA, fiber optics does not show a payoff in the short-term future (1980-1990). However, the short-haul aircraft might benefit from fiber optics as the avionics and flight control requirements become more demanding beyond 1990. This will be true to lesser extent for the short haul aircraft than the ATA type aircraft.

7.3 Weight Analyses

7.3.1 General Methodology. - The weight effect of each tradeoff was evaluated by comparing the new system, defined with vendor assistance, to a well-defined baseline. Weights of new items such as actuators and electronic boxes came directly from vendors, together with wire counts and sizes that allowed calculation of associated wiring weight. Deleted equipment, plumbing, ducting, and wiring weights were based on details of contemporary aircraft scaled to the baseline configurations. Results of each weight comparison were input to the ASSET program to determine effects on overall aircraft sizing.

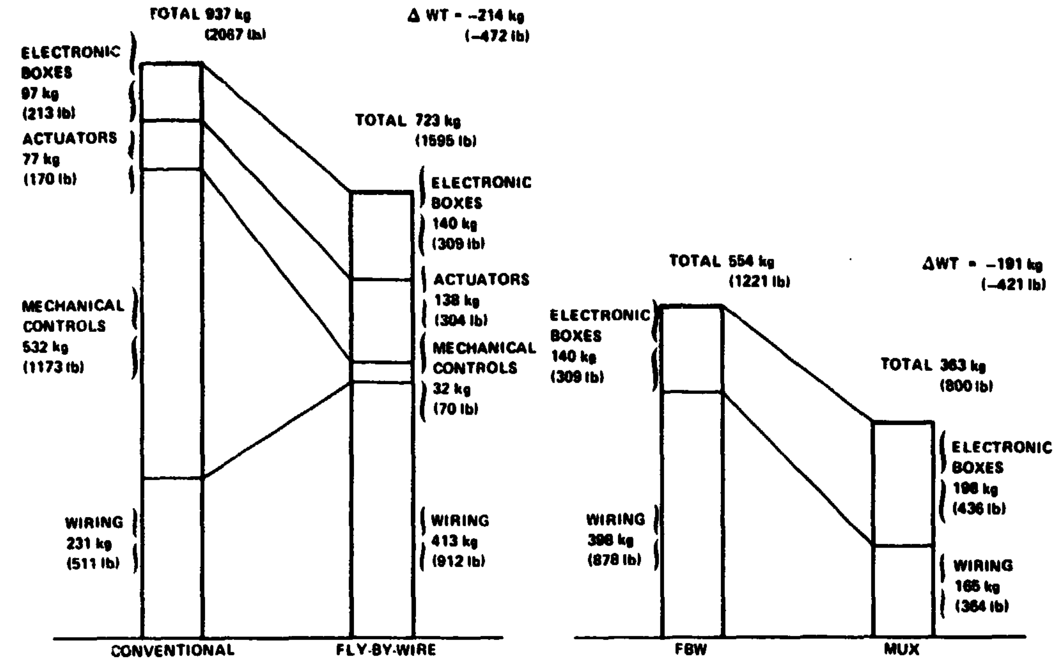
7.3.2 ATA Baseline. - The weight breakdown of the ATA, described in Section 5.1, was derived from a previous study by adjusting the systems of interest to a scaled L-1011. For example, the control system weight was based on a detailed breakdown of the L-1011 with the individual items scaled to the ATA configuration. Other advanced technologies such as improved engines and composite structure were retained in the weight model.

7.3.3 Short Haul Baseline. - The short-haul aircraft are described in Section 5.2. Their previously derived weight models were modified by more completely defining the flight control systems to enable an item-by-item comparison with the advanced technologies.

7.3.4 ASSET Program. - The ASSET program generates a group weight statement from a set of parametric equations. The entire aircraft, including engines, is scaled by the program. Thus, a weight reduction in an aircraft system results in the aircraft structure, power plants, and mission fuel being reduced as well. Each tradeoff was performed without these scaling effects and the results rescaled by ASSET.

7.3.5 ATA Tradeoffs. - Figure 79 (a) illustrates the weight reductions for using fly-by-wire in the ATA. The weight increases of electronic boxes and actuators is small since the conventional configuration, similar to the L-1011, has an advanced autopilot which incorporates extensive interfacing of electrical signals to the mechanical controls. The significant increase in wiring is more than offset by elimination of the entire control cable system due to the long distance between cockpit and control surfaces on a large aircraft.

Multiplexing the control system wiring trades increased electronic box weight against a 60-percent reduction in wire for a significant saving as shown in figure 79 (b). The laser gyro saves 17 kg (38 lb) and the integrated avionics save 23 kg (51 lb), both of which are small effects compared to the other tradeoffs in the study.



(a) FBW WEIGHT COMPARISON (b) MULTIPLEX WEIGHT COMPARISON

Figure 79. - Weight reduction using fly-by-wire in ATA.

The all-electric aircraft achieves a marked weight reduction by elimination of the hydraulic and bleed air systems. Figure 80 summarizes the weight effects. Electro-mechanical actuators are an average 26 percent heavier than their hydraulic counterparts. The 32-percent increase in electrical power generating equipment is much less than the increase in power due to the use of new technology generators without constant speed drives. The electrically driven air conditioning system is heavier than the baseline air-cycle machines, but this increase is more than compensated for by elimination of the bleed air system. The engine-starting system trades air turbine starters with associated valves and ducting against the power conditioning equipment required to operate the generators as starters resulting in a negligible weight increase.

Electro-impulse de-icing is heavier than hot-air de-icing. The hot air system would be much heavier if bleed air control valves and ducting were retained solely for de-icing, however. Elimination of hydraulic pump and starter drive pads and the higher speed generator drive combine to yield a 40-percent saving in engine accessory gearbox weight.

Wiring weight is reduced by higher voltages, the distributed power bus concept, and additional multiplexing. The power distribution system achieves redundancy without a central load center for transferring power between buses resulting in the elimination of duplicated power feeders. In addition to multiplexing control system signals, the many wires for position sensing switches, engine instruments, and miscellaneous functions can be multiplexed. Local power availability due to the distributed power bus allows reducing wire size for many functions.

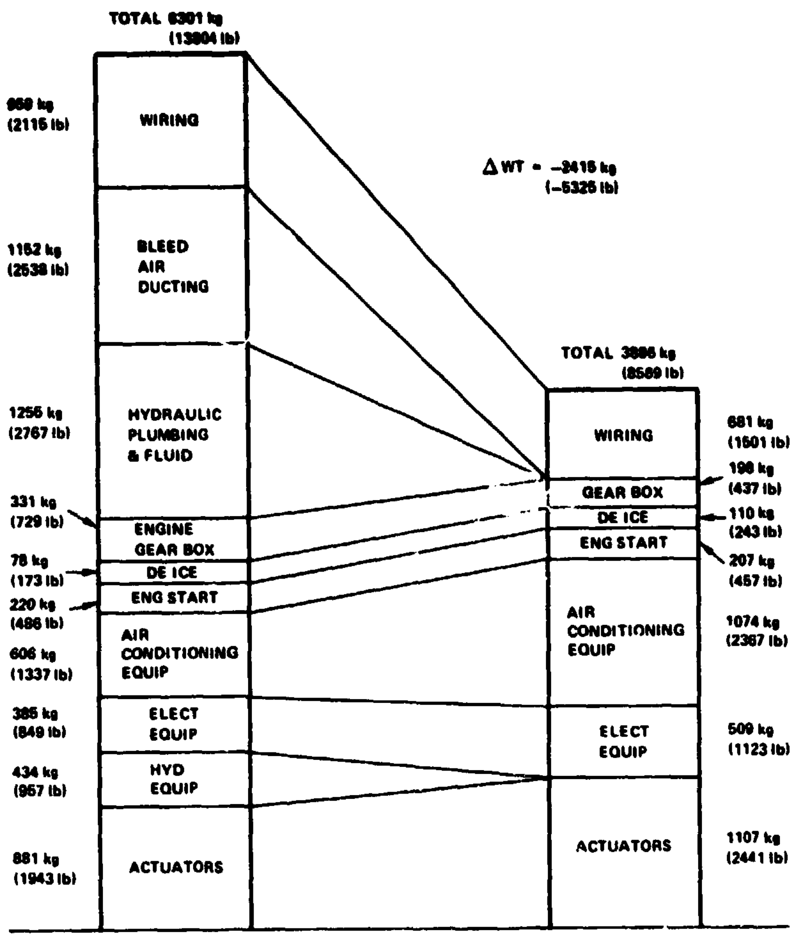


Figure 80. - All-electric weight comparison.

Figure 81 shows the relative effects of the changes. FBW and multiplex are worthwhile weight reductions and the all-electric configuration yields a significant 7-percent reduction of total aircraft systems weight. The other tradeoffs are simple equipment changes with negligible weight effect.

All weight comparisons shown are for a constant size aircraft. The output of the ASSET program shows the amplified weight savings due to resizing structural, powerplant, and fuel fractions to accommodate reduced systems weight.

7.3.6 Short-Haul Transports. - Weight comparisons for the 30- and 50-passenger short haul aircraft are shown on figures 82 and 83, respectively.

In contrast to the ATA, both fly-by-wire and multiplexing result in weight increases. This is due in part to the smaller size and shorter control runs of the short-haul aircraft and because the baseline control systems are much simpler than that of the ATA.

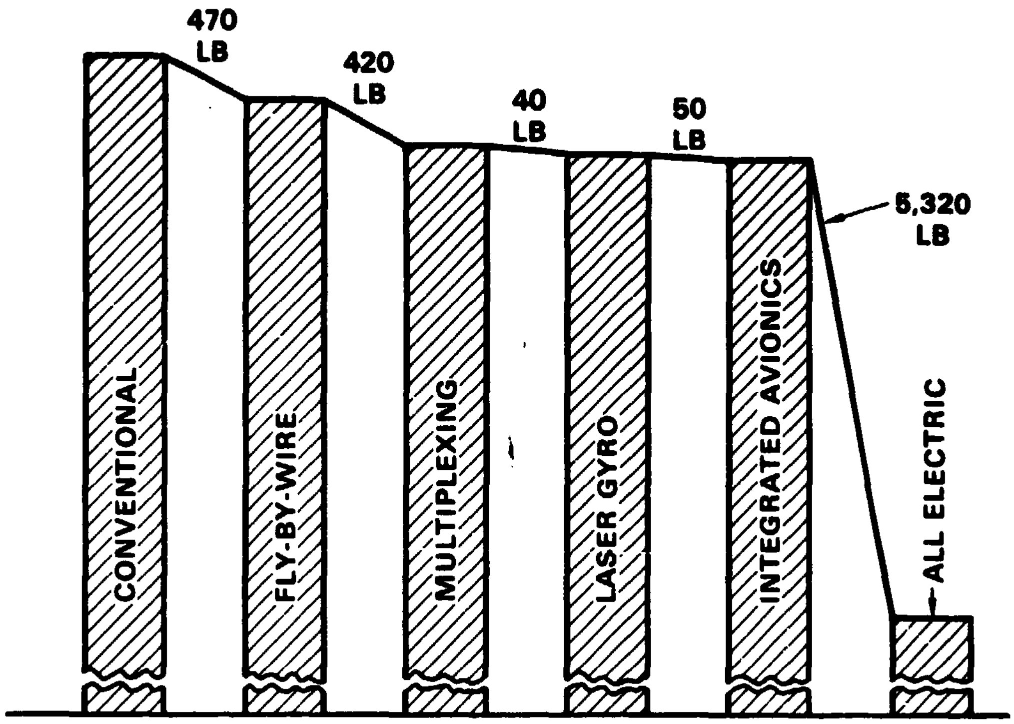


Figure 81. - ATA equipment weight trade offs.

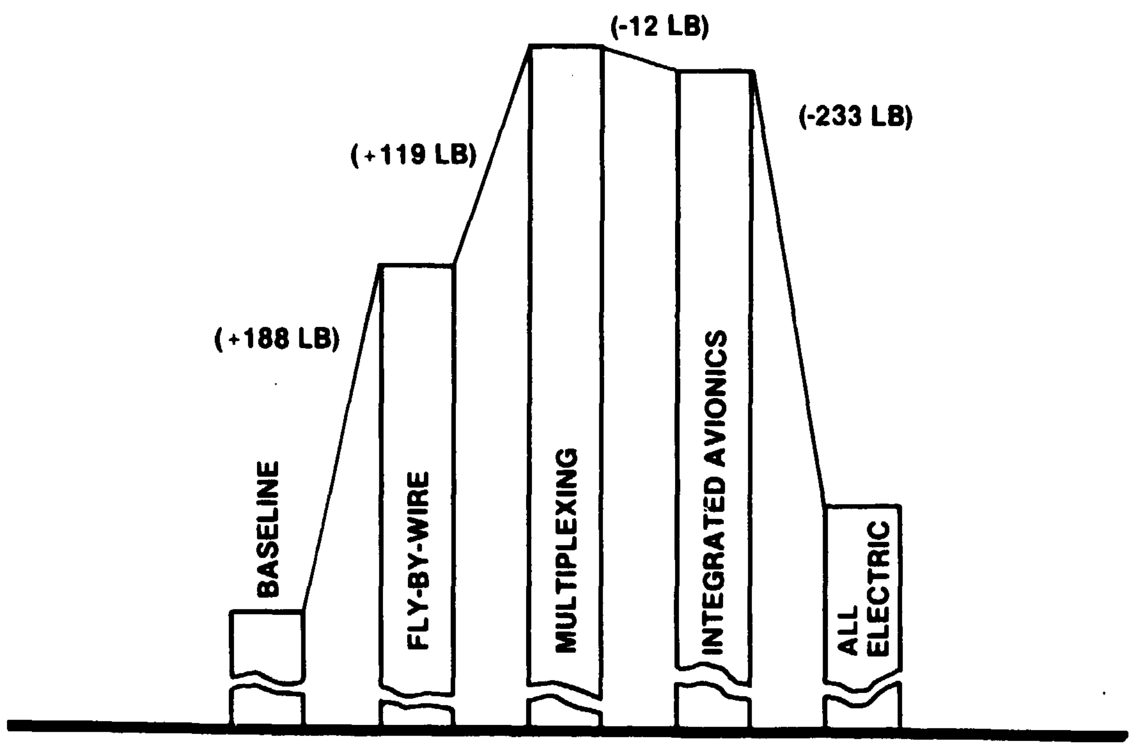


Figure 82. - 30-passenger short-haul weight comparison.

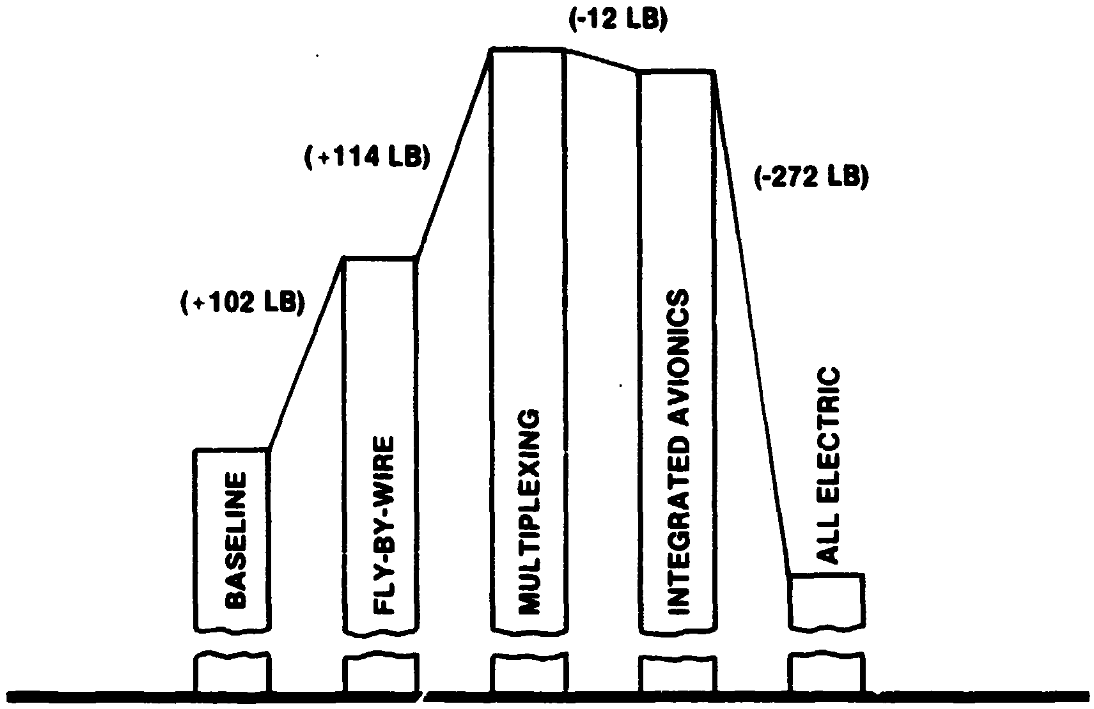


Figure 83. - 50-passenger short haul weight comparison.

The all-electric tradeoff saves most of the hydraulic system weight, but this saving can only be achieved in conjunction with the previously discussed increases.

All of the short-haul weight increments are small. Added requirements for advanced autopilot features could be accomodated more easily on the all-electric versions and would make the tradeoff much more favorable.

7.4 Cost Analysis

The purpose of the cost analysis is to determine the net value of technology. The cost analysis determines the net cost resulting from the additions and deletions of avionics, hardware, and material to the various configurations under consideration. The resultant costs for the various configurations are compared to a baseline aircraft of convetional technology. The baseline aircraft and the AE/ET aircraft configurations are described in Section 5.0.

7.4.1 Cost Premises. - The application of advanced technologies is to both the short-haul and long-haul (ATA) concepts. The short-haul concepts are for use by commuter and local operators, and the long-haul by trunk operators. The

TABLE 18. - COST PREMISES AND FACTORS

	Short Haul	ATA
Year Dollar	1979	1979
Aircraft Production Quantity (for pricing)	250	300
Fuel Cost ($/gallon)	1.00 & 1.80	0.60 & 1.80
Crew Cost ($/blk. hr)	2.5 x seats	468
Aircraft Life (yr)	12	16
Residual Value (% of Aircraft Price)	15	4
Insurance Rate (% of Aircraft Price)	1.5	0.304
Utilization (hr/yr)	2800	3636
Maintenance Labor Rate ($/hr)	10	13
Maintenance Burden Factor	0.8	2.23
Spares Factor (%)	0.2 x seats +2	12
Factors Applied Against ATA Maintenance (conventional aircraft)		
Airframe Labor/cycle	0.4	0.52
Airframe Labor/Hour	0.4	0.52
Airframe Material/cycle	0.4	0.68
Airframe Material/Hour	0.4	0.68
Engine Labor/cycle	1.0	0.62
Engine Labor/Hour	1.0	0.62
Engine Material/cycle	1.0	1.31
Engine Material/Hour	1.0	1.31

method of operation between the three types of operators are different and require different sets of operating cost factors. The inputs for the short-haul and local operators are from the combined efforts between NASA and their contractors (Lockheed, Convair, and Cessna) for the short-haul study. The inputs for the long-haul aircraft are determined from actual experience on L-1011 aircraft. These premises and factors are outlined in Table 18.

7.4.2 Method. - The first step in the process is to delineate the changes from the conventional baseline to the AE/ET configurations. The equipment changes are described in Section 5. The weights associated with these changes are noted in Section 7.3. These changes provide the inputs required to evaluate the configurations in terms of cost deltas. The physical changes made to the aircraft impact on the following elements of cost and economics of operation:

- Avionics development
- Engineering development to incorporate changes
- Development test
- Systems production

- Avionics production
- Maintenance
- Return on investment (ROI)
- Cash flow
- Operations cost (DOC/IOC)

Each of the above elements of cost and economic indicators are evaluated for each configuration and the net cost as compared to the conventional aircraft are determined.

The development and production costs for incorporating the advanced systems into the aircraft are determined through an examination of Lockheed experience on similar systems. The estimates for the development and production costs for the avionics equipment and electric actuators are provided by Honeywell and AiResearch. The data from Honeywell and AiResearch are in a format consistant with the cost premises outlined in table 18. The development and production cost for avionics equipment and electric actuators are input to the ASSET model and they are combined in the proper manner for calculating the aircraft price.

Table 19 is provided to illustrate the method for determining the delta costs for the equipment changes. The first two columns show the factors used for determining the engineering development and production cost for incorporating the equipment into the aircraft. Application of these factors to the weights produces the estimate of costs shown. The development and production cost for equipment are also shown. The remaining cost is for the Vehicle Systems Simulator (VSS) for laboratory tests and integration of the various systems.

The left side of table 19 provides the cost associated with configuration changes. The right side of the figure indicates the total delta weight and cost to the conventional aircraft. The conventional aircraft has an R&D cost of \$21.9 million for the avionics equipment and a production cost of \$462.8 thousand for the additional avionics to provide a baseline aircraft configuration with the ARINC 700 instruments. The design engineering cost to place the CRT equipment into the conventional aircraft is $\$0.957 \times 10^6$ and the installation cost is \$43 thousand. The costs for the electric wiring, the electro-hydraulic actuators, and the mechanical linkage to the actuators are also shown. The tradeoff is in substituting wiring for mechanical linkage. Removing a great deal of the mechanical system through substitution of wiring substantially reduces the weight and the number of parts that control the actuators, and thereby reduces the cost. The cost factor associated with the wiring is the highest of all the items but the weight reduction in mechanical parts overrides the difference in the cost factor and the net effect for design integration and intallation in going from the conventional system to the electric system is negative cost. The positive costs are associated with the development and production cost for the advanced technology equipment.

The changes in going from the conventional configuration to the integrated avionics have to do with the flight control system. The all-electric airplane has all of the advanced avionics that are incorporated in the integrated

TABLE 19. - AE/ET AIRCRAFT COST FACTORS
($ MILLIONS)

	R&D Factors (hrs/lb)	Prod. Factors ($/lb)	Weight	Aircraft Systems Design Cost ($ - M)	Systems Prod. Cost ($ - M)	Equipment R&D ($ - M)	Equipment Prod. Cost ($ - M)	VSS (R&D)	Delta Cost to Conventional: Weight	Systems Design	Systems Prod.	Equip. R&D	Equip. Prod.	VSS
Conventional														
Electronics	136	197	220	0.957	0.043	21.9	0.4628							
Wiring	121	325	510	1.975	0.166									
Actuators	75	227	170	0.408	0.039									
Mechanical	89	242	1180	3.361	0.286									
			2080	6.701	0.534	21.9	0.4628	–	–	–	–	–	–	–
Fly-By-Wire														
Electronics	136	197	310	1.349	0.061	22.4	0.5716							
Wiring	121	325	910	3.523	0.296									
Actuators	75	227	270	0.648	0.061									
Mechanical	89	242	110	0.313	0.027									
			1600	5.833	0.445	22.4	0.5716	2.00	-480	-0.868	-0.089	+0.50	+0.1088	+2.00
Multiplexing														
Electronics	136	197	436	1.897	0.086	23.7	0.6316							
Wiring	121	325	362	1.402	0.118									
Actuators	75	227	270	0.648	0.061									
Mechanical	89	242	110	0.313	0.027									
			1178	4.260	0.292	23.7	0.6316	2.00	-902	-2.441	-0.242	+1.80	+0.1688	+2.00
Ring Laser Gyro														
Electronics	136	197	398	1.732	0.078	23.7	0.5920							
Wiring	121	325	362	1.402	0.118									
Actuators	75	227	270	0.648	0.061									
Mechanical	89	242	110	0.313	0.027									
			1140	4.095	0.284	23.7	0.5920	2.00	-940	-2.606	-0.250	+1.80	+0.1292	+2.00
Integ. Avionics														
Electronics	136	197	347	1.510	0.068	19.1	0.538							
Wiring	121	325	362	1.402	0.118									
Actuators	75	227	270	0.648	0.061									
Mechanical	89	242	110	0.313	0.027									
			1089	3.873	0.274	19.1	0.538	2.00	-991	-2.828	-0.260	-2.80	+0.075	+2.00
All Electric Integrated Avionics			1089	3.873	0.274	19.1	0.538	2.00	-991	-2.828	-0.260	-2.80	0.075	2.00
Total Systems			-5685	-10.82	-0.927	4.08	1.036	–	-7765	-13.648	-1.187	1.28	1.111	2.00

*Qual Testing

avionics configuration and in addition replaces all of the hydraulic system with electric actuators, and replaces the ECS and engine start with motor driven units. The factors for determining the delta cost inputs to ASSET for the integrated avionics are indicated in table 19. The factors for replacement of the other systems in the all-electric configuration are handled internally in the ASSET program and are not shown in table 19. The overall affect of these plus and minus costs and the weight changes are evaluated through the use of the ASSET program.

The ASSET program evaluates the configuration in terms of development, production, operations, and return on investment. The evaluation is dependent upon the costs tradeoffs shown in table 19 and also a variation in the system weights. The ASSET program applies the cost inputs from table 19 and places them in the proper category and also resizes the aircraft to fly the same 3000 n.mi. route at the reduced weight due to the substitution of the various equipment. The resizing of the aircraft also affects the total cost of the system, so that the final cost reflects equipment change as well as change in aircraft size . Operational costs in the form of direct and indirect operating costs (DOC/IOC) are also affected by the change in equipment and aircraft size and cost. The DOC is sensitive to the aircraft characteristics and cost, whereas the IOC is system oriented and is sensitive primarily to the number of passengers and the amount of cargo transported during the year.

The maintenance cost is affected by the resizing of the aircraft and the differences in the reliabilities of the equipment being removed and added. The maintenance cost for the conventional aircraft is based on L-1011 actual experience. The maintenance cost for the L-1011 is modified for the addition of the CRT displays and this becomes the baseline case for determining the delta cost for the other configurations. The maintenance factors shown in table 18 are for the basic ATA aircraft before the ARINC 700 series avionics are added to the aircraft. The change to the maintenance factors are calculated for the addition of the equipment. The method for determining the difference in maintenance for the various configurations is presented in Section 7.5.

The derivation of the maintenance cost deltas are calculated from the estimates of the mean-time-between-failures (MTBF) for the various components, as supplied by Honeywell and AiResearch. The mainenance formulas (ATA method) in the ASSET program are modified to reflect the changes in maintenance cost. The change in maintenance cost due to the resizing is handled internally in the program. The return on investment (ROI) is calculated on the basis of the revenues, expense and investment cost for the aircraft. The direct operating cost (DOC) and investment costs are influenced by the equipment changes and cause a change in both the cash flow and ROI. The revenue is constant because the stage length, the fare level, and the load factor remains constant for all configurations.

7.4.3 Cost Summaries. - The resultant costs for the 500-passenger ATA and the 30- and 50-passenger short-haul aircraft are presented in tables 20 through 22. Costs are noted for a 20-aircraft program and a total market of 300-aircraft. The 20-aircraft system is for the purpose of evaluating the ROI in terms of a single operator. The delivery schedule and costs are set up to determine as realistically as possible the return on investment and cash flow

TABLE 20. - COST SUMMARY - 30-PASSENGER SHORT HAUL ($ MILLIONS)

	Conventional		Fly-By-Wire		Multiplexing		Ring Laser Gyro		Integrated Avionics		All Electric Airplane	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
RDT&E	167.51	167.51	176.23	176.23	179.81	179.81	–	–	181.06	181.06	177.33	177.33
Investment	78.28	1174.20	82.10	1231.50	84.14	1262.10	–	–	84.42	1266.30	84.22	1233.34
Operations												
*DOC	305.05	4575.79	311.56	4675.44	314.71	4720.71	–	–	314.87	4725.06	309.29	4639.38
IOC	–	–	–	–	–	–	–	–	–	–	–	–
Cash Flow	–	–	–	–	–	–	–	–	–	–	–	–

(1) Fleet of 20 aircraft
(2) Total market of 300 aircraft
*12 years operations
Fuel cost $1.00/gallon

TABLE 21. - COST SUMMARY - 50-PASSENGER SHORT HAUL ($ MILLIONS)

	Conventional		Fly-By-Wire		Multiplexing		Ring Laser Gyro		Integrated Avionics		All Electric Airplane	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
RDT&E	215.53	215.53	223.08	223.08	226.54	226.51	–	–	227.76	227.76	223.68	223.68
Investment	108.64	1629.60	112.14	1682.10	114.22	1713.30	·	–	114.48	1717.20	111.96	1679.40
Operations												
*DOC	449.56	6743.48	454.58	6818.75	457.80	6867.07	--	–	457.88	6868.16	451.80	6776.80
IOC	–	–	–	–	–	–	–	–	–	–	–	–
Cash Flow	–	–	–	–	–	–	–	–	–	–	–	–

(1) Fleet of 20 aircraft
(2) Total market of 300 aircraft
*12 years operation
Fuel cost $1.00/gallon

TABLE 22. - COST SUMMARY - 500-PASSENGER ATA AIRCRAFT ($ MILLIONS)

	Conventional		Fly-By-Wire		Multiplexing		Ring Laser Gyro		Integrated Avionics		All Electric Airplane	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
RDT&E	3092	3092	3089	3089	3073	3073	3071	3071	3066	3065	2934	2934
Investment	1224	18 360	1222	18 330	1219	18 287	1218	18 268	1216	18 242	1182	17 723
Operations												
*DOC	4002	60 027	3995	59 919	3987	59 811	3981	59 720	3978	59 663	3828	57 423
*IOC	3012	45 184	3012	45 184	3012	45 184	3012	45 184	3012	45 184	3012	45 184
Cash Flow	2104	–	2108	–	2113	–	2116	–	2118	–	2194	--
ROI (%)	37.40		37.48		37.60		37.66		37.72		39.33	

(1) Fleet of 20 aircraft
(2) Total market of 300 aircraft
*16 years operation

for the ATA system. The ROI and cash flow are not determined for the short-haul aircraft. The indirect operating cost (IOC) for the short-haul concept has not been investigated to the depth where these costs may be determined with any accuracy. The commuter operators are not required to report costs to the detail required for analysis. In many instances many of their system functions are tied in with the long-haul operations and their share of cost hard to determine. Without the IOC for the short haul, the ROI and cash flow cannot be determined and the cost summary is limited to development, acquisition, and DOC. All of the costs are included for the ATA aircraft due to the available CAB data on similar aircraft and Lockheed's data on L-1011 experience.

The development and acquisition costs provide the up-front costs required for the airframe manufacturer and the airline operator. The development cost indicates the impact on the producer, and the acquisition the impact on the user. Ultimately the R&D cost is passed on to the user as the R&D is prorated into the aircraft price by the number of aircraft sold in the total market.

The price of the aircraft is broken down into various elements to show the significant items. The price breakdown for the 500-passenger ATA and the 30-passenger, short-haul are shown in figures 84 and 85. The R&D is amortized over 300 aircraft for the large aircraft and 250 aircraft for the small aircraft to arrive at a prorata share of the R&D for adding to the price of the aircraft. The R&D for the smaller aircraft is spread over 250 aircraft although it is assumed that 300 aircraft will be in the total market for the costs on the summary sheets. The major differences in the price breakdown between the two aircraft is that the propulsion and avionics for the small aircraft is a greater percentage of the total price than the larger aircraft but the structure is much less. In the systems category, where the tradeoffs occur for this study, the price ratios are comparable. The price ratio for systems are approximately the same but the resultant net values for the advanced tecchnology appliccation are quite different. The reason for the opposite effect on cost between the short haul aircraft and the ATA aircraft with the advanced control system is explained in Section 8.

7.5 Reliability and Maintainability

The reliability and maintainability analyses for the AE/ET technology study address two aspects of R&M. The first aspect relates to the catastrophic failure (safety of flight) probability for the flight control sytems. The second aspect is the maintenance hours required by the alternate systems. The maintenance analysis is used as a direct input into ASSET for computing the direct operating cost.

7.5.1 Safety of Flight. - The safety-of-flight analysis performed for the AE/ET program responds to the FAA design criteria for catastrophic failures; that is, the probability of occurance must be less that 1×10^{-9} for a one-hour flight. The prediction was conducted based on loss of control of the aircraft in the roll or the pitch axes. The analyses was conducted on two configurations of the advanced ATA. The first configuration analyzed was the digital

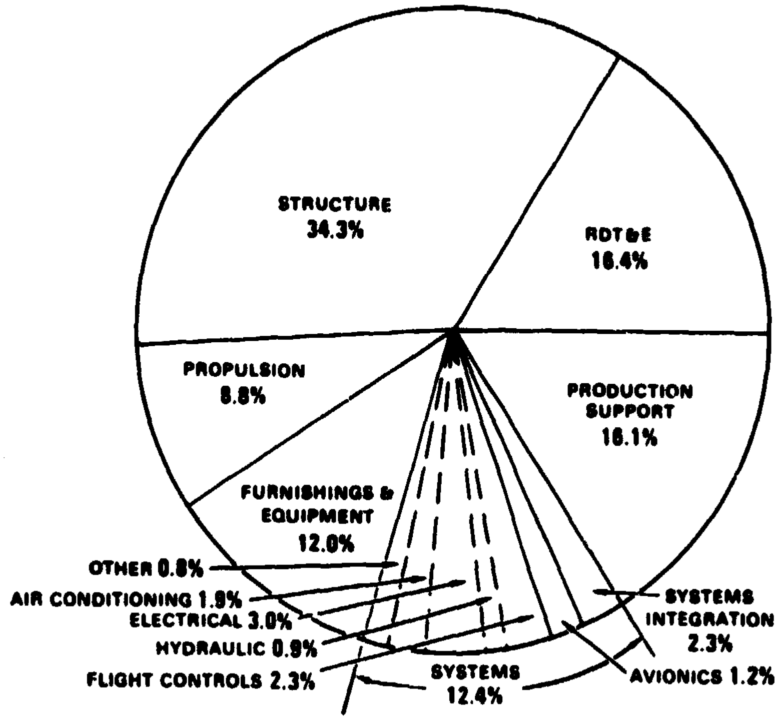


Figure 84. - ATA price breakdown.

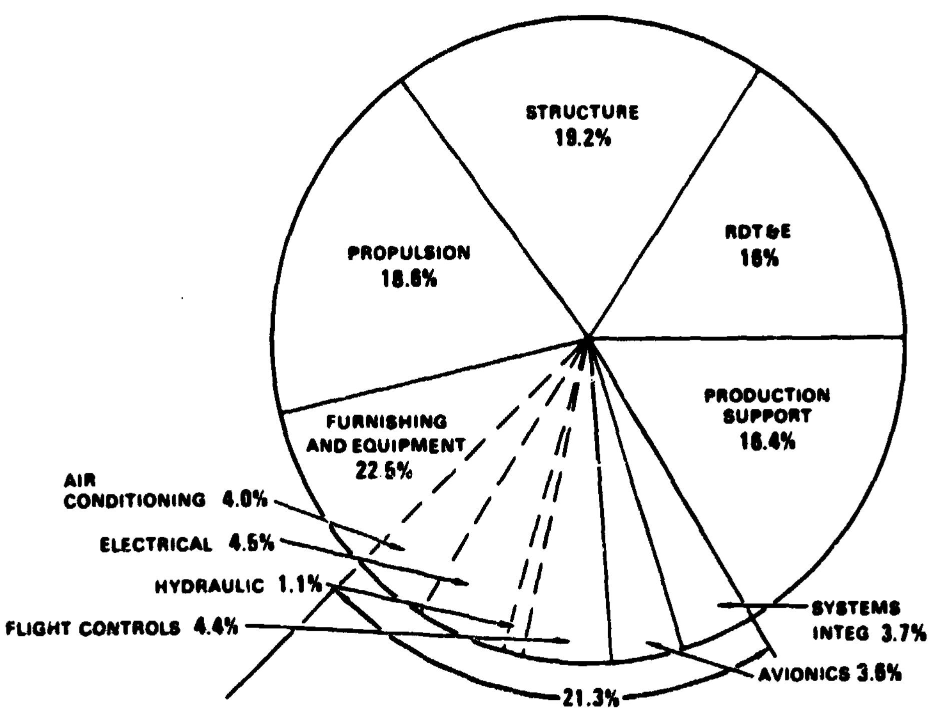


Figure 85. - Aircraft price breakdown, 30-passenger.

fly-by-wire controlled aircraft with hydraulic controls. The second configuration analyzed was the all-electric aircraft also using digital fly-by-wire control. Results are as follows.

Probability of loss of pitch control:
- conventional power - 9.99×10^{-15}
- all-electric power - 1.67×10^{-16}

Probability of partial loss of roll control:
- Loss of one outboard aileron
  - conventional power - 1.00×10^{-7}
  - all-electric power - 1.67×10^{-8}
- Loss of one inboard aileron
  - conventional power - 1.00×10^{-9}
  - all-electric power - 2.14×10^{-12}

Probability of loss of roll control (all four ailerons);
- conventional power - 1×10^{-32}
- all-electric power - 1.28×10^{-39}

7.5.1.1 Safety of flight analyses method: The analysis conducted to arrive at the predicted safety-of-flight reliability considered four design factors:

- Control effectors
- Power sources (hydraulic or electric)
- Fly-by-wire computers
- Engine, APU drive.

The configurations were analyzed using fault tree combinatorial logic to arrive at the overall failure probabilities. Failure rates were based on predictions for the new design equipment and removal rates for L-1011 equipment. Engine failure rates were based on in-flight shutdown experience. The fly-by-wire computer was modeled with four-channel redundancy with 95 percent coverage for the third failure. The Markov diagram of the failure detection logic including coverage and corresponding fault tree are shown in figure 86. Sensor monitoring and voting was handled on a similar basis. All sensors for one channel were treated as a composite unit with computer monitoring used to select a good unit. In practice, comparison monitors and software logic would enable selection between individual like components (i.e., between accelerometers), but the added analysis complexity did not appear to justify constructing a model at that level of detail.

A simplified bus structure was modeled with direct inputs from each sensor channel to the corresponding computer. Inter-computer data exchange was accomplished on dedicated two-way busses between computers with only flight critical functions considered.

An additional condition of the analysis was that all units were functioning properly at the start of the one-hour flight. Dispatch reliability was not modeled and dispatch with units failed not considered.

The reliability modeling performed was based on design-to values of fault tolerance and coverage rather than treating the system on a detailed parametric basis as is being done in design studies such as SIFT and FTMP. The analysis indicates that aircraft flight safety requirements can be met by the studied design due to the high levels of redundancy incorporated.

7.5.2 Maintenance. - The maintenance analysis was conducted to provide inputs into direct operating cost models used in the life cycle cost analysis. The starting point of the analysis was L-1011 labor expenditure data obtained from commercial operations. The experience data was modified to reflect the ATA configuration and then iteratively modified to reflect the tradeoff configurations.

7.5.2.1 Maintenance cost analysis method: Each system within the aircraft was treated seperately for each tradeoff. First the system removal rate was obtained and changed up or down based on the reliability of components added or removed. Next the labor hours were calculated based on the percentage increase or decrease in system removal rate from the baseline system.

7.5.2.2 Data Source: The baseline maintenance labor costs were obtained from the L-1011 maintenance cost group broken down by system on a labor hour per flight hour and labor hour per flight basis. Removal rates for the systems were obtained from six months worth of unscheduled component removal data obtained from the L-1011 operations analysis unit. The reliability data were the results of 225000 flight hours and 115000 flights. Predictions of new equipment reliability were obtained from study team members.

The results of the maintenance cost analysis are presented below.

Configuration	Labor Hour per Flight Hour	Labor Hour per Flight Cycle
Conventional Avionics	7.45	3.56
Digital FBW Tradeoff	7.42	3.55
MUX Tradeoff	7.42	3.55
Ring Laser Gyro Tradeoff	7.38	3.50
Avionic Integration Tradeoff	7.37	3.46
All-Electric Aircraft	7.01	3.29

7.6 Software Management

7.6.1 Higher Order Language (HOL). - Table 23, prepared by Honeywell Co., compares selected HOLs. Honeywell studied the use of HOL in depth in 1978.

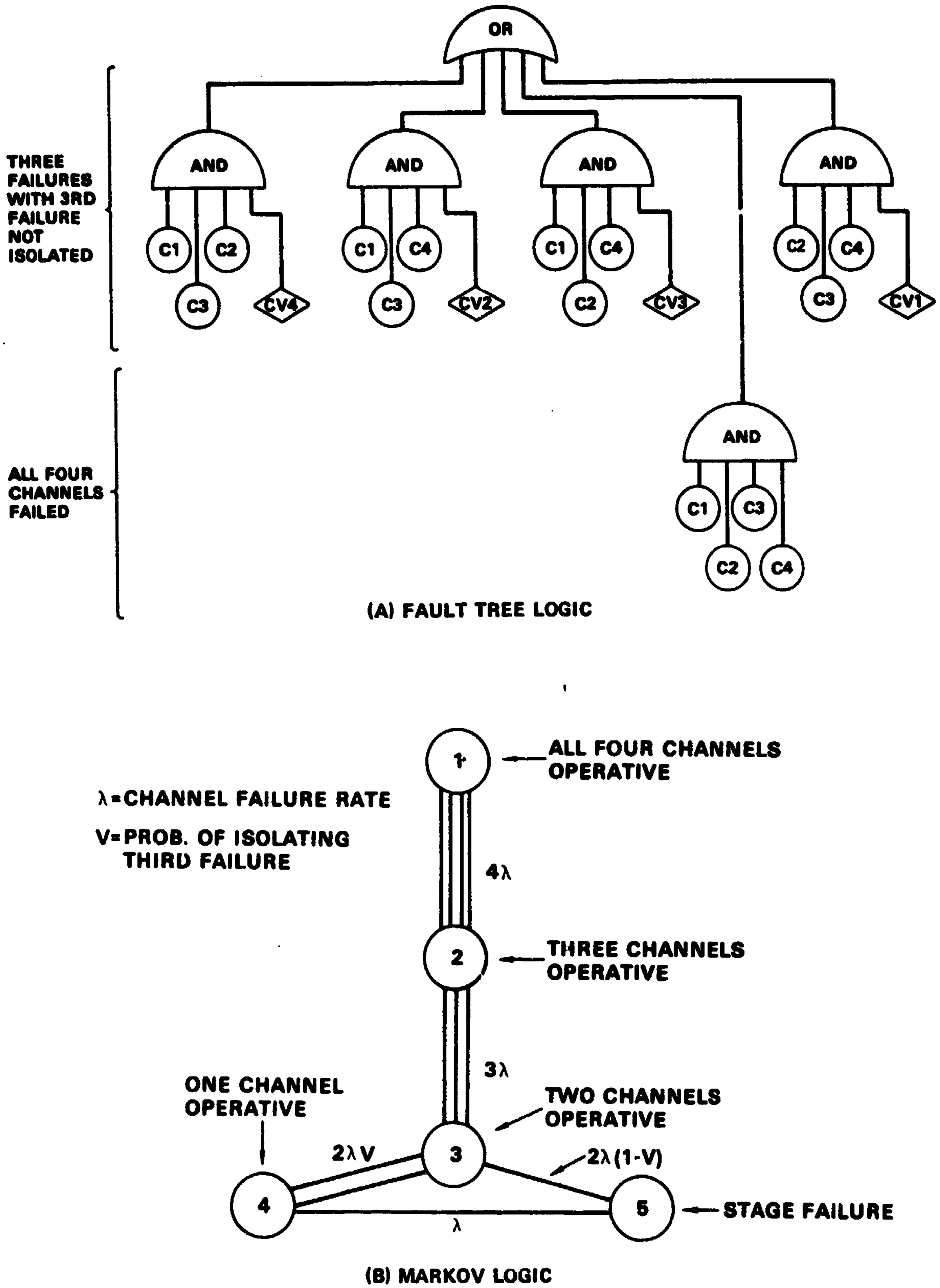


Figure 86. - Four channel autopilot.

TABLE 23. - HOL EVALUATIONS ON KEY DIGITAL AVIONIC REQUIREMENTS

Key Requirements	ALCOL 68	CMS-2	CONTROL FORTRAN	HAL/S	JOVIAL J3B	JOVIAL J73/I	LIS	PASCAL	PL/I	SPL/I	TACPOL
Real-time facilities	No	No	No	IL	No	No	No	No	No	P	No
I/O operations	OK	No	OK	P	No	No		OK		OK	OK
Floating point data type and operations	OK	OK	OK	OK	OK	OK		OK	OK	OK	OK
Scaled fixed point data type and operations	No	OK	OK	No	OK	No	No	No	OK	No	OK
Incremental compilation										No	
Machine language insertion	No	OK	OK	OK	No	No	OK	No			OK
User memory allocation	No		OK		No		OK	No		No	No
Bit packing and manipulation	No	OK	OK	OK	OK	OK		No		OK	P
Minimum run-time support software	No				P			P	No	No	P
Support for language (user base and documentation)	No	No	No	OK	P	P	No	OK	OK	OK	No

Notation Key

OK – satisfactory
P – partially satisfactory
NO – unsatisfactory
(blank) – unknown

Eleven languages were selected to be evaluated for suitability as a programming language for digital avionic applications. Support for a language and an existing or potential user base in avionic applicatons were prime considerations in narrowing the listed HOLs to the eventual selection of eleven languages. The eleven high-order languages selected are as follows:

PL/I
PASCAL
ALGOL 68
SPL/I
HAL/S
LIS
TACPOL
CMS-2
JOVIAL J3B
JOVIAL J73
CONTROL FORTRAN

The DoD listed PL/I, PASCAL and ALGOL 68 as the approved candidate base languages for modification to meet the DoD requirements as a common standard DoD language.

SPL/I, TACPOL, CMS-2 and JOVIAL (J3B and J73) are the DoD approved interim high-order programming languages for embedded computer applicatons. Each of these languages is a pseudo-standard for one of the military services.

HAL/S is a NASA language developed for space shuttle flight systems applications.

LIS, a PASCAL-based language by Compagnie Internationale Pour L-Informatigue Honeywell Bull (CII-BH), was a candidate for the DoD common standard language. LIS was the origin for the eventually selected DoD common standard language (ADA).

Control FORTRAN is a Honeywell language developed for the Honeywell Level 6 series of mini-computers.

7.6.1.1 Evaluation of HOLs: The evaluation task purpose was to determine the suitability of available HOLs as an interim programming language for digital avionic applications. The task also identified important features and facilities which are lacking in each of the languages evaluated. User's Manuals and/or Language Specifications were obtained to the extent possible for each of the eleven selected languages. The basis for the HOL evaluations was the Avionics High-Order Programming Language (AvHOL) Requirements Criteria.

A large portion of the AvHOL criteria items are obviously basic in any language, and these are satisfied by all languages evaluated. Examples are identifier requirements, reserve (or key) word lists, use of integer and boolean data types, assignment and reference operations, arithmetic operations, sequential control structure, etc. Most HOL languages have a block structure and a real floating-point data type. Some other items of the HOL criteria were considered of small importance for our language needs (although probably important for a common general language) and were not included in the actual evaluation of languages. The HOL evaluation concentrated on key criteria items which were judged important for real-time digital avionics but are not available in some of the eleven selected languages.

Each of the languages was found to have apparent deficiencies. The cited deficiencies should be considered, not so much as absolute, but as a cautionary flag. First, this report relies some on the findings of the DoD contracted HOL evaluation reports where some deficiencies may have been viewed from a different perspective than that for digital avionics usage. Second, a given deficiency possibly can be rectified by simple modification, and therefore is not disqualifying. For example, a HAL/S compiler was recently developed for a fixed point processor even though the standard HAL/S language does not have a scaled fixed point data type. Another example; even though documentation says JOVIAL J73/I does not have machine language insertion, it has been applied where the resulting machine code is partially coded in assembly language.

Table 23 summarizes the capabilities of eleven languages to satisy identified key requirements for digital avionics usage. The key requirements are discussed below.

- JOVIAL J73/I: If a near-future military real-time flight computer project should specify a required HOL programming language, the most probable language will be JOVIAL J73/I. Also, a JOVIAL language has generally high acceptance.

- HAL/S: This is the only known machine-independent language developed specifically for real-time flight control applications, and satisfies most of the essential requirements. Although the language does not have built-in scaled fixed-point data type, a HAL/S compiler has been developed for a fixed-point target computer. So, the fixed-point data feature has already been developed for HAL/S. Of concern is whether HAL/S can meet requirements necessary for target machine applications which use ROM.

- LIS: (eventually extended to the DoD common language ADA) This language, as well as the overall DoD common language effort merits special attention, and future developments should be tracked. LIS is among the most modern languages available and has been judged by DOD evaluators as one of the best extensions of the base language PASCAL.
- PASCAL and SPL/1: These were recommended as alternate languages if both JOVIAL J73/I and HAL/S should prove too difficult to implement and the LIS extension as a DoD Common Language did not materialize. Some reasons for eliminating the other evaluated languages are explained below.
- TACPOL and CMS-2: These were judged too machine dependent for transportability to other target computers. TACPOL also does not have a floating point data type.
- ALGOL68: This language is difficult to understand and apparently also difficult to implement. The language has no known user base in the U.S.A. to support the language.
- JOVIAL J3B: This language is being superseded by JOVIAL J73 within the Air Force. J3B is implemented in the language AED which is available on a restricted basis from only one vendor -- SOFTECH.
- PL/1: This is a large, complex, multipurpose language which will install significant run-time support software in the object code at the expense of code efficiency. HAL/S, a derivative of PL/1, is considered much more suitable for real-time flight computer application.
- Control FORTRAN: Being an extension of FORTRAN, the language lacks some modern concepts. An example, is the lack of control structures found in other languages to support the modern structured programming concepts.

7.6.1.2 Conclusions: Overall conclusion of the HOL study was that the selection among the existing candidate HOL languages for digital avionics can be narrowed to JOVIAL J73/8, HAL/S, LIS (which evolved to ADA) PASCAL, and SPL/1.

Each of these languages require enhancement to satisfy all essential requirements for applications. The degree of difficulty to implement the improvement modifications is an important consideration.

7.6.2 Software Verification Methodology. - Quality software requires a rigorous blend of analysis, testing, and management to ensure that the design is correct and that errors are corrected in an orderly manner when they are detected. Final proof that the program is correct is obtained by testing on actual flight hardware in a simulated environment.

7.6.2.1 Software Verification Approach: Software verification includes two major thrusts. The first is adherence to a well-defined design program with measureable completion criteria, which includes a second-party review or test as a check on the work being completed. By following this discipline, we can detect many requirements or design errors at a very early stage, when the cost of fixing errors is still relatively low. These reviews will also verify that software standards are being followed that help to ensure a high-quality design. The goal is to remove errors from the software prior to testing. It is important to provide visibility early in the design process of the areas where difficulties are likely to occur and to ensure that adequate resources are applied to prevent them. Verification steps are performed prior to the completion of each phase of the design process. These reviews accomplish three important checks:

- Software requirements confirmation
- Design documentation verification
- Code checking

These verification steps are necessary, although not sufficient, conditions for meeting the objectives of safe, complete, and correct software.

The second verification thrust is testing. Testing of the software occurs at five stages in the development cycle each stage increasing in scope of testing and configuration control. Verification test procedures form the basis for the testing to be performed. A thorough review and analysis of these procedures is required to ensure that the testing is sufficient to verify all requirements.

7.6.2.2 Module Testing: The first stage of verification testing is performed during the program module testing phase. During this stage, formal module test procedures are used and results are documented. These tests will verify that certain software requirements are met and that these tests need not be repeated in later testing. Following this test, module integration testing and hardware/software integration testing will be performed to ready the program for verification testing.

7.6.2.3 Computer Program Verification: The second stage of testing is end-to-end software verification and system validation testing of the complete software operating on the completed system. This testing will be in a simulated environment and will verify each requirement in the software and systems specification. Those requirements verified previously by module certification testing need not be reverified at this stage.

7.6.2.4 Flight Simulation Testing: Control system performance characteristics and handling qualities will be included on a flight simulator. Necessary changes will be iterated back through the earlier verification steps, if necessary.

7.6.2.5 System Validation: The fourth level of validation testing will be performed on an iron-bird simulation. This testing will integrate the proposed design with all other systems in the airplane and will be a complete functional test of the systems hardware and software.

7.6.2.6 Flight Testing: A fifth level of verification testing is the flight testing. It is anticipated that a subset of the tests used in the airplane simulation will be duplicated during the flight testing.

7.6.2.7 Reverification Process: An important matter concerns how software is reverified after changes have been made. A detailed process for addressing this issue was developed by Honeywell on the Space Shuttle main engine controller assembly software development for NASA. On this project, frequent changes were made to support field testing of the engines, and the software was reverified after each of the changes. The process used is described below.

1. Verification Steps in the Design Process for Changes: When the need for a change is identified, an overt decision must be made on which phase of the development process to reenter. Then the completion criteria for the reentered phase and for all subsequent phases must be satisfied for the change to ensure that the design process verification steps are completed for changes.

   Example 1: An error in the detail module design is discovered during preliminary verification testing. Analysis shows that the functional software design is correct. The decision would be to reenter the design process on the detail module design phase and complete the following tasks:

   - Identify the changes in the detail module design documentation
   - Identify the changes in the module test procedure
   - Code changes
   - Walk through the module design and code changes
   - Execute module retest
   - Integrate changes into tape update
   - Continue preliminary verification testing with revised tape

   This process is followed for each change in parallel with other changes and with the ongoing preliminary verification testing.

   Example 2: A requirements change is directed after software delivery. The decision would be to start with requirements and proceed through all phases of the design process. Reviews would occur on redlined documentation.

2. Verification Testing for Changes - Analysis to determine retesting necessary to verify the software changes begins after coding of the changes. The coding is analyzed to determine all modules and data locations that are changed. Then all modules that access the changed code or the changed data are identified using the concordance listing provided from the assembler. This information, together with the changed design documentation, is analyzed to define tests that will ensure that all of the changed code performs correctly. If possible, the tests are selected from existing test procedures. In some cases, however, it is necessary or more cost effective to design new tests. The retest is then performed under the same conditions as the original verification testing. Experience on the Space Shuttle main engine control software development has shown that this process ensures that the changed software is verified to the same degree of completeness as the original software.

8. RESULTS

The results, as measured in this study, are in terms of net value of technology. The net value of technology is how much cost penalty or cost saving may occur over the life of the system when the advanced systems are incorporated. The cost to the system is measured by the total operating cost which includes DOC and IOC. Since the systems cost or savings are measured as deltas from a conventional configuration, only those costs that change have an impact on the net value of technology. Indirect operating costs (IOC) are not influenced by the changes described in this study and, therefore, do not affect the outcome. The resultant values shown in this section in the summary figures are measured as a cost saving in the positive direction from the abscissa and a cost penalty in the negative direction. Results, as measured in terms of net value of technology, are opposite when these advanced systems are incorporated into a large 500-passenger transport and small transports for short-haul routes. The summary of the total net value of technology for these diverse airplane sizes are shown in figures 87 through 91. The cost saving, or cost penalty, is based on a total of 300 aircraft operating over their respective life spans with costs of $0.60 per gallon and $1.80 per gallon for fuel.

The 500-passenger, all-electric airplane exhibits a dramatic savings in cost. This is due to the significant reduction in the systems weight, the reduction in specific fuel consumption and the ultimate reduction in gross weight of the aircraft. In the application of the advanced avionics and electrical systems to the flight control systems (FBW, MUX, RLG, INT. AV.), there were weight reductions ranging from 357 kg (787 lb) to 744 kg (1640 lb) in aircraft empty weight and slight reductions in aircraft cost and maintenance. When the advanced electrical systems are added to the flight control changes, the empty weight is reduced by 5797 kg (12782 lb). In addition, the bleed requirement for the ECS from the engine in the all-electric airplane is no longer required and the SFC of the engine is improved. The net result in fuel alone is a reduction of 2439 kg (5378 lb) of block fuel between the conventional configuration and the all-electric airplane. Production cost of the aircraft is reduced because of the reduction in aircraft size. A further reduction in fuel usage is realized by relaxed static stability (RRS) which is feasible because of the advanced wing, incorporated in all configurations, and the FBW system which

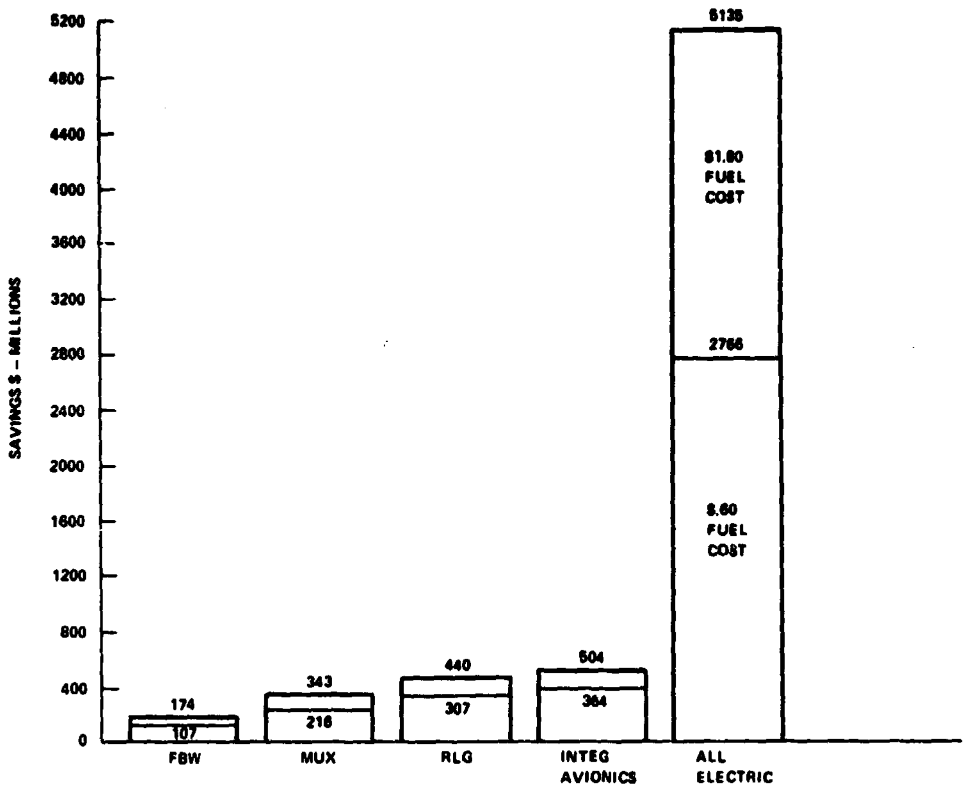


Figure 87. - Net value of technology: 500-passenger, 300 aircraft, 16 years.

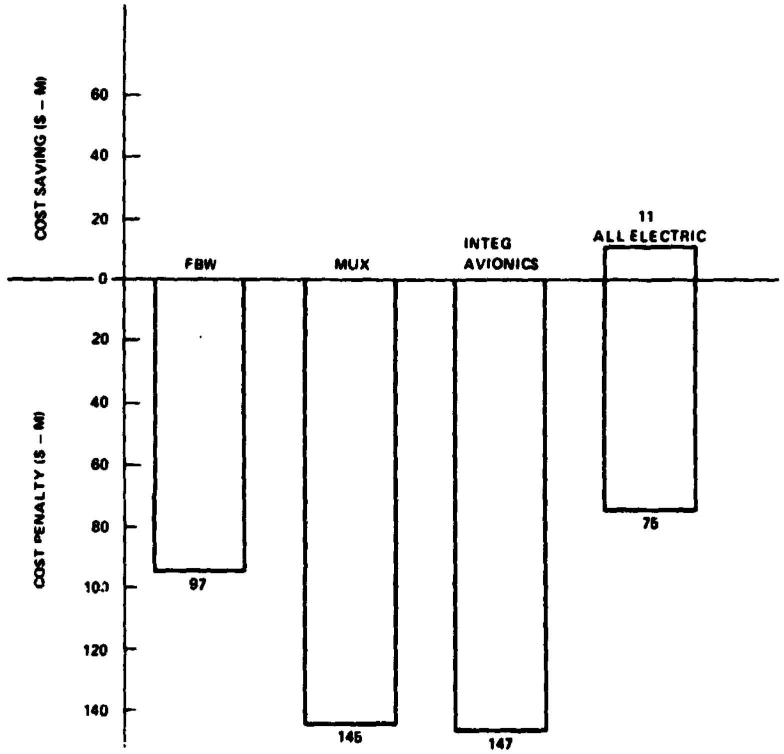


Figure 88. - Net value of technology 30-passenger short haul fuel cost $1.00/gal. 300 aircraft, 12 years

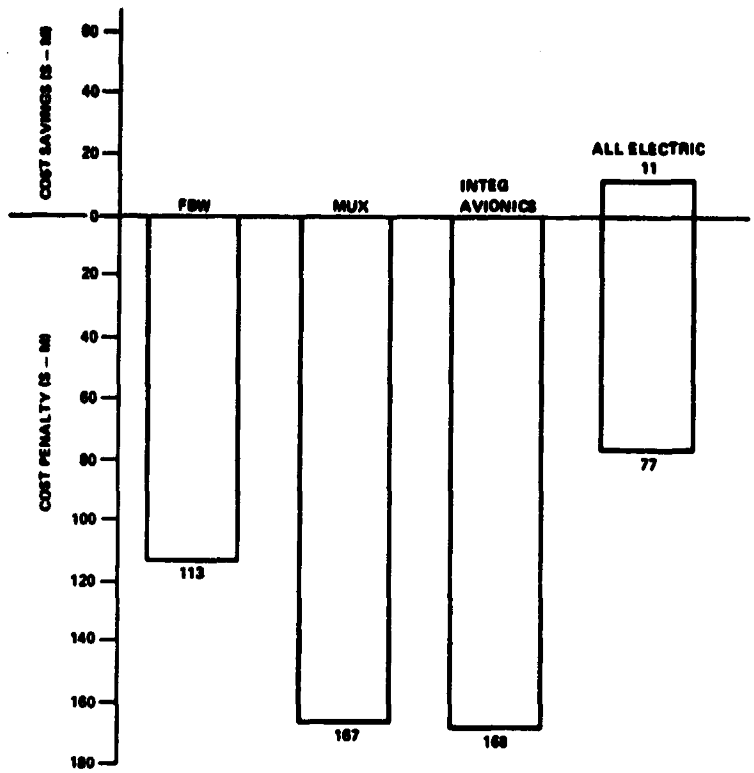


Figure 89. - Net value of technology: 30-passenger short-haul, fuel cost $1.80/gal, 300 aircraft, 12 years.

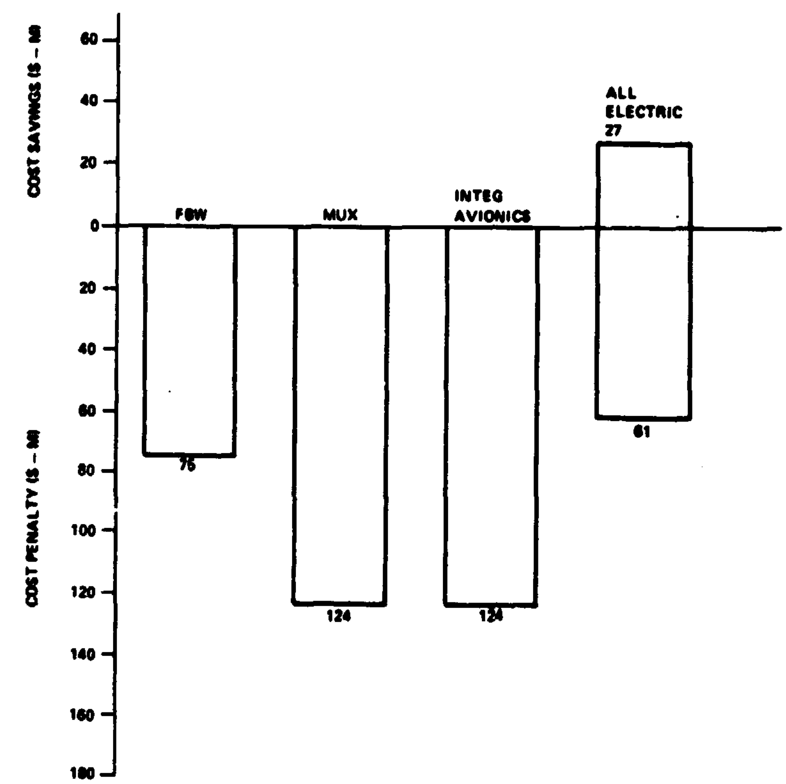


Figure 90. - Net value of technology: 50-passenger short-haul, fuel cost $1.00/gal. 300 aircraft, 12 years.

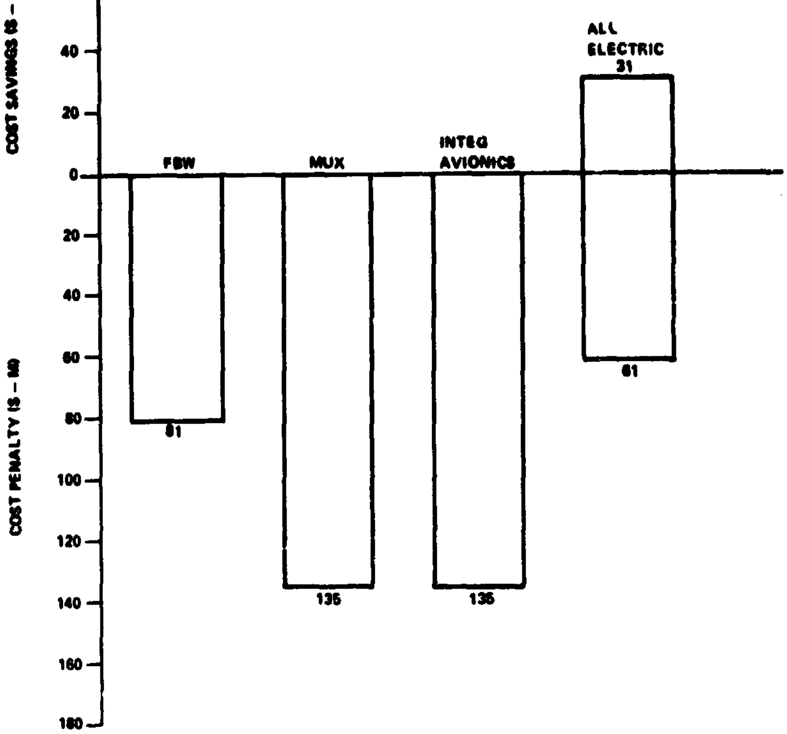


Figure 91. - Net value of technology: 50-passenger short-haul, fuel cost $1.80/gal, 300 aircraft, 12 years.

is capable of handling the aft c.g. required for maximum fuel economy. The impact of the relaxed static stability (RSS) concept is shown in figures 92 and 93. These figures illustrate the importance of fuel savings. The fuel cost is a predominant portion of the total DOC and even a small reduction can cause a significant savings; especially at the higher fuel cost. The saving in block fuel between the configuration without RSS and the configuration with RSS is approximately 1300 kg (2900 lb).

The 30- and 50-passenger aircraft show a cost penalty to incorporate the electric systems. There is a weight penalty associated with incorporation of the advanced electrical systems into the aircraft. The weight of the mechanical linkages and the hydraulic systems that are removed are not large enough to override the weight addition of the electrical systems. The avionics weight and size do not scale in a linear manner with airplane size. The avionics boxes for the small aircraft are almost the same size as those used in the large aircraft, and their weights in relationship to the removed hardware is such that it causes a weight increase for all configurations except the all-electric. The reduction in maintenance by the higher MTBF for the electrical equipment and reduced fuel begin to take effect for the all-electric configuration and the cost penalty is reduced. More detail on this is shown in subsequent figures.

It is worthy to note that the cost savings or cost penalties, shown in figures 87 through 91, are brought about by very small differences in DOC. This is illustrated in figures 94 through 97. The saving for the all-electric airplane over the conventional configuration, for the 500-passenger aircraft, is realized through a 4.8-percent reduction in DOC. For the short haul, the largest penalty for the 30-passenger airplane is caused by a 3.2-percent change in DOC. A 3.7-percent change to the DOC for the 50-passenger aircraft causes the $135 million cost penalty shown in figure 91. The RSS feature lowers the DOC in accordance with the fuel cost, since it is a fuel saver. Relaxed static stability is not considered for the short-haul configurations. The baseline configuration in the short-haul category did not have this feature designed into it as did the baseline for the 500-passenger, long-haul aircraft.

The small changes in DOC cause a significant change in total system cost by the number of seat miles flown over the useful life of the aircraft. The conversion of the DOC in terms of cents-per-seat-mile to dollars-per-year is accomplished by the number of seat miles flown by each type of aircraft. The 30- passenger aircraft flies 25 million seat miles per year, the 50-passenger aircraft 30 million seat miles per year, and the 500-passenger aircraft a little over 754 million seat miles per year.

The next set of figures (figures 98 through 103) show the main contributors to the cost savings or the cost penalty in the case of the short haul. These charts break down the DOC into maintenance, depreciation, insurance, and fuel. The only other remaining element of DOC is crew cost, and since this does not change with configuration, it does not impact on the change in DOC or net value of technology. For the ATA the change in DOC is split fairly evenly between the three elements where the price of fuel is $1.80 per gallon and RSS is not considered. With the RSS system and the accompanying fuel saving, the fuel becomes the predominant savings in the total system cost. As the fuel price goes up, the fuel portion of the total DOC becomes predominant to the point where an additional first cost to incorporate a fuel saving technology is very rapidly recouped.

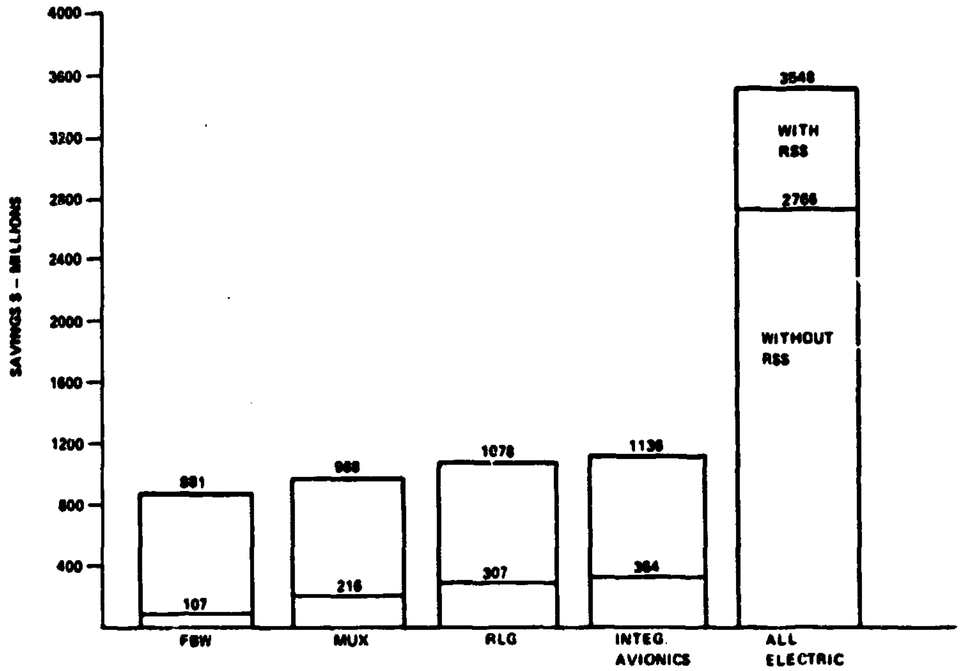


Figure 92. - Net value of technology: 500-passenger, fuel cost $.60/gal, 300 aircraft, 16 years.

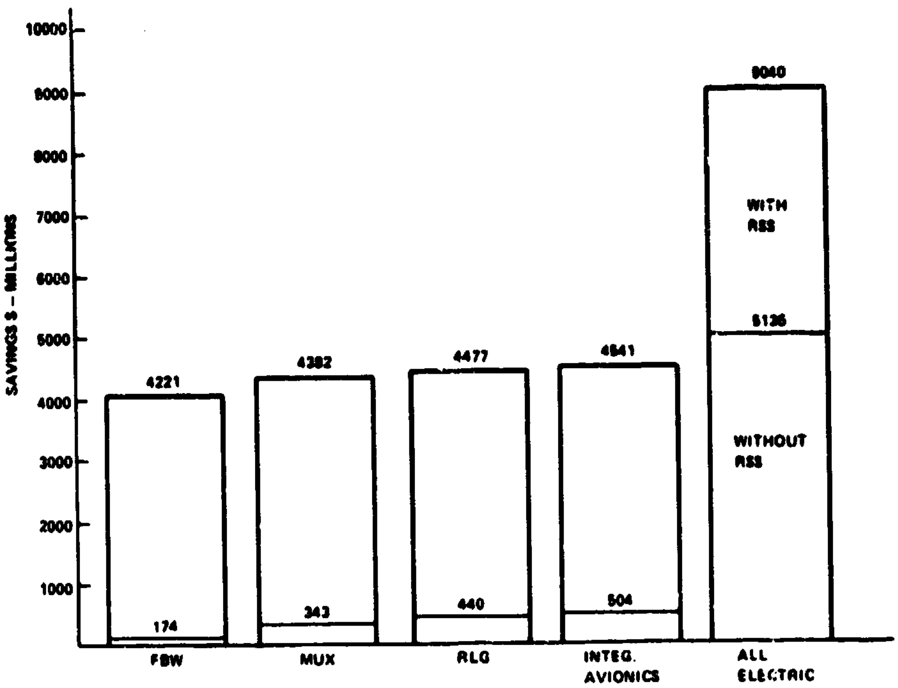


Figure 93. - Net value of technology: 500-passenger, fuel cost $1.80/gal, 300 aircraft, 16 years.

In the case of the ATA all-electric airplane, the lower engine' SFC attained by eliminating bleed air, and the systems weight reduction has reduced the size of the aircraft 8480 kg (18694 lb) in GW, to where the total aircraft development and production cost has been reduced. The all-electric airplane has approximately $165,000 per year cost savings in depreciation. Even without this reduction in development and production costs, the fuel and maintenance savings would make the all-electric configuration well worth while.

The situation for the short-haul is opposite that for the long-haul aircraft. The added weight to incorporate the systems causes the aircraft to grow in size and the depreciation expense becomes the dominant cost penalty. The maintenance cost decreases with the addition of advanced systems to the point where it starcs showing a payoff, but it is not large enough to offset the depreciation and insurance costs.

For a more detailed comparison of the costs, the ASSET outputs which incude the development, production, and operations cost, are included in the Appendix.

9. TECHNOLOGY ASSESSMENT

All the technologies traded off indicated benefits for the large aircraft. The all-electric airplane (AEA) showed a much larger benefit than the others; however, a much larger part of the systems are involved in major changes.

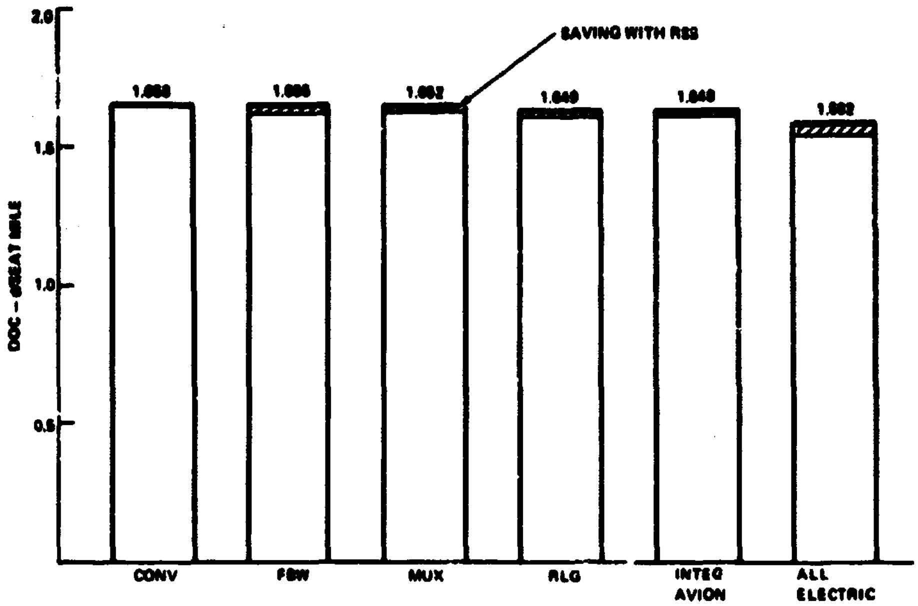


Figure 94. - Direct operating cost: 500-passenger, 300 n.mi., fuel cost $.60/gal.

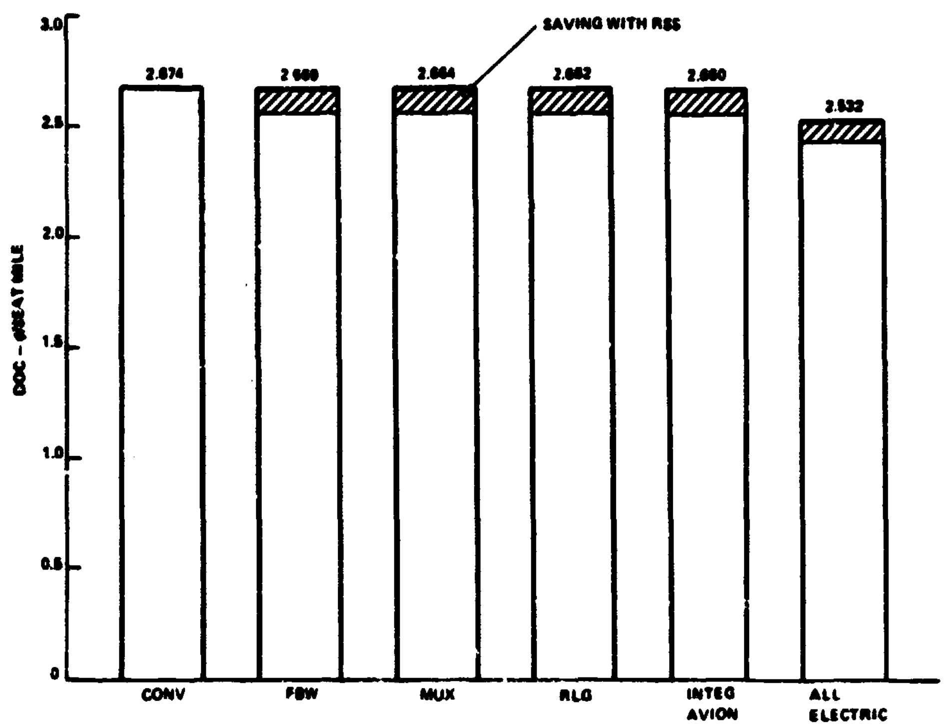


Figure 95. Direct operating cost: 500-passenger, 30000 n.mi., fuel cost $1.80/gal.

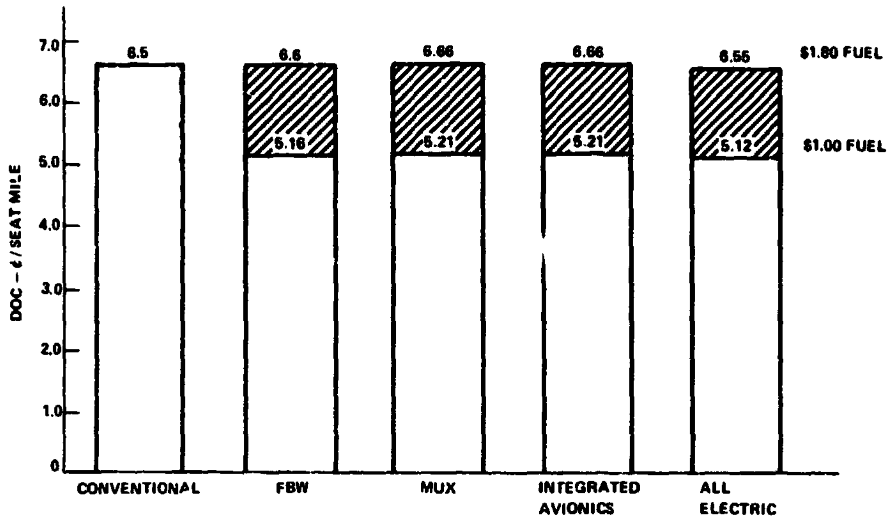


Figure 96. Direct operating cost: 30-passenger short-haul, 500 n.mi. stage length.

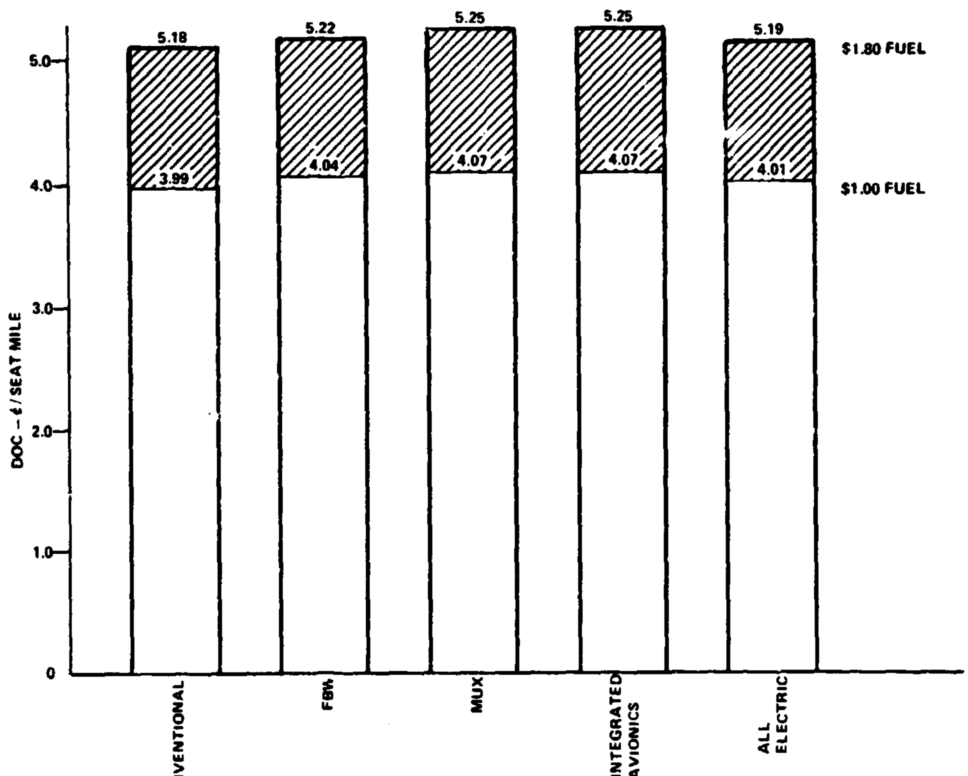


Figure 97. - Direct operating cost: 50-passenger short-haul, 600 n.mi. stage length

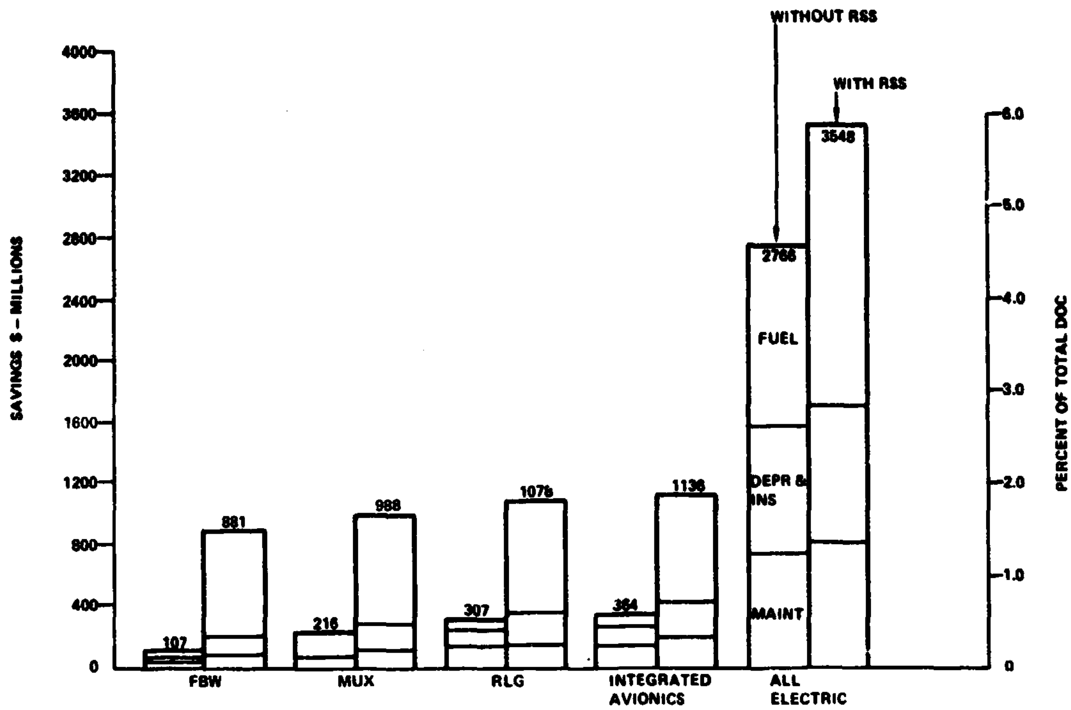


Figure 98. Net value of technology and DOC: 500-passenger, fuel cost $.60/gal, 300 aircraft, 16 years.

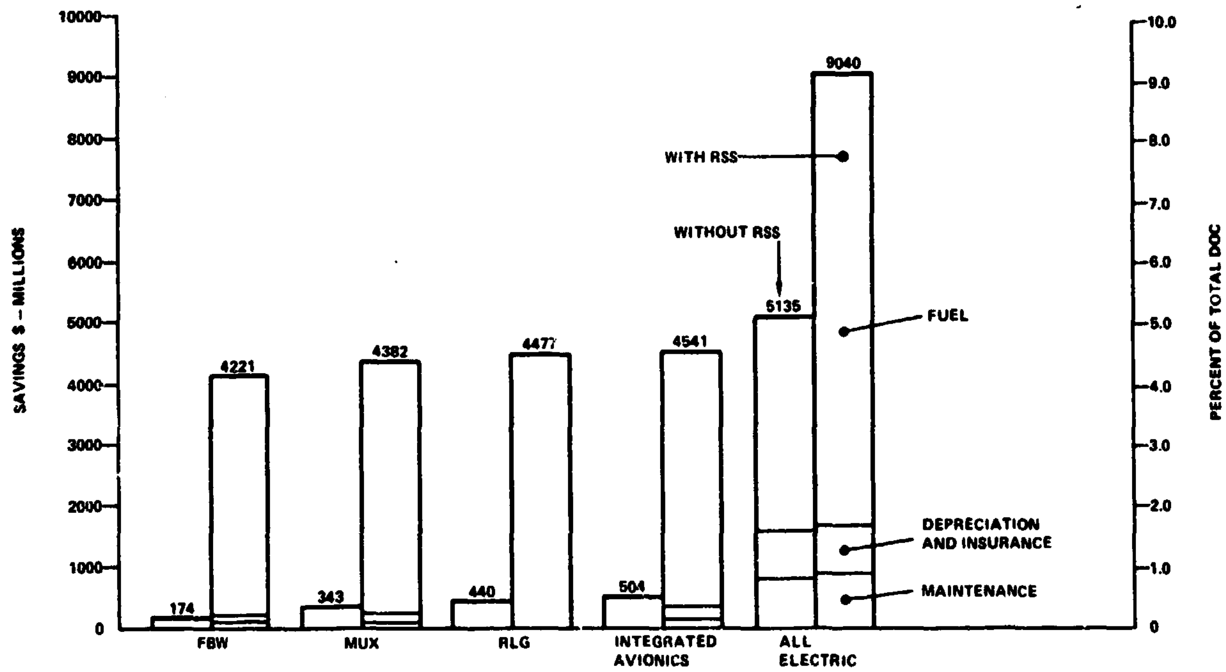


Figure 99. - Net value of technology and DOC: 500-passenger, fuel cost $1.80/gal, 300 aircraft, 16 years.

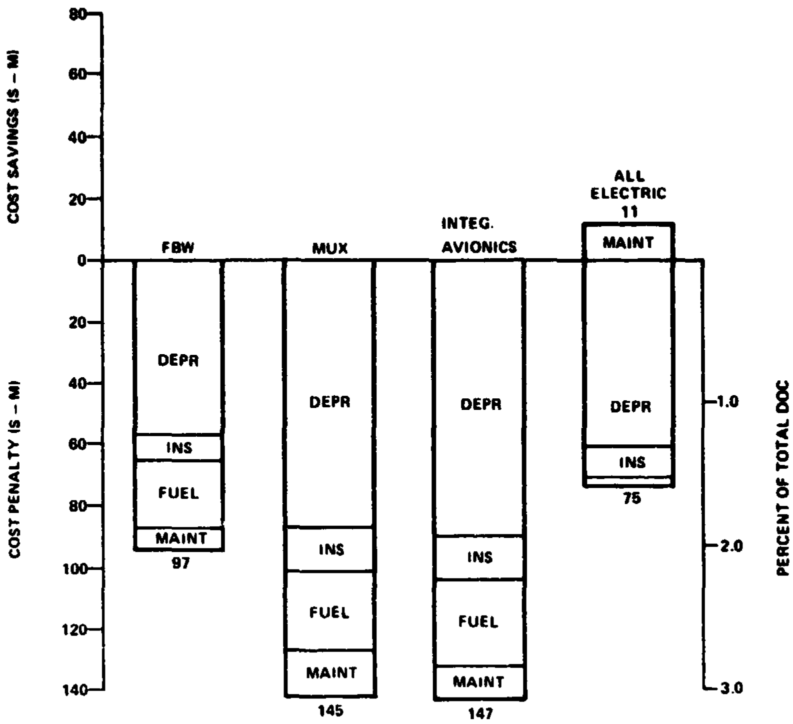


Figure 100. - Net value of technology; 30-passenger short-haul, fuel cost $1.00/gal. 300 aircraft, 12 years

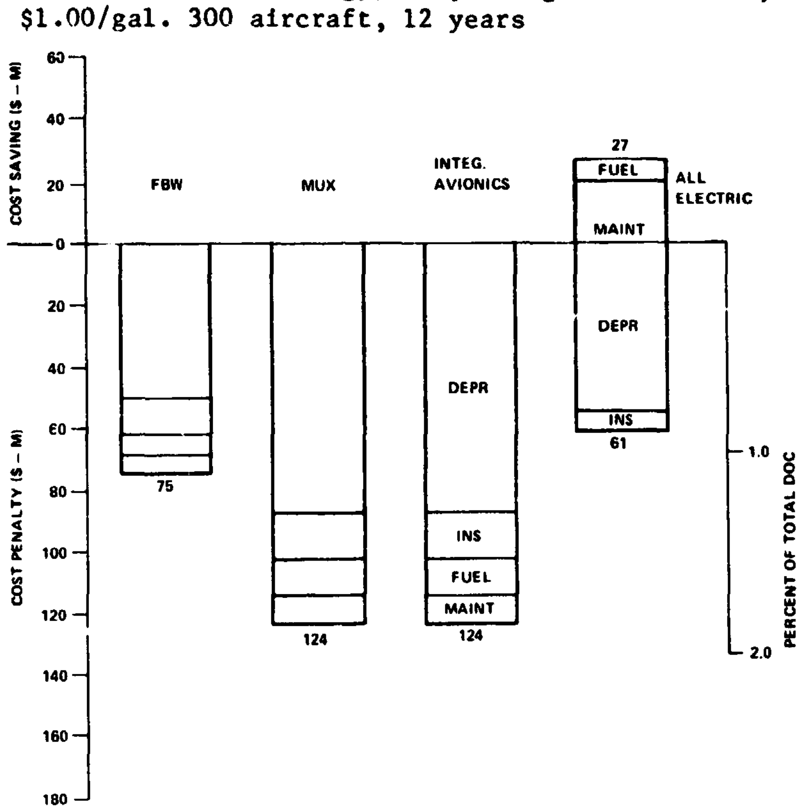


Figure 101. - Net value of technology: 500-passenger short-haul, fuel $1.00/gal. 300 aircraft, 12 years.

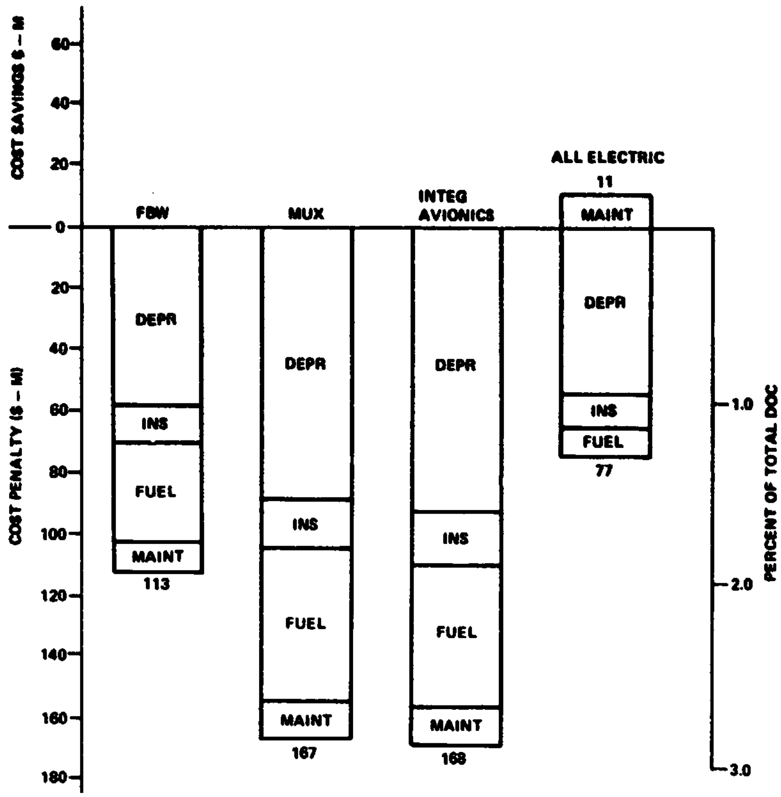


Figure 102. - Net value of technology: 30-passenger short-haul, fuel cost $1.80/gallon, 300 aircraft, 12 years.

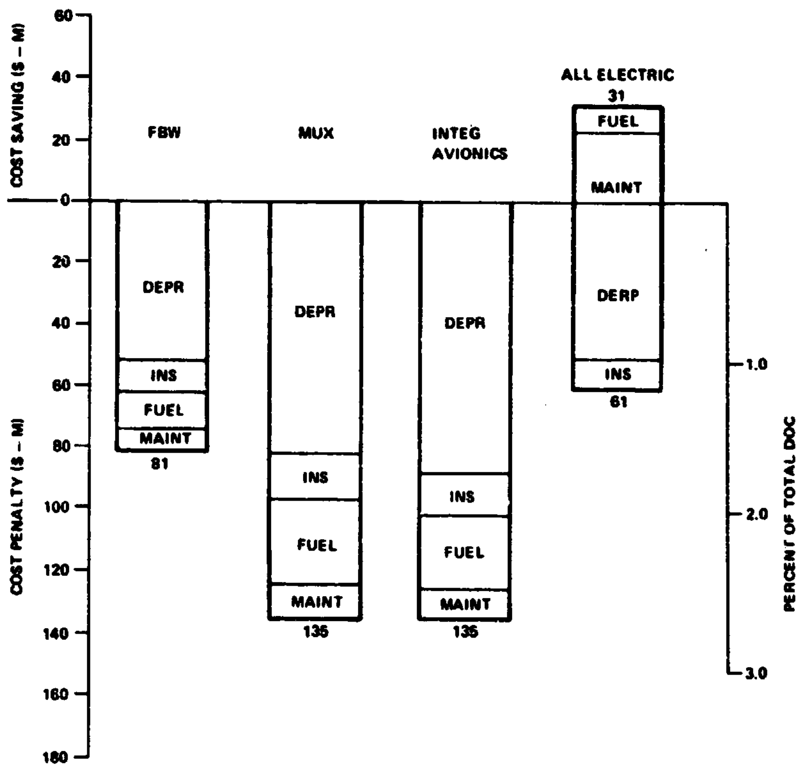


Figure 103. - Net value of technology: 50-passenger short-haul, fuel $1.80/gal. 300 aircraft, 12 years.

9.1 Recommendations

The AEA evaluated included the other technologies; FBW, MUX, RLG and integrated avionics. The benefits can be obtained without full implementation of these other technologies; however, each is valuable and should be pursued.

- FBW in conjunction with relaxed static stability (RSS) can give savings of \$4.2 X 10^9 which compares with the \$5.1 X 10^9 saved by the AEA. Considering that RSS is not practical without FBW makes FBW an extremely valuable technology, one that should be developed to its full potential for commercial transports.

- Multiplexing (MUX) is now being used and will be developed in an evolutionary manner throughout the years, although some special effort in design and testing will be necessary to develop a system reliable (safe) enough for flight control applications.

- The ring laser gyro (RLG), since Honeywell has already put up the development money and is near production, will be developed on its own merits and needs no futher governmental aid.

- Integrated avionics has obvious advantages of weight and cost savings and will progress as a result of system application such as the Space Shuttle.

- The AEA is a complex assortment of major changes in the major systems. Also, much of the payoff depends upon a complete change; eliminating the hydraulic and bleed air system. Although this is not beyond the state of the art it requires design, development and testing.

Research and Development is required in the following areas:

- Electric actuators
- Controllers
- Starter/generators
- Solid-state power switching
- Remote circuit breakers
- Electric deicing
- Electric ECS packs
- Electric brakes
- Electric reverser actuators
- Electric load management
- Flight engineers panel

- Alerting/warning system
- Engine impacts
- System architecture

Testing will be required in the following areas:

- Components
- Iron bird-simulation test
  - EMI
  - Temperature
  - Duty cycle
  - Fiber optics
  - Failure modes
- Flight test
  - S-3A
  - L-1011
  - Other aircraft
- Lightning tests

It is recommended that a NASA program office be established for advanced secondary power systems. Such an organization is pictured in figure 104. This office would coordinate the efforts leading to an AEA.

It does not appear that one airframe manufacturer, such as Lockheed, could push the AEA to fruition. It is necessary that goals, requirements, and standards be established on a mutual basis so that an equipment manufacturer, for example a flight control actuator manufacturer, can be assured that there will be some commonality in the application of his equipment. To this end it is recommended that an advisory committee of government and industry representatives be established to ensure the commonality of goals and requirements needed to implement the AEA and thus realize the attendant competitive fuel-saving advantages for the U.S.A. air transport industry.

Based upon commercial aviation experience it is seen that never does a system as sophisticated as the AEA or the FBW come into existence in one iteration or generation. It is necessary that small steps be taken with an operational evaluation period in between steps. Schematically such an evolutionary approach is shown in figure 105. An example of a first step is application of FBW electric spoilers. The spoilers on the ATA, also on the latest Lockheed L-1011 models, are used for:

- Roll control
- Speed brakes
- Ground braking
- Approach direct lift control

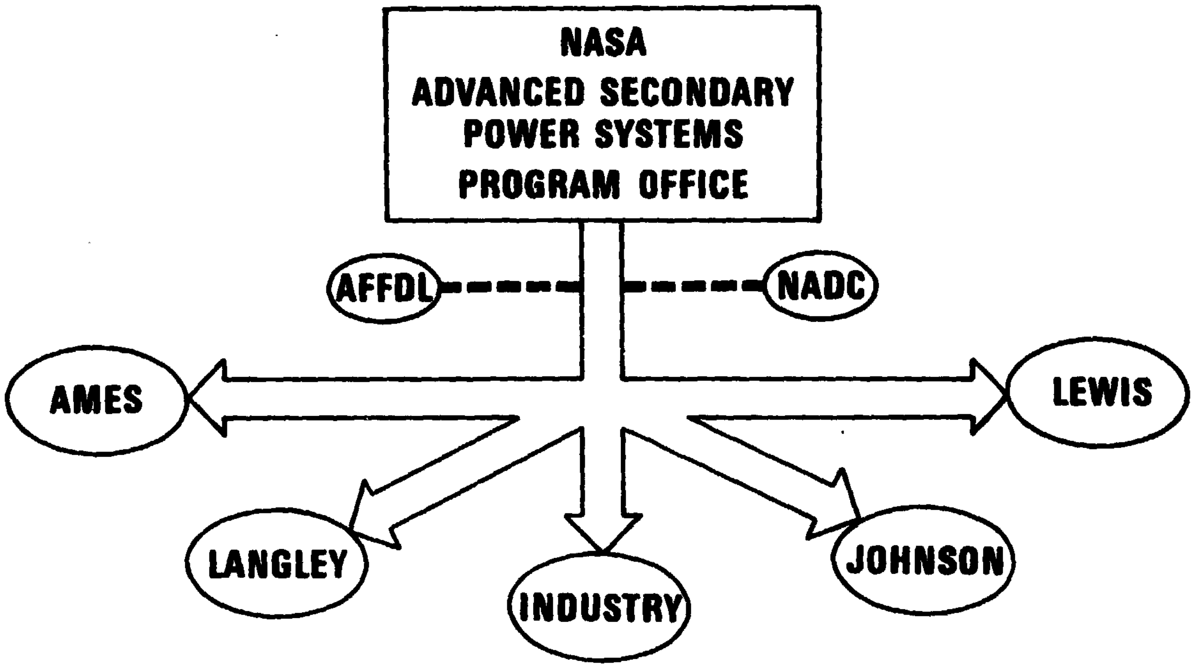


Figure 104. - Recommended development organization.

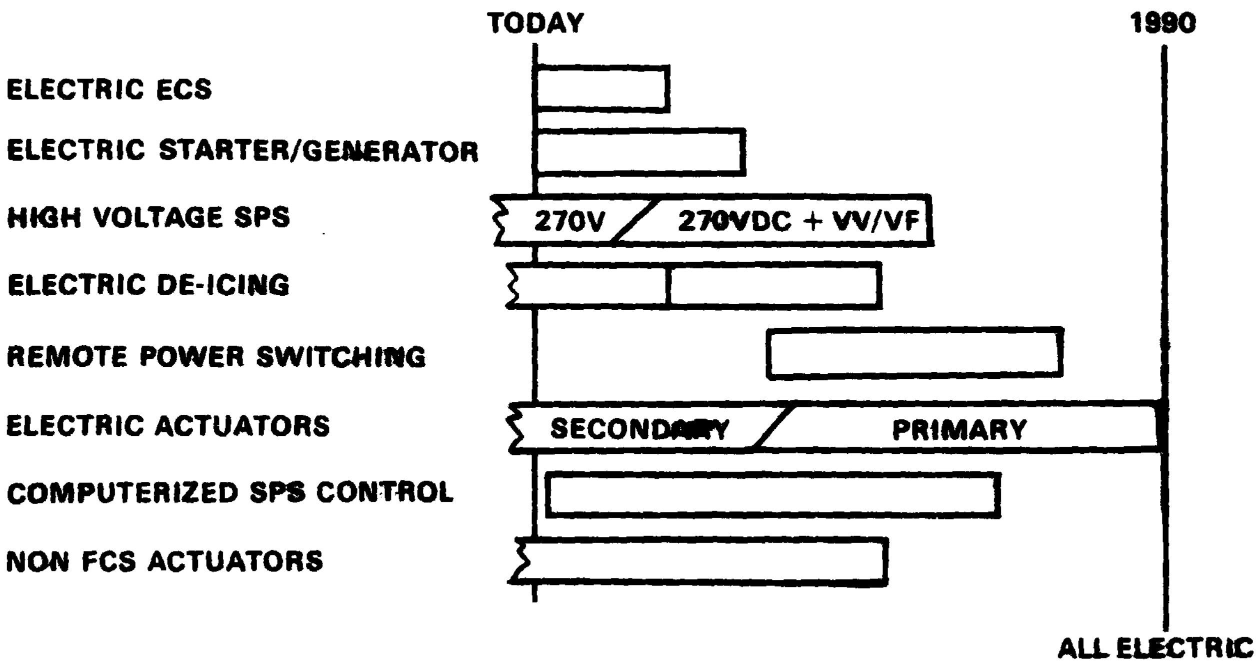


Figure 105. - Evolutionary approach - all electric.

- Maneuver direct lift control

- Profile descent direct lift control

- Vortex suppression

- Emergency pitch control

This multitude of modes, some used concurrently, requires a complicated mechanical system, with the attendent maintenance and rigging problems. Also, in the future as traffic flow is more closely controlled the required performance will increase and the mechanical system will be taxed. FBW and electrical actuators, while approximately the same weight as mechanical control and hydraulic actuators, can be competitive in the maintenance and performance areas. This spoiler application does not involve a flight critical system but one in which added performance requirements might make use of the flexibility and precision of the FBW system.

The evolutionary approach is shown in figure 106 with FBW spoilers, followed by a full time redundant digital flight control system backed up by a simplified mechanical system. This backup system could be single load path with no autopilot interface and no Mach trim/feel system. This approach would prove design philosophy and allow the necessary confidence to build up to a point where the mechanical system could be removed.

9.2 Certification

Figure 107 shows how certification is built on a pyramid of analysis and simulation leading to ground testing and eventually flight test. This process is greatly facilitated by an evolutionary approach where only small amounts of new technology are introduced between periods of operational evaluation. In this regard the evolutionary steps outlined in Section 9.1 should be considered.

Certification of certifiable systems can always be accomplished, however simulation and ground test should be used wherever possible to reduce the more expensive flight test.

9.3 1990s Technologies

- Fly-By-Wire (FBW): The technology is near term on both hardware and software. Digital FBW systems are flying now. Additional work is required in designing and testing to give the reliability (safety) required for commercial transports. The effort required is mostly in the digital system architecture and software to give the redundancy and monitoring features needed to meet the flight control reliability requirement of not more than 10^{-9} failures per hour.

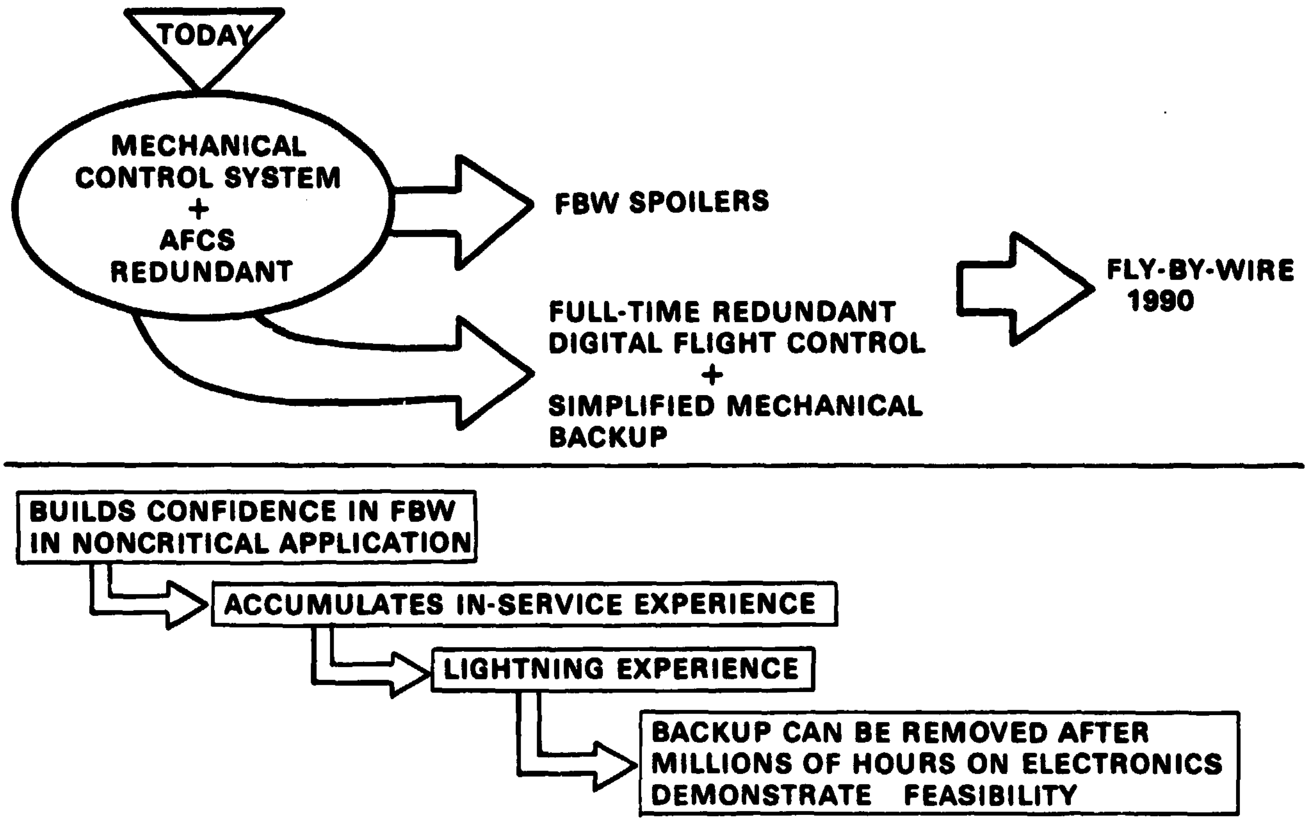


Figure 106. - Evolutionary approach - transport flight controls.

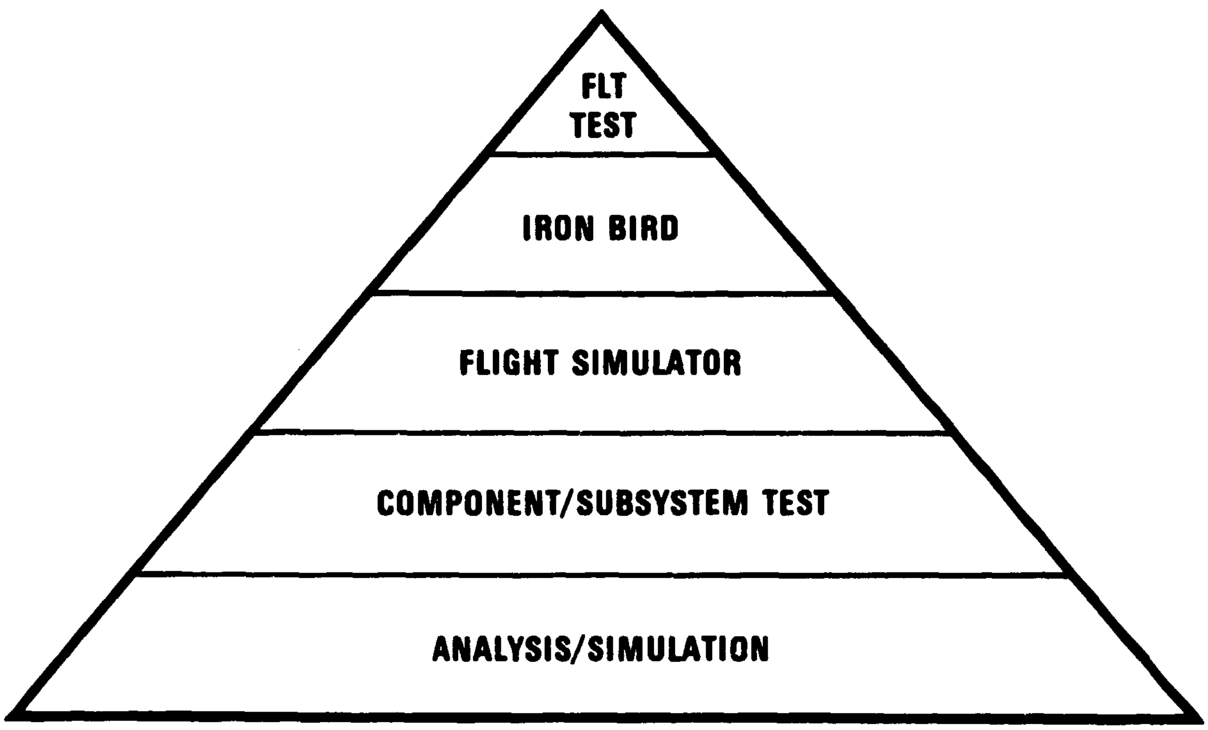


Figure 107. - Certification.

- Multiplex (MUX): MUX is in a situation similar to FBW. The technology is available but system architecture and software must be derived and tested to give the reliability required for flight controls. Advances in the component and packaging area will increase the utility of MUX. That is, smaller circuits and better thermal design will allow the MUX-DEMUX function to be closer to the using equipment and operate reliably at faster speeds.

- Ring Laser Gyro (RLG): The RLG inertial system is now in production. A seemingly easy extension of the technology is its use in place of dedicated sensors for flight control. This is possible because of the added reliability of the RLG and the strapdown feature, which gives body oriented outputs without computation.

- Integrated Avionics: Integrated Avionics is proceeding in an evolutionary manner. The tendency is to use dedicated processors and memories, with multiple digital bus providing interchange of data. This tendency is mainly due to the rapid advance of single chip processors, and large-capacity solid-state memory. The need in the area of integrated avionics is for more capability in the system architecture and software generation capability. This means more designers and more experienced designers.

- All-Electric Airplane (AEA): The AEA involves a number of varied technologies which will be discussed in later paragraphs. A system design effort is needed in making tradeoffs on the most cost effective system architecture and in establishing requirements. This system design effort should be of first priority in initiating an AEA program. A NASA program office for coordinating AEA technologies is recommended.

- Fiber Optics: Fiber optics for digital information transmission is being pursued on many fronts and the basic technology is available for almost any specific application. The application of fiber optics for transport aircraft is not clear and depends upon lightning test on composite skin aircraft and reliability (safety) capability of redundant multiplexing schemes. More specifically, the use of a two-way, high-speed bus such as MIL 1553A will be a major factor in the trade off of fiber optics vs. wired data bus.

  The lightning threat against composite skins and the protective measures to be applied are not well defined at this time. Until the structural protection is defined, the problem of electronic susceptibility is unknown. The present thinking is that if the skin is sufficiently conductive for structural protection then electronic protection can be had by conventional means of shielding and nonlinear devices. Thus lightning is not a compelling reason to use fiber optics.

- Relaxed Static Stability (RSS): For advanced air foils using super critical flow the testing completed to date indicates that large fuel savings can be obtained by an aft center of gravity, figure 26. Such an aft cg results in negative static stability and requires full-time stability and control augmentation. Such control by mechanical means becomes unwieldy to the point where the tradeoff is unquestionably in favor of FBW. The resultant fuel savings (see Section 8) show that advanced airfoils and RSS should be pursued.

- Software: Software has become one of the more expensive portions of a development program and one causing reliability problems, both in safety and maintainability. Section 7.6 discusses the software problems in detail. The selection of a standardized higher order language (HOL) is a laudable goal. This would reduce cost and errors because programmers would not have so much to learn and unlearn as they went from project to project. Software is mainly a problem of well-trained and experienced personnel. But having the architecture standardized and systemized can aid in training and can concentrate experience.

  A large relatively untouched field of software expertise is the management of redundant data-handling facilities to give maximum reliability. It involves self-checks, end-to-end checks, software verification techniques, and sophisticated system architecture. Research and development should be encouraged in this area but should be directed toward realistic situations such as the FBW flight control problem.

- Variable Voltage Variable Frequency (VVVF): Although VVVF is the most primitive of electrical systems, not much has been done with it because the main use of electric power has been for electronics which requires high-quality power. Modern large transports have large galley loads, and, when bleed air and hydraulic systems are eliminated, large motor loads which do not require high-quality power. Thus, as discussed in Section 7.1.5, all power can be generated as VVVF and only small portions converted to constant voltage-constant frequency and direct-current power. The hardware for VVVF is quite simple and conventional, however, the unconventional applications require early system design efforts to establish requirements and explore problem areas.

- Starter/Generator: A large weight saving in the AEA comes from use of a combination electric starter and generator rather than using separate machines for each. This would only be useful for aircraft where the required generator capacity is compatible with the starting requirement, as in the case of the large all-electric air transport. The machine is little different from a large ac generator, but requires a large capacity electronic controller, to provide the programmed frequency/voltage for starting. An early system design effort must define the requirements and trade off preliminary concepts such as one shaft versus two.

- Solid-State Power Controllers: Much of the AEA is dependent upon solid-state power conversion equipment for the actuators, starter/generator, and constant-frequency power supply. The technology, circuitry and components are state of the art; but the design and packaging for minimum cost and weight needs special consideration, especially in the actuator controllers which must be self cooling and reliable in adverse locations such as the wing. A major R&D effort should go into prototype design and testing of representative controllers.

- Motors: It has been assumed that samarium cobalt motors will be used for the generators, actuators and other precisely controlled motors. However more detailed tradeoffs are needed before this can be firmly established. Induction motors and alternators might replace samarium cobalt machinery in certain applications. In addition to system design effort in defining requirements and concepts, machinery design and development programs are needed for high-speed motor and for motor operation with solid-state power controllers.

- Electric Actuators: This study has gone into more detail in electric actuator design than any other facet of the candidate technologies. Also, NASA has investigated electric actuators for the Space Shuttle through Honeywell in Florida. There are still tradeoffs to be performed in selecting the best concepts, however. There are also design and development work to be done in the motor area and especially in the mechanical area for design of jam-proof, fail-operational mechanisms.

- Load Management: There is considerable system and conceptual design needed in the power distribution area. The aircraft electrical system of the past was based upon separate buses for different levels of load criticality. For emergency load shedding, buses were dropped (disconnected) leaving only the most critical equipment connected. The concept in this study is to drop individual loads by means of solid-state switching, in response to a digital processor which determines the criticality of each load. With this concept there is also the possibility of reducing the required system capacity by dropping noncritical loads during peak loading periods (see Section 7.1.5). In addition to the system design required, R&D is required in the area of dc circuit protection, overload sensing, and remote circuit switching.

- Electric Brakes: Brakes are one of the items difficult to justify as electric rather than hydraulic. Electric brakes would be desirable for an AEA and advantages can be seen for electric brakes. However, electric brakes should not be a pacing item for the AE since small electro hydraulic power supplies are easily available for operation of conventional hydraulic brakes. The advantages of electric brakes are: no hydraulic fluid to catch on fire, weight saving in hydraulic systems which would require redundancy. Therefore, an effort to develop an electrical brake should be encouraged.

- Electric Deicing: Electro-thermal deicing has been used many times for small areas and can be used for wing deicing for the AEA where an abundance of cheap (in terms of fuel) power is available. System capacity requirements would not be seriously affected by thermal deicing since galley power useage can be curtailed for periods of peak deicing. However electro-impulse deicing is desirable in terms of minimum fuel usage. This method uses the interaction of a suddenly expanding magnetic field with the conductive skin to give a sharp impact to the skin and crack the ice which is then blown off by the air stream. This method is applicable to many aircraft and therefore should be investigated as a stand-alone technology not critical to the AEA.

- Freon Air Conditioning Packs: It has long been understood that the freon cycle is about four times as efficient as the air cycle for refrigeration. Air cycle is typically used, however, because of the ready availability of bleed air and ram air for cooling the hot bleed air. This method, while equipment weight efficient, is fuel inefficient. With the high cost of fuel projected for the future, efforts should be made to use freon in place of air refrigeration in all new aircraft. Although freon is used in most commercial applications, the high-speed, centrifugal, electrically driven compressors necessary for weight competitiveness is new technology and needs encouragement by supplying design requirements and standards and the showing of commitment to the concept.

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APPENDIX A
ASSET OUTPUT

E**3 AIRCRAFT / 500 PASS / 3000 N MI / M = .80 MISS

T/C=13.00 AR=10.00 W/S=114.80 T/W=0.255

WEIGHT STATEMENT

	WEIGHT(POUNDS)	WEIGHT FRACTION	(PERCENT)
GROSS WEIGHT	(459437.)		
FUEL AVAILABLE	99821.	FUEL	21.73
EXTERNAL	0.		
INTERNAL	99817.		
ZERO FUEL WEIGHT	359617.		
PAYLOAD	100000.	PAYLOAD	21.77
PASSENGERS	85000.		
BAGGAGE	0.		
CARGO	15000.		
STORES	0.		
OPERATIONAL EMPTY WEIGHT	259617.		
OPERATIONAL ITEMS	16188.	OPERATIONAL ITEMS	4.70
STANDARD ITEMS	5410.		
EMPTY WEIGHT	238019.		
STRUCTURE	136689.	STRUCTURE	29.75
WING	48946.		
ROTOR	0.		
TAIL	5863.		
BODY	56695.		
ALIGHTING GEAR	18999.		
ENGINE SECTION AND NACELLE	6186.		
PROPULSION	29298.	PROPULSION	6.38
CRUISE ENGINES	22642.		
LIFT ENGINES	0.		
THRUST REVERSER	4443.		
EXHAUST SYSTEM	0.		
ENGINE CONTROL	199.		
STARTING SYSTEM	532.		
PROPELLERS	0.		
LUBRICATING SYSTEM	0.		
FUEL SYSTEM	1482.		
DRIVE SYSTEM (POWER TRANS)	0.		
SYSTEMS	72033.		
FLIGHT CONTROLS	5993.		
AUXILIARY POWER PLANT	1116.		
INSTRUMENTS	903.		
HYDRAULIC AND PNEUMATIC	2708.		
ELECTRICAL	5965.		
AVIONICS	2964.	SYSTEMS	15.68
ARMAMENT	0.		
FURNISHINGS AND EQUIPMENT	44293.		
AIR CONDITIONING	7682.		
ANTI-ICING	408.		
PHOTOGRAPHIC	0.		
LOAD AND HANDLING	0.		
		TOTAL	(100.)

Conventional ATA
No RSS

COST SUMMARY

RDT AND E

	TOTAL *
DEVELOPMENT - NONRECURRING	
ENGINEERING	1138.88
TOOLING	737.16
TEST ARTICLES	89.53
DATA	0.0
SYSTEMS ENG/MNGMT	0.0
CRUISE ENGINE	0.0
LIFT ENGINE	0.0
FAN	0.0
AVIONICS	21.90
OTHER SYSTEMS	0.0
FACILITIES	0.0
TOTAL AIR VEHICLE	1987.48
INTEGR LOGISTICS SUPPORT	
PLANNING	10.03
TRAINING	3.41
HANDBOOKS	23.61
SSE	4.91
TOTAL ILS	41.96
TOTAL DVLPMNT-NONREC	2029.43
DEVELOPMENT - RECUR(PROTOTYPES)	
AIR VEHICLE	844.96
SPARES	217.97
TOTAL DVLPMNT-RECUR	1062.94
GOVMNT DVLPMNT COST	0.0
TOTAL DVLPMNT COST	3092.37

Conventional ATA
No RSS

PRODUCTION

	MATERIAL	LABOR	TOTAL PER PROD A/C**
STRUCTURE	5591.29	16010.41	21601.70
WING	2529.56	3310.16	5839.72
ROTOR	0.0	0.0	0.0
TAIL	252.76	515.01	767.77
BODY	1662.29	10978.51	12640.80
ALIGHTING GEAR	820.48	38.10	858.58
ENG SECT + NACELLE	326.19	1168.63	1494.82
ENG SECTION	0.0	0.0	0.0
NACELLE	245.36	1060.58	1305.94
AIR INDUCTION	80.84	108.05	188.88
PROPULSION	156.31	146.52	302.83
ENGINE INSTALL	0.0	35.25	35.25
THRUST REVERSER	0.0	6.92	6.92
EXHAUST SYSTEM	0.0	0.0	0.0
ENGINE CONTROLS	4.61	6.55	11.16
STARTING SYSTEM	70.56	11.98	82.54
PROPELLER INSTALL	0.0	0.0	0.0
LUBRICATING SYSTEM	0.0	0.0	0.0
FUEL SYSTEM	81.14	85.83	166.97
DRIVE SYS(PWR TRN)	0.0	0.0	0.0
SYSTEMS	3857.87	9318.16	13176.02
FLIGHT CONTROLS	864.43	584.56	1449.00
AUX POWER PLANT	166.84	27.17	194.01
INSTRUMENTS	86.54	75.67	162.21
HYDRAULIC + PNEUM	179.59	435.28	614.86
ELECTRICAL	546.38	1392.75	1939.13
AVIONIC INSTALL	53.05	529.74	582.79
ARMAMENT	0.0	0.0	0.0
FURN AND EQUIP	1398.92	5599.60	6998.52
AIR CONDITIONING	533.75	639.39	1173.14
ANTI-ICING	28.38	33.99	62.37
PHOTOGRAPHIC	0.0	0.0	0.0
LOAD AND HANDLING	0.0	0.0	0.0
SYSTEMS INTEGR	751.75	714.56	1466.30
TOTAL COST	10357.21	26189.57	36546.78
TOTAL HRS **		785.30	785.30
ENG CHANGE ORDERS			1198.54
SUSTAINING ENG COST			2114.05
PROD TOOLING COST			2212.57
QUALITY ASSURANCE			3522.05
MISCELLANEOUS ***			798.84
TOTAL AIRFRAME COST			46392.78
ENGINE COST			5256.18
AVIONICS COST			710.45
TOTAL MANUFACTURING COST			52359.41
WARRANTY			281.14
TOTAL PRODUCTION COST			52640.54

PROCUREMENT

	PER PROD A/C**
TOTAL PRODUCTION	52640.54
INTEGR LOGISTICS SUPPORT	
PLANNING	30.66
TRAINING	10.42
TRAINERS	360.68
HANDBOOKS	46.21
FACILITIES	0.0
SSE - CFE	26.32
SSE - GFE	751.07
TOTAL ILS	1225.36
INITIAL SPARES COST	7169.42
PRODUCTION DEVELOPMENT	
ENGINEERING	368.83
TOOLING	-201.44
ENGINES	0.0
TOTAL PROD DEV	167.39
TOTAL PROCUREMENT	61202.69

* - MILLIONS OF DOLLARS

** -1000 OF DOLLARS OR HOURS PER PROD A/C

*** - INCLUDES PROD DATA, SYSTEMS ENGR AND OTHER SYSTEMS

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)	C/SM***	PERCENT
FLIGHT CREW	0.22560	13.60734
FUEL AND OIL	0.50790	30.63474
INSURANCE	0.02544	1.53432
DEPRECIATION	0.55910	33.72244
MAINTENANCE	0.33989	20.50113
TOTAL DOC	1.65793	100.000

INDIRECT OPERATIONAL COST (IOC)	C/SM***	PERCENT
SYSTEM	0.03098	2.48231
LOCAL	0.07333	5.87531
AIRCRAFT CONTROL	0.00202	0.16180
CABIN ATTENDANT	0.22697	18.18617
FOOD AND BEVERAGE	0.13629	10.91981
PASSENGER HANDLING	0.15707	12.58509
CARGO HANDLING	0.05804	4.65077
OTHER PASSENGER EXPENSE	0.42408	33.97914
OTHER CARGO EXPENSE	0.00853	0.68319
GENERAL + ADMINISTRATION	0.13075	10.47647
TOTAL IOC	1.24806	100.000

MISC. DATA	
FLIGHT DISTANCE (N. MI.)	2999.95
BLOCK FUEL (LBS)	83577.25
BLOCK TIME (HRS)	7.23
FLIGHT TIME (HRS)	6.80
AVG STAGE LENGTH (N. MI.)	1144.00
AVG CARGO PER FLIGHT	17413.00
UTILIZATION (HRS PER YR)	3636.00
FLIGHTS PER A/C PER YEAR	502.86
FARE ($)	357.59
FUEL COST ($/LB)	0.09000

*** - CENTS PER SEAT N. MILE

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR	CUMULATIVE DEPRECIATION	AVERAGE BOOK VALUE OF FLEET	REVENUE	INTEREST EXPENSE	OPERATING EXPENSE	CASH FLOW	ROI
			$M	$M	$M	$M	$M	$M	$M	PERCENT
1	6.3	10.0	446.94	26.82	420.12	345.38	42.91	136.99	-90.67	29.91
2	16.3	10.0	1162.05	96.54	1065.51	898.00	104.69	356.19	30.84	30.34
3	20.0	0.0	1430.21	182.35	1247.86	1105.22	116.71	438.38	246.46	31.40
4	20.0	0.0	1430.21	268.16	1162.05	1105.22	102.98	438.38	253.33	33.12
5	20.0	0.0	1430.21	353.98	1076.23	1105.22	89.25	438.38	260.19	35.13
6	20.0	0.0	1430.21	439.79	990.42	1105.22	75.52	438.38	267.06	37.48
7	20.0	0.0	1430.21	525.60	904.61	1105.22	61.79	438.38	273.92	40.27
8	20.0	0.0	1430.21	611.41	818.80	1105.22	48.06	438.38	280.79	43.66
9	20.0	0.0	1430.21	697.23	732.99	1105.22	34.33	438.38	287.65	47.83
10	20.0	0.0	1430.21	783.04	647.17	1105.22	20.60	438.38	294.52	53.11

AVG ROI OVER THE 10 YEAR PERIOD = 37.40 PERCENT

Conventional ATA
No RSS

SUMMARY ID NO. 1 — ASSET PARAMETRIC ANALYSIS — APRIL 29 1980

AIRCRAFT MODEL -- CL1332-1
I.O.C. DATE --1985
DESIGN SPEED --SUBSONIC

ENGINE I.D. -- 416000
SLS SCALE 1.0 = 40850
NUMBER OF ENGINES = 3.

WING QUARTER CHORD SWEEP = 30.00 DEG
WING TAPER RATIO = 0.300

1 W/S	114.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 T/W	0.255	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 AR	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 T/C	13.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 SWEEP	30.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 FPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 OPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8 TIT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9 NPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 AUG T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11 RADIUS N. MI	3000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 GROSS WEIGHT	459437	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 FUEL WEIGHT	99821	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 OP. WT. EMPTY	259617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ZERO FUEL WT.	359617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 ENGINE SCALE	0.956	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17 THRUST/ENGINE	39052	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 WING AREA	4002.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19 WING SPAN	200.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20 H. TAIL AREA	925.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 V. TAIL AREA	576.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22 ENG. LENGTH	10.29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23 ENG. DIAMETER	7.07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24 BODY LENGTH	228.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25 WING FUEL LIMIT	3.002	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COST DATA																
26 RDTE - BIL.	3.092	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27 FLYAWAY - MIL.	63.12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 INVESTMNT-BIL.	1.430	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 DOC - C/SM	1.658	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30 IOC - C/SM	1.248	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31 ROI A.T. - 0/0	37.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MISSION PARAMETERS																
32 MISN V1(1,1)	37000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33 MISN V2(1,1)	83577	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSTRAINT OUTPUT																
34 TAKEOFF DST(1)	6967	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35 CLIMB GRAD(1)	0.1141	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36 TAKEOFF DST(2)	6616	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37 CLIMB GRAD(2)	0.0411	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38 CTOL LNDG D(1)	6116	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39 AP SPEED-KT(1)	136.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40 SEP(1) - FPS	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41 SEP(2) - FPS	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Conventional ATA
No RSS

E**3 AIRCRAFT / 500 PASS / 3000 N MI / M = .80 MISS

T/C=13.00 AR=10.00 W/S=114.80 T/W=0.255

W E I G H T   S T A T E M E N T

	WEIGHT(POUNDS)	WEIGHT FRACTION	(PERCENT)
GROSS WEIGHT	(458466.)		
FUEL AVAILABLE	99638.	FUEL	21.73
EXTERNAL	0.		
INTERNAL	99634.		
ZERO FUEL WEIGHT	358829.		
PAYLOAD	100000.	PAYLOAD	21.81
PASSENGERS	85000.		
BAGGAGE	0.		
CARGO	15000.		
STORES	0.		
OPERATIONAL EMPTY WEIGHT	258829.		
OPERATIONAL ITEMS	16187.	OPERATIONAL ITEMS	4.71
STANDARD ITEMS	5410.		
EMPTY WEIGHT	237232.		
STRUCTURE	136450.	STRUCTURE	29.76
WING	48802.		
ROTOR	0.		
TAIL	5844.		
BODY	56666.		
ALIGHTING GEAR	18967.		
ENGINE SECTION AND NACELLE	6171.		
PROPULSION	29235.	PROPULSION	6.38
CRUISE ENGINES	22587.		
LIFT ENGINES	0.		
THRUST REVERSER	4436.		
EXHAUST SYSTEM	0.		
ENGINE CONTROL	199.		
STARTING SYSTEM	532.		
PROPELLERS	0.		
LUBRICATING SYSTEM	0.		
FUEL SYSTEM	1480.		
DRIVE SYSTEM (POWER TRANS)	0.		
SYSTEMS	71547.		
FLIGHT CONTROLS	5517.		
AUXILIARY POWER PLANT	1116.		
INSTRUMENTS	902.		
HYDRAULIC AND PNEUMATIC	2703.		
ELECTRICAL	5963.		
AVIONICS	2964.	SYSTEMS	15.61
ARMAMENT	0.		
FURNISHINGS AND EQUIPMENT	44293.		
AIR CONDITIONING	7682.		
ANTI-ICING	408.		
PHOTOGRAPHIC	0.		
LOAD AND HANDLING	0.		
		TOTAL	(100.)

FBW
NO RSS

COST SUMMARY

RDT AND E

	TOTAL *
DEVELOPMENT - NONRECURRING	
ENGINEERING	1141.18
TOOLING	734.98
TEST ARTICLES	89.04
DATA	0.0
SYSTEMS ENG/MNGMT	0.0
CRUISE ENGINE	0.0
LIFT ENGINE	0.0
FAN	0.0
AVIONICS	22.40
OTHER SYSTEMS	0.0
FACILITIES	0.0
TOTAL AIR VEHICLE	1987.61
INTEGR LOGISTICS SUPPORT	
PLANNING	10.02
TRAINING	3.41
HANDBOOKS	23.39
SSE	4.91
TOTAL ILS	41.73
TOTAL DVLPMNT-NONREC	2029.33
DEVELOPMENT - RECUR(PROTOTYPES)	
AIR VEHICLE	842.21
SPARES	217.13
TOTAL DVLPMNT-RECUR	1059.34
GOVMNT DVLPMNT COST	0.0
TOTAL DVLPMNT COST	3088.68

PRODUCTION

	MATERIAL	LABOR	TOTAL PER PROD A/C**
STRUCTURE	5580.29	15993.61	21573.90
WING	2522.28	3301.13	5823.40
ROTOR	0.0	0.0	0.0
TAIL	251.94	513.40	765.34
BODY	1661.52	10975.01	12636.53
ALIGHTING GEAR	819.13	38.04	857.18
ENG SECT + NACELLE	325.42	1166.03	1491.46
ENG SECTION	0.0	0.0	0.0
NACELLE	244.78	1058.22	1303.00
AIR INDUCTION	80.65	107.81	188.46
PROPULSION	156.20	146.33	302.53
ENGINE INSTALL	0.0	35.17	35.17
THRUST REVERSER	0.0	6.91	6.91
EXHAUST SYSTEM	0.0	0.0	0.0
ENGINE CONTROLS	4.60	6.54	11.14
STARTING SYSTEM	70.56	11.98	82.54
PROPELLER INSTALL	0.0	0.0	0.0
LUBRICATING SYSTEM	0.0	0.0	0.0
FUEL SYSTEM	81.04	85.73	166.77
DRIVE SYS(PWR TRN)	0.0	0.0	0.0
SYSTEMS	3857.78	9179.26	13037.04
FLIGHT CONTROLS	864.89	445.44	1310.33
AUX POWER PLANT	166.84	27.18	194.02
INSTRUMENTS	86.43	75.59	162.02
HYDRAULIC + PNEUM	179.25	434.54	613.79
ELECTRICAL	546.20	1392.50	1938.70
AVIONIC INSTALL	53.05	529.84	582.89
ARMAMENT	0.0	0.0	0.0
FURN AND EQUIP	1398.99	5600.69	6999.68
AIR CONDITIONING	533.77	639.51	1173.29
ANTI-ICING	28.35	33.96	62.31
PHOTOGRAPHIC	0.0	0.0	0.0
LOAD AND HANDLING	0.0	0.0	0.0
SYSTEMS INTEGR	749.29	712.33	1461.63
TOTAL COST	10343.57	26031.47	36375.04
TOTAL HRS **		780.55	780.55
ENG CHANGE ORDERS			1192.77
SUSTAINING ENG COST			2121.43
PROD TOOLING COST			2199.21
QUALITY ASSURANCE			3500.79
MISCELLANEOUS ***			794.02
TOTAL AIRFRAME COST			46183.25
ENGINE COST			5249.18
AVIONICS COST			828.49
TOTAL MANUFACTURING COST			52260.89
WARRANTY			280.34
TOTAL PRODUCTION COST			52541.23

PROCUREMENT

	PER PROD A/C**
TOTAL PRODUCTION	52541.23
INTEGR LOGISTICS SUPPORT	
PLANNING	30.64
TRAINING	10.42
TRAINERS	360.68
HANDBOOKS	46.03
FACILITIES	0.0
SSE - CFE	26.27
SSE - GFE	751.07
TOTAL ILS	1225.10
INITIAL SPARES COST	7155.20
PRODUCTION DEVELOPMENT	
ENGINEERING	368.58
TOOLING	-190.03
ENGINES	0.0
TOTAL PROD DEV	178.55
TOTAL PROCUREMENT	61100.06

* - MILLIONS OF DOLLARS

** -1000 OF DOLLARS OR HOURS PER PROD A/C

*** - INCLUDES PROD DATA, SYSTEMS ENGR AND OTHER SYSTEMS

FBW
No RSS

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)	C/SM***	PERCENT
FLIGHT CREW	0.22560	13.63174
FUEL AND OIL	0.50698	30.63377
INSURANCE	0.02540	1.53462
DEPRECIATION	0.55818	33.72778
MAINTENANCE	0.33881	20.47208
TOTAL DOC	1.65496	100.000

INDIRECT OPERATIONAL COST (IOC)	C/SM***	PERCENT
SYSTEM	0.03087	2.47413
LOCAL	0.07317	5.86479
AIRCRAFT CONTROL	0.00202	0.16185
CABIN ATTENDANT	0.22697	18.19205
FOOD AND BEVERAGE	0.13629	10.92334
PASSENGER HANDLING	0.15707	12.58916
CARGO HANDLING	0.05804	4.65227
OTHER PASSENGER EXPENSE	0.42408	33.99013
OTHER CARGO EXPENSE	0.00853	0.68341
GENERAL + ADMINISTRATION	0.13062	10.46887
TOTAL IOC	1.24765	100.000

MISC. DATA	
FLIGHT DISTANCE (N. MI.)	2999.95
BLOCK FUEL (LBS)	83424.88
BLOCK TIME (HRS)	7.23
FLIGHT TIME (HRS)	6.80
AVG STAGE LENGTH (N. MI.)	1144.00
AVG CARGO PER FLIGHT	17413.00
UTILIZATION (HRS PER YR)	3636.00
FLIGHTS PER A/C PER YEAR	502.86
FARE ($)	357.59
FUEL COST ($/LB)	0.09000

*** - CENTS PER SEAT N. MILE

- -

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR	CUMULATIVE DEPRECIATION	AVERAGE BOOK VALUE OF FLEET	REVENUE	INTEREST EXPENSE	OPERATING EXPENSE	CASH FLOW	ROI
			$M	$M	$M	$M	$M	$M	$M	PERCENT
1	6.3	10.0	446.22	26.77	419.45	345.38	42.84	136.84	-90.28	29.97
2	16.3	10.0	1160.18	96.38	1063.79	898.00	104.52	355.77	31.44	30.40
3	20.0	0.0	1427.91	182.06	1245.85	1105.23	116.52	437.87	246.86	31.46
4	20.0	0.0	1427.91	267.73	1160.18	1105.23	102.81	437.87	253.71	33.19
5	20.0	0.0	1427.91	353.41	1074.50	1105.23	89.10	437.87	260.57	35.28
6	20.0	0.0	1427.91	439.08	988.83	1105.23	75.39	437.87	267.42	37.86
7	20.0	0.0	1427.91	524.76	903.16	1105.23	61.69	437.87	274.27	40.36
8	20.0	0.0	1427.91	610.43	817.48	1105.23	47.98	437.87	281.13	43.75
9	20.0	0.0	1427.91	696.11	731.81	1105.23	34.27	437.87	287.98	47.94
10	20.0	0.0	1427.91	781.78	646.13	1105.23	20.56	437.87	294.84	53.23

AVG ROI OVER THE 10 YEAR PERIOD = 37.48 PERCENT

FBW
No RSS

SUMMARY ID NO. 1   A S S E T   P A R A M E T R I C   A N A L Y S I S   APRIL 29 1980

AIRCRAFT MODEL -- CL1332-1
I.O.C. DATE --1985
DESIGN SPEED --SUBSONIC

ENGINE I.D. -- 416000
SLS SCALE 1.0 = 40850
NUMBER OF ENGINES = 3.

WING QUARTER CHORD SWEEP = 30.00 DEG
WING TAPER RATIO = 0.300

1 W/S	114.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 T/W	0.255	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 AR	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 T/C	13.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 SWEEP	30.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 FPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 OPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8 TIT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9 NFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 AUG T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11 RADIUS N. MI	3000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 GROSS WEIGHT	458466	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 FUEL WEIGHT	99638	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 OP. WT. EMPTY	258829	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ZERO FUEL WT.	359829	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 ENGINE SCALE	0.954	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17 THRUST, ENGINE	38970	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 WING AREA	3994.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19 WING SPAN	199.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20 H. TAIL AREA	922.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 V. TAIL AREA	574.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22 ENG. LENGTH	10.28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23 ENG. DIAMETER	7.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24 BODY LENGTH	228.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25 WING FUEL LIMIT	2.998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COST DATA																
26 RDTE - BIL.	3.089	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27 FLYAWAY - MIL.	63.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 INVESTMNT-BIL.	1.428	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 DOC - C/SM	1.655	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30 IOC - C/SM	1.248	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31 ROI A.T. - O/O	37.48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MISSION PARAMETERS																
32 MISN V1(1,1)	37000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33 MISN V2(1,1)	83425	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSTRAINT OUTPUT																
34 TAKEOFF DST(1)	6968	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35 CLIMB GRAD(1)	0.1141	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36 TAKEOFF DST(2)	6616	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37 CLIMB GRAD(2)	0.0411	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38 CTOL LNDG D(1)	6116	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39 AP SPEED-KT(1)	136.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40 SEP(1) - FPS	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41 SEP(2) - FPS	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FBW
No RSS

E**3 AIRCRAFT / 500 PASS / 3000 N MI / M = .80 MISS

T/C=13.00 AR=10.00 W/S=114.80 T/W=0.255

W E I G H T   S T A T E M E N T

	WEIGHT(POUNDS)
GROSS WEIGHT	(457597.)
FUEL AVAILABLE	99473.
EXTERNAL	0.
INTERNAL	99469.
ZERO FUEL WEIGHT	358124.
PAYLOAD	100000.
PASSENGERS	85000.
BAGGAGE	0.
CARGO	15000.
STORES	0.
OPERATIONAL EMPTY WEIGHT	258124.
OPERATIONAL ITEMS	16187.
STANDARD ITEMS	5409.
EMPTY WEIGHT	236527.
STRUCTURE	136236.
WING	48674.
ROTOR	0.
TAIL	5826.
BODY	56640.
ALIGHTING GEAR	18938.
ENGINE SECTION AND NACELLE	6155.
PROPULSION	29178.
CRUISE ENGINES	22538.
LIFT ENGINES	0.
THRUST REVERSER	4431.
EXHAUST SYSTEM	0.
ENGINE CONTROL	198.
STARTING SYSTEM	532.
PROPELLERS	0.
LUBRICATING SYSTEM	0.
FUEL SYSTEM	1478.
DRIVE SYSTEM (POWER TRANS)	0.
SYSTEMS	71113.
FLIGHT CONTROLS	5091.
AUXILIARY POWER PLANT	1116.
INSTRUMENTS	901.
HYDRAULIC AND PNEUMATIC	2698.
ELECTRICAL	5961.
AVIONICS	2964.
ARMAMENT	0.
FURNISHINGS AND EQUIPMENT	44293.
AIR CONDITIONING	7682.
ANTI-ICING	408.
PHOTOGRAPHIC	0.
LOAD AND HANDLING	0.

WEIGHT FRACTION	(PERCENT)
FUEL	21.74
PAYLOAD	21.85
OPERATIONAL ITEMS	4.72
STRUCTURE	29.77
PROPULSION	6.38
SYSTEMS	15.54
TOTAL	(100.)

MUX
No RSS

COST SUMMARY

RDT AND E

	TOTAL *
DEVELOPMENT - NONRECURRING	
ENGINEERING	1129.81
TOOLING	733.04
TEST ARTICLES	88.78
DATA	0.0
SYSTEMS ENG/MNGMT	0.0
CRUISE ENGINE	0.0
LIFT ENGINE	0.0
FAN	0.0
AVIONICS	23.70
OTHER SYSTEMS	0.0
FACILITIES	0.0
TOTAL AIR VEHICLE	1975.32
INTEGR LOGISTICS SUPPORT	
PLANNING	10.02
TRAINING	3.41
HANDBOOKS	23.20
SSE	4.90
TOTAL ILS	41.52
TOTAL DVLPMNT-NONREC	2016.84
DEVELOPMENT - RECUR(PROTOTYPES)	
AIR VEHICLE	839.61
SPARES	216.39
TOTAL DVLPMNT-RECUR	1055.99
GOVMNT DVLPMNT COST	0.0
TOTAL DVLPMNT COST	3072.84

PRODUCTION

	MATERIAL	LABOR	TOTAL PER PROD A/C**
STRUCTURE	5570.45	15978.58	21549.02
WING	2515.77	3293.04	5808.80
ROTOR	0.0	0.0	0.0
TAIL	251.20	511.96	763.16
BODY	1660.83	10971.88	12632.70
ALIGHTING GEAR	817.93	37.99	855.92
ENG SECT + NACELLE	324.74	1163.71	1488.45
ENG SECTION	0.0	0.0	0.0
NACELLE	244.26	1056.11	1300.36
AIR INDUCTION	80.48	107.60	188.08
PROPULSION	156.10	146.16	302.26
ENGINE INSTALL	0.0	35.10	35.10
THRUST REVERSER	0.0	6.90	6.90
EXHAUST SYSTEM	0.0	0.0	0.0
ENGINE CONTROLS	4.59	6.53	11.12
STARTING SYSTEM	70.56	11.99	82.55
PROPELLER INSTALL	0.0	0.0	0.0
LUBRICATING SYSTEM	0.0	0.0	0.0
FUEL SYSTEM	80.95	85.65	166.59
DRIVE SYS(PWR TRN)	0.0	0.0	0.0
SYSTEMS	3777.57	9138.34	12915.90
FLIGHT CONTROLS	785.16	404.32	1189.47
AUX POWER PLANT	166.85	27.19	194.04
INSTRUMENTS	86.34	75.51	161.85
HYDRAULIC + PNEUM	178.96	433.87	612.83
ELECTRICAL	546.04	1392.28	1938.31
AVIONIC INSTALL	53.05	529.94	582.99
ARMAMENT	0.0	0.0	0.0
FURN AND EQUIP	1399.05	5601.67	7000.72
AIR CONDITIONING	533.80	639.63	1173.42
ANTI-ICING	28.32	33.94	62.26
PHOTOGRAPHIC	0.0	0.0	0.0
LOAD AND HANDLING	0.0	0.0	0.0
SYSTEMS INTEGR	747.10	710.34	1457.44
TOTAL COST	10251.23	25973.34	36224.56
TOTAL HRS **		778.81	778.81
ENG CHANGE ORDERS			1188.03
SUSTAINING ENG COST			2103.09
PROD TOOLING COST			2194.30
QUALITY ASSURANCE			3492.97
MISCELLANEOUS ***			792.24
TOTAL AIRFRAME COST			45995.18
ENGINE COST			5242.91
AVIONICS COST			894.95
TOTAL MANUFACTURING COST			52133.04
WARRANTY			279.47
TOTAL PRODUCTION COST			52412.51

PROCUREMENT

	PER PROD A/C**
TOTAL PRODUCTION	52412.51
INTEGR LOGISTICS SUPPORT	
PLANNING	30.62
TRAINING	10.41
TRAINERS	360.68
HANDBOOKS	45.86
FACILITIES	0.0
SSE - CFE	26.21
SSE - GFE	751.07
TOTAL ILS	1224.84
INITIAL SPARES COST	7138.12
PRODUCTION DEVELOPMENT	
ENGINEERING	368.40
TOOLING	-187.33
ENGINES	0.0
TOTAL PROD DEV	181.06
TOTAL PROCUREMENT	60956.51

* - MILLIONS OF DOLLARS

** -1000 OF DOLLARS OR HOURS PER PROD A/C

*** - INCLUDES PROD DATA, SYSTEMS ENGR AND OTHER SYSTEMS

MUX
No RSS

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)

	C/SM***	PERCENT
FLIGHT CREW	0.22560	13.65642
FUEL AND OIL	0.50615	30.63913
INSURANCE	0.02533	1.53303
DEPRECIATION	0.55662	33.69440
MAINTENANCE	0.33827	20.47701
TOTAL DOC	1.65197	100.000

INDIRECT OPERATIONAL COST (IOC)

	C/SM***	PERCENT
SYSTEM	0.03081	2.46995
LOCAL	0.07303	5.85506
AIRCRAFT CONTROL	0.00202	0.16189
CABIN ATTENDANT	0.22697	18.19630
FOOD AND BEVERAGE	0.13629	10.92590
PASSENGER HANDLING	0.15707	12.59215
CARGO HANDLING	0.05804	4.65338
OTHER PASSENGER EXPENSE	0.42408	33.99820
OTHER CARGO EXPENSE	0.00853	0.68357
GENERAL + ADMINISTRATION	0.13052	10.46363
TOTAL IOC	1.24736	100.000

MISC. DATA

FLIGHT DISTANCE (N. MI.)	2999.95
BLOCK FUEL (LBS)	83288.38
BLOCK TIME (HRS)	7.23
FLIGHT TIME (HRS)	6.80
AVG STAGE LENGTH (N. MI.)	1144.00
AVG CARGO PER FLIGHT	17413.00
UTILIZATION (HRS PER YR)	3636.00
FLIGHTS PER A/C PER YEAR	502.86
FARE ($)	357.59
FUEL COST ($/LB)	0.39000

*** - CENTS PER SEAT N. MILE

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR	CUMULATIVE DEPRECIATION	AVERAGE BOOK VALUE OF FLEET	REVENUE	INTEREST EXPENSE	OPERATING EXPENSE	CASH FLOW	ROI
			$M	$M	$M	$M	$M	$M	$M	PERCENT
1	6.3	10.0	445.00	26.70	418.30	345.38	42.72	136.68	-89.67	30.05
2	16.3	10.0	1156.99	96.12	1060.87	898.00	104.24	355.37	32.30	30.49
3	20.0	0.0	1423.99	181.56	1242.43	1105.23	116.20	437.38	247.35	31.55
4	20.0	0.0	1423.99	267.00	1156.99	1105.23	102.53	437.38	254.18	33.29
5	20.0	0.0	1423.99	352.44	1071.55	1105.23	88.86	437.38	261.02	35.31
6	20.0	0.0	1423.99	437.87	986.11	1105.23	75.19	437.38	267.85	37.68
7	20.0	0.0	1423.99	523.31	900.67	1105.23	61.52	437.38	274.69	40.49
8	20.0	0.0	1423.99	608.75	815.23	1105.23	47.85	437.38	281.52	43.90
9	20.0	0.0	1423.99	694.19	729.79	1105.23	34.18	437.38	288.36	48.10
10	20.0	0.0	1423.99	779.63	644.36	1105.23	20.51	437.38	295.19	53.41

AVG ROI OVER THE 10 YEAR PERIOD = 37.60 PERCENT

MUX
No RSS

SUMMARY ID NO. 1 — A S S E T   P A R A M E T R I C   A N A L Y S I S — APRIL 29 1980

AIRCRAFT MODEL -- CL1332-1
I.O.C. DATE --1985
DESIGN SPEED --SUBSONIC

ENGINE I.D. -- 416000
SLS SCALE 1.0 = 40850
NUMBER OF ENGINES = 3.

WING QUARTER CHORD SWEEP = 30.00 DEG
WING TAPER RATIO = 0.300

1 W/S	114.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 T/W	0.255	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 AR	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 T/C	13.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 SWEEP	30.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 FPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 OPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8 TIT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9 NPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 AUG T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11 RADIUS N. MI	3000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 GROSS WEIGHT	457597	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 FUEL WEIGHT	99473	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 OP. WT. EMPTY	258124	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ZERO FUEL WT.	358124	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 ENGIN. SCALE	0.952	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17 THRUS./ENGINE	38876	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 WING AREA	3986.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19 WING SPAN	199.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20 H. TAIL AREA	920.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 V. TAIL AREA	573.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22 ENG. LENGTH	10.27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23 ENG. DIAMETER	7.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24 BODY LENGTH	228.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25 WING FUEL LIMIT	2.994	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COST DATA																
26 RDTE - BIL.	3.073	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27 FLYAWAY - MIL.	62.84	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 INVESTMNT-BIL.	1.424	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 DOC - C/SM	1.652	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30 IOC - C/SM	1.247	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31 ROI A.T. - 0/0	37.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MISSION PARAMETERS																
32 MISN V1(1,1)	37000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33 MISN V2(1,1)	83288	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSTRAINT OUTPUT																
34 TAKEOFF DST(1)	6968	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35 CLIMB GRAD(1)	0.1141	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36 TAKEOFF DST(2)	6617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37 CLIMB GRAD(2)	0.0411	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38 CTOL LNDG D(1)	6115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39 AP SPEED-KT(1)	136.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40 SEP(1) - FPS	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41 SEP(2) - FPS	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

MUX
No RSS

E**3 AIRCRAFT / 500 PASS / 3000 N MI / M = .80 MISS

T/C=13.00 AR=10.00 W/S=114.80 T/W=0.255

WEIGHT STATEMENT

	WEIGHT(POUNDS)	WEIGHT FRACTION	(PERCENT)
GROSS WEIGHT	(457519.)		
FUEL AVAILABLE	99458.	FUEL	21.74
EXTERNAL	0.		
INTERNAL	99454.		
ZERO FUEL WEIGHT	358060.		
PAYLOAD	100000.	PAYLOAD	21.86
PASSENGERS	85000.		
BAGGAGE	0.		
CARGO	15000.		
STORES	0.		
OPERATIONAL EMPTY WEIGHT	258060.		
OPERATIONAL ITEMS	16187.	OPERATIONAL ITEMS	4.72
STANDARD ITEMS	5409.		
EMPTY WEIGHT	236464.		
STRUCTURE	136217.	STRUCTURE	29.77
WING	48663.		
ROTOR	0.		
TAIL	5825.		
BODY	56637.		
ALIGHTING GEAR	18936.		
ENGINE SECTION AND NACELLE	6157.		
PROPULSION	29173.	PROPULSION	6.38
CRUISE ENGINES	22534.		
LIFT ENGINES	0.		
THRUST REVERSER	4430.		
EXHAUST SYSTEM	0.		
ENGINE CONTROL	198.		
STARTING SYSTEM	532.		
PROPELLERS	0.		
LUBRICATING SYSTEM	0.		
FUEL SYSTEM	1478.		
DRIVE SYSTEM (POWER TRANS)	0.		
SYSTEMS	71074.		
FLIGHT CONTROLS	5091.		
AUXILIARY POWER PLANT	1116.		
INSTRUMENTS	901.		
HYDRAULIC AND PNEUMATIC	2698.		
ELECTRICAL	5961.		
AVIONICS	2926.	SYSTEMS	15.53
ARMAMENT	0.		
FURNISHINGS AND EQUIPMENT	44293.		
AIR CONDITIONING	7682.		
ANTI-ICING	408.		
PHOTOGRAPHIC	0.		
LOAD AND HANDLING	0.		
		TOTAL	(100.)

RLG
No RSS

COST SUMMARY

RDT AND E

	TOTAL *
DEVELOPMENT - NONRECURRING	
ENGINEERING	1129.11
TOOLING	732.98
TEST ARTICLES	88.75
DATA	0.0
SYSTEMS ENG/MNGMT	0.0
CRUISE ENGINE	0.0
LIFT ENGINE	0.0
FAN	0.0
AVIONICS	23.70
OTHER SYSTEMS	0.0
FACILITIES	0.0
TOTAL AIR VEHICLE	1974.53
INTEGR LOGISTICS SUPPORT	
PLANNING	10.01
TRAINING	3.40
HANDBOOKS	23.04
SSE	4.90
TOTAL ILS	41.36
TOTAL DVLPMNT-NONREC	2015.90
DEVELOPMENT - RECUR(PROTOTYPES)	
AIR VEHICLE	839.15
SPARES	216.33
TOTAL DVLPMNT-RECUR	1055.48
GOVMNT DVLPMNT COST	0.0
TOTAL DVLPMNT COST	3071.37

PRODUCTION

	MATERIAL	LABOR	TOTAL PER PROD A/C**
STRUCTURE	5569.57	15977.23	21546.80
WING	2515.18	3292.31	5807.49
ROTOR	0.0	0.0	0.0
TAIL	251.13	511.83	762.96
BODY	1660.76	10971.60	12632.36
ALIGHTING GEAR	817.82	37.99	855.81
ENG SECT + NACELLE	324.68	1163.50	1488.18
ENG SECTION	0.0	0.0	0.0
NACELLE	244.21	1055.92	1300.13
AIR INDUCTION	80.47	107.58	188.05
PROPULSION	156.09	146.14	302.23
ENGINE INSTALL	0.0	35.09	35.09
THRUST REVERSER	0.0	6.90	6.90
EXHAUST SYSTEM	0.0	0.0	0.0
ENGINE CONTROLS	4.59	6.53	11.12
STARTING SYSTEM	70.56	11.99	82.55
PROPELLER INSTALL	0.0	0.0	0.0
LUBRICATING SYSTEM	0.0	0.0	0.0
FUEL SYSTEM	80.94	85.64	166.58
DRIVE SYS(PWR TRN)	0.0	0.0	0.0
SYSTEMS	3776.81	9131.55	12908.36
FLIGHT CONTROLS	785.13	404.31	1189.44
AUX POWER PLANT	166.85	27.19	194.04
INSTRUMENTS	86.33	75.51	161.84
HYDRAULIC + PNEUM	178.93	433.81	612.74
ELECTRICAL	546.02	1392.26	1938.28
AVIONIC INSTALL	52.37	523.15	575.52
ARMAMENT	0.0	0.0	0.0
FURN AND EQUIP	1399.06	5601.76	7000.82
AIR CONDITIONING	533.80	639.64	1173.43
ANTI-ICING	28.32	33.94	62.26
PHOTOGRAPHIC	0.0	0.0	0.0
LOAD AND HANDLING	0.0	0.0	0.0
SYSTEMS INTEGR	746.91	710.16	1457.07
TOTAL COST	10249.38	25964.99	36214.37
TOTAL HRS **		778.56	778.56
ENG CHANGE ORDERS			1187.69
SUSTAINING ENG COST			2102.28
PROD TOOLING COST			2193.59
QUALITY ASSURANCE			3491.85
MISCELLANEOUS ***			791.99
TOTAL AIRFRAME COST			45981.74
ENGINE COST			5242.34
AVIONICS COST			851.67
TOTAL MANUFACTURING COST			52075.74
WARRANTY			279.22
TOTAL PRODUCTION COST			52354.96

PROCUREMENT

	PER PROD A/C**
TOTAL PRODUCTION	52354.96
INTEGR LOGISTICS SUPPORT	
PLANNING	30.62
TRAINING	10.41
TRAINERS	360.68
HANDBOOKS	45.68
FACILITIES	0.0
SSE - CFE	26.18
SSE - GFE	751.87
TOTAL ILS	1224.63
INITIAL SPARES COST	7131.59
PRODUCTION DEVELOPMENT	
ENGINEERING	368.34
TOOLING	-186.65
ENGINES	0.0
TOTAL PROD DEV	181.69
TOTAL PROCUREMENT	60892.85

* - MILLIONS OF DOLLARS

** -1000 OF DOLLARS OR HOURS PER PROD A/C

*** - INCLUDES PROD DATA, SYSTEMS ENGR AND OTHER SYSTEMS

RLG
No RSS

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)	C/SM***	PERCENT
FLIGHT CREW	0.22560	13.67717
FUEL AND OIL	0.50607	30.68117
INSURANCE	0.02530	1.53385
DEPRECIATION	0.55608	33.71265
MAINTENANCE	0.33641	20.39511
TOTAL DOC	1.64946	100.000

INDIRECT OPERATIONAL COST (IOC)	C/SM***	PERCENT
SYSTEM	0.03059	2.45321
LOCAL	0.07302	5.85575
AIRCRAFT CONTROL	0.00202	0.16194
CABIN ATTENDANT	0.22697	18.20155
FOOD AND BEVERAGE	0.13629	10.92905
PASSENGER HANDLING	0.15707	12.59578
CARGO HANDLING	0.05804	4.65472
OTHER PASSENGER EXPENSE	0.42408	34.00800
OTHER CARGO EXPENSE	0.00853	0.68377
GENERAL + ADMINISTRATION	0.13039	10.45627
TOTAL IOC	1.24700	100.000

MISC. DATA	
FLIGHT DISTANCE (N. MI.)	2999.95
BLOCK FUEL (LBS)	83276.13
BLOCK TIME (HRS)	7.23
FLIGHT TIME (HRS)	6.80
AVG STAGE LENGTH (N. MI.)	1144.00
AVG CARGO PER FLIGHT	17413.00
UTILIZATION (HRS PER YR)	3636.08
FLIGHTS PER A/C PER YEAR	502.86
FARE ($)	357.59
FUEL COST ($/LB)	0.09000

*** - CENTS PER SEAT N. MILE

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR	CUMULATIVE DEPRECIATION	AVERAGE BOOK VALUE OF FLEET	REVENUE	INTEREST EXPENSE	OPERATING EXPENSE	CASH FLOW	ROI
			$M	$M	$M	$M	$M	$M	$M	PERCENT
1	6.3	10.0	444.57	26.67	417.89	345.38	42.68	136.55	-89.41	30.09
2	16.3	10.0	1155.87	96.03	1059.85	898.00	104.14	355.02	32.70	30.53
3	20.0	0.0	1422.61	181.38	1241.23	1105.23	116.09	436.95	247.65	31.60
4	20.0	0.0	1422.61	266.74	1155.87	1105.23	102.43	436.95	254.47	33.34
5	20.0	0.0	1422.61	352.10	1070.52	1105.23	88.77	436.95	261.30	35.36
6	20.0	0.0	1422.61	437.45	985.16	1105.23	75.11	436.95	268.13	37.73
7	20.0	0.0	1422.61	522.81	899.81	1105.23	61.46	436.95	274.96	40.55
8	20.0	0.0	1422.61	608.17	814.45	1105.23	47.80	436.95	281.79	43.96
9	20.0	0.0	1422.61	693.52	729.09	1105.23	34.14	436.95	288.62	48.17
10	20.0	0.0	1422.61	778.88	643.74	1105.23	20.49	436.95	295.45	53.50

AVG ROI OVER THE 10 YEAR PERIOD = 37.66 PERCENT

RLG
No RSS

C-3

SUMMARY ID NO. 1 — A S S E T   P A R A M E T R I C   A N A L Y S I S — APRIL 29 1980

AIRCRAFT MODEL -- CL1332-1
I.O.C. DATE --1985
DESIGN SPEED --SUBSONIC

ENGINE I.D. -- 416000
SLS SCALE 1.0 = 40850
NUMBER OF ENGINES = 3.

WING QUARTER CHORD SWEEP = 30.00 DEG
WING TAPER RATIO = 0.300

1 W/S	114.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 T/W	0.255	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 AR	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 T/C	13.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 SWEEP	30.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 FPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 OPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8 TIT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9 NFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 AUG T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11 RADIUS N. MI	3000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 GROSS WEIGHT	457519	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 FUEL WEIGHT	99458	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 OP. WT. EMPTY	258060	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ZERO FUEL WT.	358060	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 ENGINE SCALE	0.952	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17 THRUST/ENGINE	38889	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 WING AREA	3985.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19 WING SPAN	199.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20 H. TAIL AREA	919.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 V. TAIL AREA	572.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22 ENG. LENGTH	10.27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23 ENG. DIAMETER	7.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24 BODY LENGTH	228.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25 WING FUEL LIMIT	2.994	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COST DATA																
26 RDTE - BIL.	3.071	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27 FLYAWAY - MIL.	62.77	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 INVESTMNT-BIL.	1.423	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 DOC - C/SM	1.649	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30 IOC - C/SM	1.247	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31 ROI A.T. - O/O	37.66	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MISSION PARAMETERS																
32 MISN V1(1,1)	37000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33 MISN V2(1,1)	83276	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSTRAINT OUTPUT																
34 TAKEOFF DST(1)	6968	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35 CLIMB GRAD(1)	0.1141	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36 TAKEOFF DST(2)	6617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37 CLIMB GRAD(2)	0.0411	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38 CTOL LNDG D(1)	6115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39 AP SPEED-KT(1)	136.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40 SEP(1) - FPS	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41 SEP(2) - FPS	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

RLG
No RSS

E**3 AIRCRAFT / 500 PASS / 3000 N MI / M = .80 MISS

T/C=13.00 AR=10.00 W/S=114.80 T/W=0.255

W E I G H T   S T A T E M E N T

	WEIGHT(POUNDS)	WEIGHT FRACTION	(PERCENT)
GROSS WEIGHT	(457414.)		
FUEL AVAILABLE	99438.	FUEL	21.74
EXTERNAL	0.		
INTERNAL	99434.		
ZERO FUEL WEIGHT	357975.		
PAYLOAD	100000.	PAYLOAD	21.86
PASSENGERS	85000.		
BAGGAGE	0.		
CARGO	15000.		
STORES	0.		
OPERATIONAL EMPTY WEIGHT	257975.		
OPERATIONAL ITEMS	16187.	OPERATIONAL ITEMS	4.72
STANDARD ITEMS	5409.		
EMPTY WEIGHT	236379.		
STRUCTURE	136191.	STRUCTURE	29.77
WING	48647.		
ROTOR	0.		
TAIL	5822.		
BODY	56634.		
ALIGHTING GEAR	18932.		
ENGINE SECTION AND NACELLE	6155.		
PROPULSION	29166.	PROPULSIÓN	6.38
CRUISE ENGINES	22528.		
LIFT ENGINES	0.		
THRUST REVERSER	4430.		
EXHAUST SYSTEM	0.		
ENGINE CONTROL	198.		
STARTING SYSTEM	532.		
PROPELLERS	0.		
LUBRICATING SYSTEM	0.		
FUEL SYSTEM	1478.		
DRIVE SYSTEM (POWER TRANS)	0.		
SYSTEMS	71022.		
FLIGHT CONTROLS	5091.		
AUXILIARY POWER PLANT	1116.		
INSTRUMENTS	901.		
HYDRAULIC AND PNEUMATIC	2697.		
ELECTRICAL	5961.	SYSTEMS	15.53
AVIONICS	2875.		
ARMAMENT	0.		
FURNISHINGS AND EQUIPMENT	44293.		
AIR CONDITIONING	7682.		
ANTI-ICING	407.		
PHOTOGRAPHIC	0.		
LOAD AND HANDLING	0.	TOTAL	(100.)

Integrated Avionics
No RSS

COST SUMMARY

RDT AND E

	TOTAL *
DEVELOPMENT - NONRECURRING	
ENGINEERING	1128.16
TOOLING	732.90
TEST ARTICLES	88.71
DATA	0.0
SYSTEMS ENG/MNGMT	0.0
CRUISE ENGINE	0.0
LIFT ENGINE	0.0
FAN	0.0
AVIONICS	19.10
OTHER SYSTEMS	0.0
FACILITIES	0.0
TOTAL AIR VEHICLE	1968.87
INTEGR LOGISTICS SUPPORT	
PLANNING	10.01
TRAINING	3.40
HANDBOOKS	22.83
SSE	4.90
TOTAL ILS	41.15
TOTAL DVLPMNT-NONREC	2010.02
DEVELOPMENT - RECUR(PROTOTYPES)	
AIR VEHICLE	838.54
SPARES	216.24
TOTAL DVLPMNT-RECUR	1054.79
GOVMNT DVLPMNT COST	0.0
TOTAL DVLPMNT COST	3064.80

Integrated Avionics
No RSS

PRODUCTION

	MATERIAL	LABOR	TOTAL PER PROD A/C**
STRUCTURE	5568.38	15975.42	21543.79
WING	2514.40	3291.34	5805.73
ROTOR	0.0	0.0	0.0
TAIL	251.04	511.66	762.70
BODY	1660.68	10971.22	12631.90
ALIGHTING GEAR	817.67	37.98	855.65
ENG SECT + NACELLE	324.59	1163.22	1487.81
ENG SECTION	0.0	0.0	0.0
NACELLE	244.15	1055.66	1299.81
AIR INDUCTION	80.45	107.56	188.00
PROPULSION	156.08	146.12	302.20
ENGINE INSTALL	0.0	35.08	35.08
THRUST REVERSER	0.0	6.90	6.90
EXHAUST SYSTEM	0.0	0.0	0.0
ENGINE CONTROLS	4.59	6.52	11.12
STARTING SYSTEM	70.56	11.99	82.55
PROPELLER INSTALL	0.0	0.0	0.0
LUBRICATING SYSTEM	0.0	0.0	0.0
FUEL SYSTEM	80.93	85.63	166.55
DRIVE SYS(PWR TRN)	0.0	0.0	0.0
SYSTEMS	3775.80	9122.44	12898.25
FLIGHT CONTROLS	785.09	404.29	1189.39
AUX POWER PLANT	166.85	27.19	194.04
INSTRUMENTS	86.32	75.50	161.82
HYDRAULIC + PNEUM	178.90	433.73	612.63
ELECTRICAL	546.00	1392.23	1938.23
AVIONIC INSTALL	51.46	514.04	565.50
ARMAMENT	0.0	0.0	0.0
FURN AND EQUIP	1399.06	5601.88	7000.94
AIR CONDITIONING	533.80	639.65	1173.45
ANTI-ICING	28.32	33.93	62.25
PHOTOGRAPHIC	0.0	0.0	0.0
LOAD AND HANDLING	0.0	0.0	0.0
SYSTEMS INTEGR	746.64	709.92	1456.56
TOTAL COST	10246.91	25953.87	36200.77
TOTAL HRS **		778.23	778.23
ENG CHANGE ORDERS			1187.24
SUSTAINING ENG COST			2101.20
PROD TOOLING COST			2192.65
QUALITY ASSURANCE			3490.35
MISCELLANEOUS ***			791.65
TOTAL AIRFRAME COST			45963.82
ENGINE COST			5241.59
AVIONICS COST			792.42
TOTAL MANUFACTURING COST			51997.82
WARRANTY			278.88
TOTAL PRODUCTION COST			52276.70

PROCUREMENT

	PER PROD A/C**
TOTAL PRODUCTION	52276.70
INTEGR LOGISTICS SUPPORT	
PLANNING	30.61
TRAINING	10.41
TRAINERS	360.68
HANDBOOKS	45.44
FACILITIES	0.0
SSE - CFE	26.14
SSE - GFE	751.07
TOTAL ILS	1224.34
INITIAL SPARES COST	7122.71
PRODUCTION DEVELOPMENT	
ENGINEERING	368.27
TOOLING	-185.75
ENGINES	0.0
TOTAL PROD DEV	182.52
TOTAL PROCUREMENT	60806.25

* - MILLIONS OF DOLLARS

** -1000 OF DOLLARS OR HOURS PER PROD A/C

*** - INCLUDES PROD DATA, SYSTEMS ENGR AND OTHER SYSTEMS

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)	C/SM***	PERCENT
FLIGHT CREW	0.22560	13.69038
FUEL AND OIL	0.50597	30.70464
INSURANCE	0.02526	1.53290
DEPRECIATION	0.55522	33.69298
MAINTENANCE	0.33582	20.37909
TOTAL DOC	1.64787	100.000

INDIRECT OPERATIONAL COST (IOC)	C/SM***	PERCENT
SYSTEM	0.03052	2.44803
LOCAL	0.07300	5.85503
AIRCRAFT CONTROL	0.00202	0.16196
CABIN ATTENDANT	0.22697	18.20349
FOOD AND BEVERAGE	0.13629	10.93021
PASSENGER HANDLING	0.15707	12.59712
CARGO HANDLING	0.05804	4.65522
OTHER PASSENGER EXPENSE	0.42408	34.01161
OTHER CARGO EXPENSE	0.00853	0.68384
GENERAL + ADMINISTRATION	0.13034	10.45353
TOTAL IOC	1.24687	100.000

MISC. DATA	
FLIGHT DISTANCE (N. MI.)	2999.95
BLOCK FUEL (LBS)	83259.38
BLOCK TIME (HRS)	7.23
FLIGHT TIME (HRS)	6.80
AVG STAGE LENGTH (N. MI.)	1144.00
AVG CARGO PER FLIGHT	17413.00
UTILIZATION (HRS PER YR)	3636.00
FLIGHTS PER A/C PER YEAR	502.86
FARE ($)	357.59
FUEL COST ($/LB)	0.09000

*** - CENTS PER SEAT N. MILE

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR	CUMULATIVE DEPRECIATION	AVERAGE BOOK VALUE OF FLEET	REVENUE	INTEREST EXPENSE	OPERATING EXPENSE	CASH FLOW	ROI
			$M	$M	$M	$M	$M	$M	$M	PERCENT
1	6.3	10.0	443.89	26.63	417.26	345.38	42.61	136.46	-89.08	30.14
2	16.3	10.0	1154.11	95.88	1058.23	898.00	103.98	354.81	33.17	30.58
3	20.0	0.0	1420.44	181.11	1239.34	1105.23	115.91	436.69	247.91	31.65
4	20.0	0.0	1420.44	266.33	1154.11	1105.23	102.27	436.69	254.73	33.39
5	20.0	0.0	1420.44	351.56	1068.89	1105.23	88.64	436.69	261.54	35.42
6	20.0	0.0	1420.44	436.79	983.66	1105.23	75.00	436.69	268.36	37.79
7	20.0	0.0	1420.44	522.01	898.43	1105.23	61.36	436.69	275.18	40.62
8	20.0	0.0	1420.44	607.24	813.21	1105.23	47.73	436.69	282.00	44.04
9	20.0	0.0	1420.44	692.46	727.98	1105.23	34.09	436.69	283.82	48.26
10	20.0	0.0	1420.44	777.69	642.75	1105.23	20.45	436.69	295.63	53.60

AVG ROI OVER THE 10 YEAR PERIOD = 37.72 PERCENT

Integrated Avionics
No RSS

SUMMARY ID NO. 1 — A S S E T   P A R A M E T R I C   A N A L Y S I S — APRIL 29 1980

AIRCRAFT MODEL -- CL1332-1
I.O.C. DATE --1985
DESIGN SPEED --SUBSONIC

ENGINE I.D. -- 416000
SLS SCALE 1.0 = 40850
NUMBER OF ENGINES = 3.

WING QUARTER CHORD SWEEP = 30.00 DEG
WING TAPER RATIO = 0.300

1 W/S	114.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 T/W	0.255	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 AR	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 T/C	13.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 SWEEP	30.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 FPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 OFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8 TIT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9 NFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 AUG T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11 RADIUS N. MI	3000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 GROSS WEIGHT	457414	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 FUEL WEIGHT	99438	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 OP. WT. EMPTY	257975	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ZERO FUEL WT.	357975	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 ENGINE SCALE	0.952	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17 THRUST/ENGINE	38880	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 WING AREA	3934.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19 WING SPAN	199.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20 H. TAIL AREA	919.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 V. TAIL AREA	572.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22 ENG. LENGTH	10.27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23 ENG. DIAMETER	7.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24 BODY LENGTH	228.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25 WING FUEL LIMIT	2.993	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COST DATA																
26 RDTE - BIL.	3.065	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27 FLYAWAY - MIL.	62.68	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 INVESTMNT-BIL.	1.420	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 DOC - C/SM	1.648	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30 IOC - C/SM	1.247	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31 ROI A.T. - 0/0	37.72	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MISSION PARAMETERS																
32 MISN V1(1,1)	37000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33 MISN V2(1,1)	83259	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSTRAINT OUTPUT																
34 TAKEOFF DST(1)	6968	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35 CLIMB GRAD(1)	0.1141	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36 TAKEOFF DST(2)	6617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37 CLIMB GRAD(2)	0.0411	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38 CTOL LNDG D(1)	6115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39 AP SPEED-KT(1)	136.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40 SEP(1) - FPS	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41 SEP(2) - FPS	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Integrated Avionics
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E**3 AIRCRAFT / 500 PASS / 3000 N MI / M = .80 MISS

T/C=13.00 AR=10.00 W/S=114.80 T/W=0.255

W E I G H T   S T A T E M E N T

	WEIGHT(POUNDS)		WEIGHT FRACTION	(PERCENT)
GROSS WEIGHT	(440743.)			
FUEL AVAILABLE		93922.	FUEL	21.31
EXTERNAL	0.			
INTERNAL	93918.			
ZERO FUEL WEIGHT		346821.		
PAYLOAD		100000.	PAYLOAD	22.69
PASSENGERS	85000.			
BAGGAGE	0.			
CARGO	15000.			
STORES	0.			
OPERATIONAL EMPTY WEIGHT		246821.		
OPERATIONAL ITEMS	16183.		OPERATIONAL ITEMS	4.90
STANDARD ITEMS	5401.			
EMPTY WEIGHT		225237.		
STRUCTURE	131949.		STRUCTURE	29.94
WING	46432.			
ROTOR	0.			
TAIL	5493.			
BODY	56167.			
ALIGHTING GEAR	18009.			
ENGINE SECTION AND NACELLE	5850.			
PROPULSION	26923.		PROPULSION	6.11
CRUISE ENGINES	21313.			
LIFT ENGINES	0.			
THRUST REVERSER	4232.			
EXHAUST SYSTEM	0.			
ENGINE CONTROL	191.			
STARTING SYSTEM	503.			
PROPELLERS	0.			
LUBRICATING SYSTEM	0.			
FUEL SYSTEM	1432.			
DRIVE SYSTEM (POWER TRANS)	0.			
SYSTEMS	66364.		SYSTEMS	15.06
FLIGHT CONTROLS	5069.			
AUXILIARY POWER PLANT	1116.			
INSTRUMENTS	881.			
HYDRAULIC AND PNEUMATIC	0.			
ELECTRICAL	5484.			
AVIONICS	2875.			
ARMAMENT	0.			
FURNISHINGS AND EQUIPMENT	44293.			
AIR CONDITIONING	6177.			
ANTI-ICING	469.			
PHOTOGRAPHIC	0.			
LOAD AND HANDLING	0.			
			TOTAL	(100.)

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COST SUMMARY

RDT AND E

	TOTAL *
DEVELOPMENT - NONRECURRING	
ENGINEERING	1052.68
TOOLING	705.58
TEST ARTICLES	85.39
DATA	0.0
SYSTEMS ENG/MNGMT	0.0
CRUISE ENGINE	0.0
LIFT ENGINE	0.0
FAN	0.0
AVIONICS	23.18
OTHER SYSTEMS	0.0
FACILITIES	0.0
TOTAL AIR VEHICLE	1866.83
INTEGR LOGISTICS SUPPORT	
PLANNING	9.80
TRAINING	3.33
HANDBOOKS	20.55
SSE	4.80
TOTAL ILS	38.49
TOTAL DVLPMNT-NONREC	1905.32
DEVELOPMENT - RECUR(PROTOTYPES)	
AIR VEHICLE	810.48
SPARES	208.69
TOTAL DVLPMNT-RECUR	1019.17
GOVMNT DVLPMNT COST	0.0
TOTAL DVLPMNT COST	2924.48

PRODUCTION

	MATERIAL	LABOR	TOTAL PER PROD A/C**
STRUCTURE	5373.36	15687.34	21060.69
WING	2401.56	3150.38	5551.94
ROTOR	0.0	0.0	0.0
TAIL	236.99	484.05	721.04
BODY	1648.13	10911.64	12559.77
ALIGHTING GEAR	778.33	36.23	814.56
ENG SECT + NACELLE	308.36	1105.03	1413.39
ENG SECTION	0.0	0.0	0.0
NACELLE	231.14	1001.56	1232.69
AIR INDUCTION	77.22	103.47	180.69
PROPULSION	149.66	140.78	290.44
ENGINE INSTALL	0.0	33.28	33.28
THRUST REVERSER	0.0	6.61	6.61
EXHAUST SYSTEM	0.0	0.0	0.0
ENGINE CONTROLS	4.43	6.30	10.73
STARTING SYSTEM	66.75	11.36	78.11
PROPELLER INSTALL	0.0	0.0	0.0
LUBRICATING SYSTEM	0.0	0.0	0.0
FUEL SYSTEM	78.48	83.22	161.70
DRIVE SYS(PWR TRN)	0.0	0.0	0.0
SYSTEMS	3514.68	8510.76	12025.44
FLIGHT CONTROLS	846.83	436.52	1283.35
AUX POWER PLANT	166.97	27.26	194.23
INSTRUMENTS	84.46	74.03	158.49
HYDRAULIC + PNEUM	0.0	0.0	0.0
ELECTRICAL	502.72	1284.62	1787.34
AVIONIC INSTALL	51.50	515.51	567.00
ARMAMENT	0.0	0.0	0.0
FURN AND EQUIP	1400.04	5617.83	7017.88
AIR CONDITIONING	429.54	515.82	945.36
ANTI-ICING	32.62	39.17	71.78
PHOTOGRAPHIC	0.0	0.0	0.0
LOAD AND HANDLING	0.0	0.0	0.0
SYSTEMS INTEGR	711.94	678.38	1390.33
TOTAL COST	9749.65	25017.17	34766.81
TOTAL HRS **		750.14	750.14
ENG CHANGE ORDERS			1140.57
SUSTAINING ENG COST			2010.09
PROD TOOLING COST			2113.52
QUALITY ASSURANCE			3364.38
MISCELLANEOUS ***			763.08
TOTAL AIRFRAME COST			44158.41
ENGINE COST			5132.37
AVIONICS COST			1099.55
TOTAL MANUFACTURING COST			50390.34
WARRANTY			269.25
TOTAL PRODUCTION COST			50659.58

PROCUREMENT

	PER PROD A/C**
TOTAL PRODUCTION	50659.58
INTEGR LOGISTICS SUPPORT	
PLANNING	30.11
TRAINING	10.24
TRAINERS	360.68
HANDBOOKS	43.22
FACILITIES	0.0
SSE - CFE	25.33
SSE - GFE	751.07
TOTAL ILS	1220.64
INITIAL SPARES COST	6908.11
PRODUCTION DEVELOPMENT	
ENGINEERING	362.23
TOOLING	-137.50
ENGINES	0.0
TOTAL PROD DEV	224.73
TOTAL PROCUREMENT	59013.05

* - MILLIONS OF DOLLARS

** -1000 OF DOLLARS OR HOURS PER PROD A/C

*** - INCLUDES PROD DATA, SYSTEMS ENGR AND OTHER SYSTEMS

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OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)	C/SM***	PERCENT
FLIGHT CREW	0.22560	14.26494
FUEL AND OIL	0.47524	30.04950
INSURANCE	0.02444	1.54518
DEPRECIATION	0.53727	33.97166
MAINTENANCE	0.31897	20.16873
TOTAL DOC	1.58152	100.000

INDIRECT OPERATIONAL COST (IOC)	C/SM***	PERCENT
SYSTEM	0.02866	2.31289
LOCAL	0.07034	5.67642
AIRCRAFT CONTROL	0.00202	0.16295
CABIN ATTENDANT	0.22698	18.31594
FOOD AND BEVERAGE	0.13629	10.99774
PASSENGER HANDLING	0.15707	12.67478
CARGO HANDLING	0.05804	4.68392
OTHER PASSENGER EXPENSE	0.42408	34.22127
OTHER CARGO EXPENSE	0.00853	0.68806
GENERAL + ADMINISTRATION	0.12722	10.26602
TOTAL IOC	1.23923	100.000

MISC. DATA	
FLIGHT DISTANCE (N. MI.)	2999.94
BLOCK FUEL (LBS)	78199.31
BLOCK TIME (HRS)	7.23
FLIGHT TIME (HRS)	6.80
AVG STAGE LENGTH (N. MI.)	1144.00
AVG CARGO PER FLIGHT	17413.00
UTILIZATION (HRS PER YR)	3636.00
FLIGHTS PER A/C PER YEAR	502.85
FARE ($)	357.59
FUEL COST ($/LB)	0.09000

*** - CENTS PER SEAT N. MILE

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR	CUMULATIVE DEPRECIATION	AVERAGE BOOK VALUE OF FLEET	REVENUE	INTEREST EXPENSE	OPERATING EXPENSE	CASH FLOW	ROI
			$M	$M	$M	$M	$M	$M	$M	PERCENT
1	6.3	10.0	429.76	25.79	403.97	345.38	41.26	132.97	-81.17	31.40
2	16.3	10.0	1117.37	92.83	1024.54	897.99	100.67	345.73	45.29	31.86
3	20.0	0.0	1375.23	175.34	1199.89	1105.21	112.22	425.52	256.23	33.00
4	20.0	0.0	1375.23	257.85	1117.37	1105.21	99.02	425.52	262.83	34.85
5	20.0	0.0	1375.23	340.37	1034.86	1105.21	85.81	425.52	269.44	36.99
6	20.0	0.0	1375.23	422.88	952.34	1105.21	72.61	425.52	276.04	39.50
7	20.0	0.0	1375.23	505.39	869.83	1105.21	59.41	425.52	282.64	42.49
8	20.0	0.0	1375.23	587.91	787.32	1105.21	46.21	425.52	289.24	46.10
9	20.0	0.0	1375.23	670.42	704.81	1105.21	33.01	425.52	295.84	50.56
10	20.0	0.0	1375.23	752.93	622.29	1105.21	19.80	425.52	302.44	56.20

AVG ROI OVER THE 10 YEAR PERIOD = 39.42 PERCENT

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SUMMARY ID NO. 1 — A S S E T   P A R A M E T R I C   A N A L Y S I S — MAY 02 1980

AIRCRAFT MODEL -- CL1332-1
I.O.C. DATE --1985
DESIGN SPEED --SUBSONIC

ENGINE I.D. -- 416000
SLS SCALE 1.0 = 40850
NUMBER OF ENGINES = 3.

WING QUARTER CHORD SWEEP = 30.00 DEG
WING TAPER RATIO = 0.300

1 W/S	114.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 T/W	0.255	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 AR	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 T/C	13.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 SWEEP	30.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 FPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 OPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8 TIT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9 NPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 AUG T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11 RADIUS N. MI	3000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 GROSS WEIGHT	440743	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 FUEL WEIGHT	93922	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 OP. WT. EMPTY	246821	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ZERO FUEL WT.	346821	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 ENGINE SCALE	0.917	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17 THRUST/ENGINE	37463	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 WING AREA	3839.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19 WING SPAN	195.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20 H. TAIL AREA	867.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 V. TAIL AREA	540.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22 ENG. LENGTH	10.11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23 ENG. DIAMETER	6.93	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24 BODY LENGTH	228.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25 WING FUEL LIMIT	2.993	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COST DATA																
26 RDTE - BIL.	2.924	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27 FLYAWAY - MIL.	60.63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 INVESTMNT-BIL.	1.375	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 DOC - C/SM	1.582	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30 IOC - C/SM	1.239	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31 ROI A.T. - 0/0	39.42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MISSION PARAMETERS																
32 MISN V1(1,1)	37000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33 MISN V2(1,1)	78199	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSTRAINT OUTPUT																
34 TAKEOFF DST(1)	6977	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35 CLIMB GRAD(1)	0.1140	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36 TAKEOFF DST(2)	6628	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37 CLIMB GRAD(2)	0.0411	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38 CTOL LNDG D(1)	6130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39 AP SPEED-KT(1)	136.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40 SEP(1) - FPS	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41 SEP(2) - FPS	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

All Electric
No RSS

E**3 AIRCRAFT / 500 PASS / 3000 N MI / M = .80 MISS

T/C=13.00 AR=10.00 W/S=114.80 T/W=0.255

W E I G H T   S T A T E M E N T

	WEIGHT(POUNDS)	WEIGHT FRACTION	(PERCENT)
GROSS WEIGHT	(454372.)		
FUEL AVAILABLE	96718.	FUEL	21.29
EXTERNAL	0.		
INTERNAL	96713.		
ZERO FUEL WEIGHT	357655.		
PAYLOAD	100000.	PAYLOAD	22.01
PASSENGERS	85000.		
BAGGAGE	0.		
CARGO	15000.		
STORES	0.		
OPERATIONAL EMPTY WEIGHT	257655.		
OPERATIONAL ITEMS	16186.	OPERATIONAL ITEMS	4.75
STANDARD ITEMS	5405.		
EMPTY WEIGHT	236063.		
STRUCTURE	135609.	STRUCTURE	29.85
WING	48329.		
ROTOR	0.		
TAIL	5762.		
BODY	56578.		
ALIGHTING GEAR	18831.		
ENGINE SECTION AND NACELLE	6103.		
PROPULSION	28957.	PROPULSION	6.37
CRUISE ENGINES	22357.		
LIFT ENGINES	0.		
THRUST REVERSER	4410.		
EXHAUST SYSTEM	0.		
ENGINE CONTROL	197.		
STARTING SYSTEM	532.		
PROPELLERS	0.		
LUBRICATING SYSTEM	0.		
FUEL SYSTEM	1461.		
DRIVE SYSTEM (POWER TRANS)	0.		
SYSTEMS	71498.	SYSTEMS	15.74
FLIGHT CONTROLS	5506.		
AUXILIARY POWER PLANT	1116.		
INSTRUMENTS	877.		
HYDRAULIC AND PNEUMATIC	2681.		
ELECTRICAL	5954.		
AVIONICS	2964.		
ARMAMENT	0.		
FURNISHINGS AND EQUIPMENT	44293.		
AIR CONDITIONING	7682.		
ANTI-ICING	406.		
PHOTOGRAPHIC	0.		
LOAD AND HANDLING	0.		
		TOTAL	(100.)

FBW
with RSS

FBW

COST SUMMARY

RDT AND E

	TOTAL *
DEVELOPMENT - NONRECURRING	
ENGINEERING	1135.17
TOOLING	732.30
TEST ARTICLES	88.77
DATA	0.0
SYSTEMS ENG/MGMT	0.0
CRUISE ENGINE	0.0
LIFT ENGINE	0.0
FAN	0.0
AVIONICS	22.40
OTHER SYSTEMS	0.0
FACILITIES	0.0
TOTAL AIR VEHICLE	1976.64
INTEGR LOGISTICS SUPPORT	
PLANNING	9.98
TRAINING	3.39
HANDBOOKS	23.22
SSE	4.88
TOTAL ILS	41.47
TOTAL DVLPMNT-NONREC	2020.11
DEVELOPMENT - RECUR (PROTOTYPES)	
AIR VEHICLE	839.50
SPARES	216.41
TOTAL DVLPMNT-RECUR	1055.91
GOVMNT DVLPMNT COST	0.0
TOTAL DVLPMNT COST	3076.02

PRODUCTION

	MATERIAL	LABOR	TOTAL PER PROD A/C**
STRUCTURE	5540.94	15929.92	21470.86
WING	2497.97	3270.02	5767.98
ROTOR	0.0	0.0	0.0
TAIL	248.43	506.36	754.79
BODY	1659.07	10961.27	12620.34
ALIGHTING GEAR	813.34	37.78	851.12
ENG SECT + NACELLE	322.14	1154.49	1476.63
ENG SECTION	0.0	0.0	0.0
NACELLE	242.30	1047.72	1290.02
AIR INDUCTION	79.85	106.77	186.61
PROPULSION	155.13	144.81	299.94
ENGINE INSTALL	0.0	34.82	34.82
THRUST REVERSER	0.0	6.87	6.87
EXHAUST SYSTEM	0.0	0.0	0.0
ENGINE CONTROLS	4.56	6.48	11.04
STARTING SYSTEM	70.57	11.99	82.55
PROPELLER INSTALL	0.0	0.0	0.0
LUBRICATING SYSTEM	0.0	0.0	0.0
FUEL SYSTEM	80.00	84.66	164.66
DRIVE SYS(PWR TRN)	0.0	0.0	0.0
SYSTEMS	3853.35	9174.74	13028.10
FLIGHT CONTROLS	863.15	444.64	1307.78
AUX POWER PLANT	166.86	27.19	194.04
INSTRUMENTS	85.97	75.20	161.17
HYDRAULIC + PNEUM	177.83	431.18	609.02
ELECTRICAL	545.37	1390.70	1936.07
AVIONIC INSTALL	53.05	530.00	583.05
ARMAMENT	0.0	0.0	0.0
FURN AND EQUIP	1399.09	5602.32	7001.41
AIR CONDITIONING	533.81	639.70	1173.51
ANTI-ICING	28.22	33.82	62.05
PHOTOGRAPHIC	0.0	0.0	0.0
LOAD AND HANDLING	0.0	0.0	0.0
SYSTEMS INTEGR	745.66	709.03	1454.69
TOTAL COST	10295.09	25958.46	36253.55
TOTAL HRS **		778.37	778.37
ENG CHANGE ORDERS			1188.84
SUSTAINING ENG COST			2113.49
PROD TOOLING COST			2193.04
QUALITY ASSURANCE			3490.97
MISCELLANEOUS ***			791.79
TOTAL AIRFRAME COST			46031.64
ENGINE COST			5219.62
AVIONICS COST			828.49
TOTAL MANUFACTURING COST			52079.74
WARRANTY			279.43
TOTAL PRODUCTION COST			52359.17

PROCUREMENT

	PER PROD A/C**
TOTAL PRODUCTION	52359.17
INTEGR LOGISTICS SUPPORT	
PLANNING	30.53
TRAINING	10.38
TRAINERS	360.68
HANDBOOKS	45.82
FACILITIES	0.0
SSE - CFE	26.18
SSE - GFE	751.07
TOTAL ILS	1224.65
INITIAL SPARES COST	7128.44
PRODUCTION DEVELOPMENT	
ENGINEERING	367.23
TOOLING	-186.93
ENGINES	0.0
TOTAL PROD DEV	180.30
TOTAL PROCUREMENT	60892.53

* - MILLIONS OF DOLLARS

** -1000 OF DOLLARS OR HOURS PER PROD A/C

*** - INCLUDES PROD DATA, SYSTEMS ENGR AND OTHER SYSTEMS

FBW with RSS

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)	C/SM***	PERCENT
FLIGHT CREW	0.22561	13.81048
FUEL AND OIL	0.40920	29.94662
INSURANCE	0.02531	1.54925
DEPRECIATION	0.55621	34.04863
MAINTENANCE	0.33725	20.64499
TOTAL DOC	1.63359	100.000

INDIRECT OPERATIONAL COST (IOC)	C/SM***	PERCENT
SYSTEM	0.03074	2.46760
LOCAL	0.07252	5.82160
AIRCRAFT CONTROL	0.00202	0.16211
CABIN ATTENDANT	0.22698	18.22121
FOOD AND BEVERAGE	0.13629	10.94084
PASSENGER HANDLING	0.15707	12.60933
CARGO HANDLING	0.05804	4.65962
OTHER PASSENGER EXPENSE	0.42408	34.04375
OTHER CARGO EXPENSE	0.00853	0.69449
GENERAL + ADMINISTRATION	0.12942	10.38979
TOTAL IOC	1.24569	100.000

MISC. DATA	
FLIGHT DISTANCE (N. MI.)	2999.95
BLOCK FUEL (LBS)	80498.56
BLOCK TIME (HRS)	7.23
FLIGHT TIME (HRS)	6.83
AVG STAGE LENGTH (N. MI.)	1144.00
AVG CARGO PER FLIGHT	17413.80
UTILIZATION (HRS PER YR)	3636.00
FLIGHTS PER A/C PER YEAR	502.85
FARE ($)	357.59
FUEL COST ($/LB)	0.09000

*** - CENTS PER SEAT N. MILE

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR	CUMULATIVE DEPRECIATION	AVERAGE BOOK VALUE OF FLEET	REVENUE	INTEREST EXPENSE	OPERATING EXPENSE	CASH FLOW	ROI
			$M	$M	$M	$M	$M	$M	$M	PERCENT
1	6.3	10.0	444.66	26.68	417.98	345.37	42.69	135.73	-89.05	30.18
2	16.3	10.0	1155.12	96.05	1060.07	897.97	104.16	352.90	33.70	30.62
3	20.0	0.0	1422.92	181.42	1241.50	1105.20	116.11	434.34	248.91	31.69
4	20.0	0.0	1422.92	266.80	1156.12	1105.20	102.45	434.34	255.74	33.44
5	20.0	0.0	1422.92	352.17	1070.75	1105.20	88.79	434.34	262.57	35.47
6	20.0	0.0	1422.92	437.55	985.37	1105.20	75.13	434.34	269.40	37.85
7	20.0	0.0	1422.92	522.92	900.00	1105.20	61.47	434.34	276.23	40.68
8	20.0	0.0	1422.92	608.30	814.62	1105.20	47.81	434.34	283.06	44.11
9	20.0	0.0	1422.92	693.67	729.25	1105.20	34.15	434.34	289.89	48.34
10	20.0	0.0	1422.92	779.05	643.87	1105.20	20.49	434.34	296.72	53.69

AVG ROI OVER THE 10 YEAR PERIOD = 37.78 PERCENT

FBW with RSS
Fuel $.60/gal

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)	C/SM***	PERCENT
FLIGHT CREW	0.22561	8.82259
FUEL AND OIL	1.41276	55.24757
INSURANCE	0.02531	0.98972
DEPRECIATION	0.55621	21.75139
MAINTENANCE	0.33725	13.18871
TOTAL DOC	2.55714	100.000

INDIRECT OPERATIONAL COST (IOC)	C/SM***	PERCENT
SYSTEM	0.03074	2.36418
LOCAL	0.07252	5.57762
AIRCRAFT CONTROL	0.00202	0.15531
CABIN ATTENDANT	0.22698	17.45757
FOOD AND BEVERAGE	0.13629	10.48232
PASSENGER HANDLING	0.15707	12.08060
CARGO HANDLING	0.05804	4.46434
OTHER PASSENGER EXPENSE	0.42408	32.61700
OTHER CARGO EXPENSE	0.00853	0.65580
GENERAL + ADMINISTRATION	0.18391	14.14530
TOTAL IOC	1.30018	100.000

MISC. DATA	
FLIGHT DISTANCE (N. MI.)	2999.95
BLOCK FUEL (LBS)	80498.56
BLOCK TIME (HRS)	7.23
FLIGHT TIME (HRS)	6.89
AVG STAGE LENGTH (N. MI.)	1144.00
AVG CARGO PER FLIGHT	17413.00
UTILIZATION (HRS PER YR)	3636.00
FLIGHTS PER A/C PER YEAR	502.85
FARE ($)	357.59
FUEL COST ($/LB)	0.26000

*** - CENTS PER SEAT N. MILE

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR	CUMULATIVE DEPRECIATION	AVERAGE BOOK VALUE OF FLEET	REVENUE	INTEREST EXPENSE	OPERATING EXPENSE	CASH FLOW	ROI
			$M	$M	$M	$M	$M	$M	$M	PERCENT
1	6.3	10.0	444.66	26.68	417.98	345.37	42.69	181.84	-112.10	24.67
2	16.3	10.0	1156.12	96.05	1060.07	897.97	104.16	472.78	-26.24	24.97
3	20.0	0.0	1422.92	181.42	1241.50	1105.20	116.11	581.83	175.14	25.75
4	20.0	0.0	1422.92	266.80	1156.12	1105.20	102.45	581.88	181.97	27.06
5	20.0	0.0	1422.92	352.17	1070.75	1105.20	88.79	581.88	188.80	28.58
6	20.0	0.0	1422.92	437.55	985.37	1105.20	75.13	581.88	195.63	30.37
7	20.0	0.0	1422.92	522.92	900.00	1105.20	61.47	581.88	202.46	32.49
8	20.0	0.0	1422.92	608.30	814.62	1105.20	47.81	581.88	209.29	35.05
9	20.0	0.0	1422.92	693.67	729.25	1105.20	34.15	581.88	216.12	33.22
10	20.0	0.0	1422.92	779.05	643.87	1105.20	20.49	581.88	222.95	42.23

AVG ROI OVER THE 10 YEAR PERIOD = 30.31 PERCENT

FBW with RSS
Fuel $1.80/gal

SUMMARY ID NO. 1 — ASSET PARAMETRIC ANALYSIS — MAY 09 1980

AIRCRAFT MODEL -- CL1332-1
I.O.C. DATE --1985
DESIGN SPEED --SUBSONIC

ENGINE I.D. -- 416000
SLS SCALE 1.0 = 40850
NUMBER OF ENGINES = 3.

WING QUARTER CHORD SWEEP = 30.00 DEG
WING TAPER RATIO = 0.300

1 W/S	114.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 T/W	0.255	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 AR	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 T/C	13.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 SWEEP	30.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 F.R	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 OFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8 TIT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9 NPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 AUG T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11 RADIUS N. MI	3000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 GROSS WEIGHT	454372	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 FUEL WEIGHT	96718	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 OP. WT. EMPTY	257655	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ZERO FUEL WT.	357655	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 ENGINE SCALE	0.945	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17 THRUST/ENGINE	38622	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 WING AREA	3958.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19 WING SPAN	199.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20 H. TAIL AREA	909.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 V. TAIL AREA	566.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22 ENG. LENGTH	10.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23 ENG. DIAMETER	7.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24 BODY LENGTH	228.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25 WING FUEL LIMIT	3.046	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COST DATA																
26 RDTE - BIL.	3.076	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27 FLYAWAY - MIL.	62.79	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 INVESTMNT-BIL.	1.423	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 DOC - C/SM	1.634	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30 IOC - C/SM	1.246	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31 ROI A.T. - O/O	37.78	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32 DOC - C/SM	2.537	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33 IOC - C/SM	1.300	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34 ROI A.T. - O/O	30.31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MISSION PARAMETERS																
35 MISN V1(1,1)	37000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36 MISN V2(1,1)	80499	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSTRAINT OUTPUT																
37 TAKEOFF DST(1)	6970	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38 CLIMB GRAD(1)	0.1140	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39 TAKEOFF DST(2)	6619	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40 CLIMB GRAD(2)	0.0411	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41 CTOL LNDG D(1)	6141	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42 AP SPEED-KT(1)	136.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43 SEP(1) - FPS	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44 SEP(2) - FPS	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FBW with RSS
Fuel \$.60/gal

E**3 AIRCRAFT / 500 PASS / 3000 N MI / M = .80 MISS

T/C=13.00 AR=10.00 W/S=114.80 T/W=0.255

W E I G H T   S T A T E M E N T

	WEIGHT(POUNDS)	WEIGHT FRACTION	(PERCENT)
GROSS WEIGHT	(453513.)		
FUEL AVAILABLE	96559.	FUEL	21.29
EXTERNAL	0.		
INTERNAL	96555.		
ZERO FUEL WEIGHT	356954.		
PAYLOAD	100000.	PAYLOAD	22.05
PASSENGERS	85000.		
BAGGAGE	0.		
CARGO	15000.		
STORES	0.		
OPERATIONAL EMPTY WEIGHT	256954.		
OPERATIONAL ITEMS	16166.	OPERATIONAL ITEMS	4.76
STANDARD ITEMS	5405.		
EMPTY WEIGHT	235363.		
STRUCTURE	135397.	STRUCTURE	29.86
WING	48202.		
ROTOR	0.		
TAIL	5745.		
BODY	56552.		
ALIGHTING GEAR	18803.		
ENGINE SECTION AND NACELLE	6095.		
PROPULSION	28901.	PROPULSION	6.37
CRUISE ENGINES	22308.		
LIFT ENGINES	0.		
THRUST REVERSER	4404.		
EXHAUST SYSTEM	0.		
ENGINE CONTROL	197.		
STARTING SYSTEM	532.		
PROPELLERS	0.		
LUBRICATING SYSTEM	0.		
FUEL SYSTEM	1459.		
DRIVE SYSTEM (POWER TRANS)	0.		
SYSTEMS	71065.		
FLIGHT CONTROLS	5080.		
AUXILIARY POWER PLANT	1116.		
INSTRUMENTS	896.		
HYDRAULIC AND PNEUMATIC	2676.		
ELECTRICAL	5952.		
AVIONICS	2964.	SYSTEMS	15.67
ARMAMENT	0.		
FURNISHINGS AND EQUIPMENT	44293.		
AIR CONDITIONING	7682.		
ANTI-ICING	406.		
PHOTOGRAPHIC	0.		
LOAD AND HANDLING	0.		
		TOTAL	(100.)

MUX with RSS

COST SUMMARY

MUX

RDT AND E

	TOTAL *
DEVELOPMENT - NONRECURRING	
ENGINEERING	1123.85
TOOLING	730.36
TEST ARTICLES	83.51
DATA	0.0
SYSTEMS ENG/MNGMT	0.0
CRUISE ENGINE	0.0
LIFT ENGINE	0.0
FAN	0.0
AVIONICS	23.70
OTHER SYSTEMS	0.0
FACILITIES	0.0
TOTAL AIR VEHICLE	1966.42
INTEGR LOGISTICS SUPPORT	
PLANNING	9.97
TRAINING	3.39
HANDBOOKS	23.02
SSE	4.83
TOTAL ILS	41.26
TOTAL DVLPMNT-NONREC	2007.69
DEVELOPMENT - RECUR(PROTOTYPES)	
AIR VEHICLE	836.91
SPARES	215.67
TOTAL DVLPMNT-RECUR	1052.58
GOVMNT DVLPMNT COST	0.0
TOTAL DVLPMNT COST	3060.26

MUX with RSS

PRODUCTION

	MATERIAL	LABOR	TOTAL PER PROD A/C**
STRUCTURE	5531.22	15915.06	21446.27
WING	2491.53	3262.03	5753.56
ROTOR	0.0	0.0	0.0
TAIL	247.70	504.95	752.65
BODY	1658.38	10958.15	12616.54
ALIGHTING GEAR	812.14	37.73	849.87
ENG SECT + NACELLE	321.46	1152.20	1473.66
ENG SECTION	0.0	0.0	0.0
NACELLE	241.78	1045.64	1287.42
AIR INDUCTION	79.68	106.56	186.24
PROPULSION	155.03	144.64	299.68
ENGINE INSTALL	0.0	34.75	34.75
THRUST REVERSER	0.0	6.86	6.86
EXHAUST SYSTEM	0.0	0.0	0.0
ENGINE CONTROLS	4.55	6.47	11.02
STARTING SYSTEM	70.57	11.99	82.56
PROPELLER INSTALL	0.0	0.0	0.0
LUBRICATING SYSTEM	0.0	0.0	0.0
FUEL SYSTEM	79.91	84.57	164.48
DRIVE SYS(PWR TRN)	0.0	0.0	0.0
SYSTEMS	3773.31	9133.91	12907.22
FLIGHT CONTROLS	783.58	403.59	1187.17
AUX POWER PLANT	166.86	27.19	194.06
INSTRUMENTS	85.87	75.13	161.00
HYDRAULIC + PNEUM	177.54	430.53	608.07
ELECTRICAL	545.21	1390.48	1935.69
AVIONIC INSTALL	53.06	530.09	583.15
ARMAMENT	0.0	0.0	0.0
FURN AND EQUIP	1399.15	5603.30	7002.45
AIR CONDITIONING	533.84	639.81	1173.65
ANTI-ICING	28.20	33.80	62.00
PHOTOGRAPHIC	0.0	0.0	0.0
LOAD AND HANDLING	0.0	0.0	0.0
SYSTEMS INTEGR	743.48	707.05	1450.53
TOTAL COST	10203.04	25900.57	36103.61
TOTAL HRS **		776.63	776.63
ENG CHANGE ORDERS			1184.12
SUSTAINING ENG COST			2095.22
PROD TOOLING COST			2188.15
QUALITY ASSURANCE			3483.18
MISCELLANEOUS ***			790.03
TOTAL AIRFRAME COST			45844.27
ENGINE COST			5213.40
AVIONICS COST			894.95
TOTAL MANUFACTURING COST			51952.61
WARRANTY			278.57
TOTAL PRODUCTION COST			52231.17

PROCUREMENT

	PER PROD A/C**
TOTAL PRODUCTION	52231.17
INTEGR LOGISTICS SUPPORT	
PLANNING	30.51
TRAINING	10.37
TRAINERS	360.68
HANDBOOKS	45.65
FACILITIES	0.0
SSE - CFE	26.12
SSE - GFE	751.07
TOTAL ILS	1224.40
INITIAL SPARES COST	7111.45
PRODUCTION DEVELOPMENT	
ENGINEERING	367.05
TOOLING	-184.24
ENGINES	0.0
TOTAL PROD DEV	182.80
TOTAL PROCUREMENT	60749.80

* - MILLIONS OF DOLLARS

** -1000 OF DOLLARS OR HOURS PER PROD A/C

*** - INCLUDES PROD DATA, SYSTEMS ENGR AND OTHER SYSTEMS

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)

	C/SM***	PERCENT
FLIGHT CREW	0.22561	13.83543
FUEL AND OIL	0.48841	29.95193
INSURANCE	0.02524	1.54765
DEPRECIATION	0.55466	34.01500
MAINTENANCE	0.33673	20.64996
TOTAL DOC	1.63064	100.000

INDIRECT OPERATIONAL COST (IOC)

	C/SM***	PERCENT
SYSTEM	0.03068	2.46344
LOCAL	0.07238	5.81195
AIRCRAFT CONTROL	0.00202	0.16215
CABIN ATTENDANT	0.22698	18.22545
FOOD AND BEVERAGE	0.13629	10.94339
PASSENGER HANDLING	0.15707	12.61197
CARGO HANDLING	0.05804	4.66070
OTHER PASSENGER EXPENSE	0.42408	34.05170
OTHER CARGO EXPENSE	0.00853	0.68465
GENERAL + ADMINISTRATION	0.12933	10.38468
TOTAL IOC	1.24540	100.000

MISC. DATA

FLIGHT DISTANCE (N. MI.)	2999.94
BLOCK FUEL (LBS)	80367.50
BLOCK TIME (HRS)	7.23
FLIGHT TIME (HRS)	6.80
AVG STAGE LENGTH (N. MI.)	1144.00
AVG CARGO PER FLIGHT	17413.00
UTILIZATION (HRS PER YR)	3636.00
FLIGHTS PER A/C PER YEAR	502.85
FARE ($)	357.59
FUEL COST ($/LB)	0.09000

*** - CENTS PER SEAT N. MILE

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR	CUMULATIVE DEPRECIATION	AVERAGE BOOK VALUE OF FLEET	REVENUE	INTEREST EXPENSE	OPERATING EXPENSE	CASH FLOW	ROI
			$M	$M	$M	$M	$M	$M	$M	PERCENT
1	6.3	10.0	443.44	26.61	416.83	345.37	42.57	135.58	-88.44	30.27
2	16.3	10.0	1152.95	95.78	1057.16	897.97	103.87	352.51	34.55	30.71
3	20.0	0.0	1419.01	180.92	1233.09	1105.20	115.79	433.85	249.40	31.79
4	20.0	0.0	1419.01	266.06	1152.95	1105.20	102.17	433.85	256.21	33.55
5	20.0	0.0	1419.01	351.21	1067.81	1105.20	88.55	433.85	263.02	35.58
6	20.0	0.0	1419.01	436.35	982.67	1105.20	74.92	433.85	269.83	37.97
7	20.0	0.0	1419.01	521.49	897.53	1105.20	61.30	433.85	276.64	40.81
8	20.0	0.0	1419.01	606.63	812.39	1105.20	47.68	433.85	283.45	44.25
9	20.0	0.0	1419.01	691.77	727.25	1105.20	34.06	433.85	290.26	48.50
10	20.0	0.0	1419.01	776.91	642.11	1105.20	20.43	433.85	297.08	53.87

AVG ROI OVER THE 10 YEAR PERIOD = 37.90 PERCENT

MUX with RSS
Fuel $.60/gal

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)

	C/SM***	PERCENT
FLIGHT CREW	0.22561	8.83797
FUEL AND OIL	1.41046	55.25385
INSURANCE	0.02524	0.98863
DEPRECIATION	0.55466	21.72853
MAINTENANCE	0.33673	13.19105
TOTAL DOC	2.55269	100.000

INDIRECT OPERATIONAL COST (IOC)

	C/SM***	PERCENT
SYSTEM	0.03068	2.36033
LOCAL	0.07238	5.56870
AIPCRAFT CONTROL	0.00202	0.15536
CABIN ATTENDANT	0.22698	17.46265
FOOD AND BEVERAGE	0.13629	10.48537
PASSENGER HANDLING	0.15707	12.08412
CAPGO HANDLING	0.05804	4.46564
OTHER PASSENGER EXPENSE	0.42408	32.62651
OTHER CARGO EXPENSE	0.00853	0.65599
GENERAL + ADMINISTRATION	0.18373	14.13536
TOTAL IOC	1.29980	100.000

MISC. DATA

FLIGHT DISTANCE (N. MI.)	2999.94
BLOCK FUEL (LBS)	80367.50
BLOCK TIME (HRS)	7.23
FLIGHT TIME (HRS)	6.80
AVG STAGE LENGTH (N. MI.)	1144.00
AVG CARGO PER FLIGHT	17413.00
UTILIZATION (HRS PER YR)	3636.00
FLIGHTS PER A/C PER YEAR	502.85
FARE ($)	357.59
FUEL COST ($/LB)	0.26000

*** - CENTS PER SEAT N. MILE

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR $M	CUMULATIVE DEPRECIATION $M	AVERAGE BOOK VALUE OF FLEET $M	REVENUE $M	INTEREST EXPENSE $M	OPERATING EXPENSE $M	CASH FLOW $M	ROI PERCENT
1	6.3	10.0	443.44	26.61	416.83	345.37	42.57	181.61	-111.46	24.75
2	16.3	10.0	1152.95	95.78	1057.16	897.97	103.87	472.19	-25.29	25.05
3	20.0	0.0	1419.01	180.92	1238.09	1105.20	115.79	581.15	175.75	25.84
4	20.0	0.0	1419.01	266.06	1152.95	1105.20	102.17	581.15	182.56	27.16
5	20.0	0.0	1419.01	351.21	1067.81	1105.20	88.55	581.15	189.37	28.68
6	20.0	0.0	1419.01	436.35	982.67	1105.20	74.92	581.15	196.18	30.48
7	20.0	0.0	1419.01	521.49	897.53	1105.20	61.30	581.15	202.99	32.61
8	20.0	0.0	1419.01	606.63	812.39	1105.20	47.68	581.15	209.80	35.19
9	20.0	0.0	1419.01	691.77	727.25	1105.20	34.06	581.15	216.61	33.37
10	20.0	0.0	1419.01	776.91	642.11	1105.20	20.43	581.15	223.43	42.40

AVG ROI OVER THE 10 YEAR PERIOD = 30.42 PERCENT

MUX with RSS
Fuel $1.80/gal

SUMMARY ID NO. 1   A S S E T   P A R A M E T R I C   A N A L Y S I S   MAY 09 1980

AIRCRAFT MODEL -- CL1332-1
I.O.C. DATE --1985
DESIGN SPEED --SUBSONIC

ENGINE I.D. -- 416000
SLS SCALE 1.0 = 40850
NUMBER OF ENGINES = 3.

WING QUARTER CHORD SWEEP = 30.00 DEG
WING TAPER RATIO = 0.300

MUX

1 W/S	114.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 T/W	0.255	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 AR	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 T/C	13.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 SWEEP	30.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 FPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 OPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8 TIT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9 NPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 AUG T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11 RADIUS N. MI	3000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 GROSS WEIGHT	453513	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 FUEL WEIGHT	96559	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 OP. WT. EMPTY	256954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ZERO FUEL WT.	356954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 ENGINE SCALE	0.944	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17 THRUST/ENGINE	38549	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 WING AREA	3950.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19 WING SPAN	198.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20 H. TAIL AREA	907.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 V. TAIL AREA	565.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22 ENG. LENGTH	10.23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23 ENG. DIAMETER	7.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24 BODY LENGTH	228.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25 WING FUEL LIMIT	3.042	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COST DATA																
26 RDTE - BIL.	3.060	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27 FLYAWAY - MIL.	62.61	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 INVESTMNT-BIL.	1.419	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 DOC - C/SM	1.631	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30 IOC - C/SM	1.245	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31 ROI A.T. - O/O	37.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32 DOC - C/SM	2.553	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33 IOC - C/SM	1.300	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34 ROI A.T. - O/O	30.42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MISSION PARAMETERS																
35 MISN V1(1,1)	37000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36 MISN V2(1,1)	80368	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSTRAINT OUTPUT																
37 TAKEOFF DST(1)	6970	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38 CLIMB GRAD(1)	0.1140	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39 TAKEOFF DST(2)	6620	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40 CLIMB GRAD(2)	0.0411	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41 CTOL LNDG D(1)	6140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42 AP SPEED-KT(1)	136.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43 SEP(1) - FPS	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44 SEP(2) - FPS	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

E**3 AIRCRAFT / 500 PASS / 3000 N MI / M = .80 MISS

T/C=13.00 AR=10.00 W/S=114.80 T/W=0.255

W E I G H T   S T A T E M E N T

	WEIGHT(POUNDS)	WEIGHT FRACTION	(PERCENT)
GROSS WEIGHT	(453436.)		
FUEL AVAILABLE	95545.	FUEL	21.29
EXTERNAL	0.		
INTERNAL	96541.		
ZERO FUEL WEIGHT	356891.		
PAYLOAD	100000.	PAYLOAD	22.05
PASSENGERS	85000.		
BAGGAGE	0.		
CARGO	15000.		
STORES	0.		
OPERATIONAL EMPTY WEIGHT	256891.		
OPERATIONAL ITEMS	16186.	OPERATIONAL ITEMS	4.76
STANDARD ITEMS	5405.		
EMPTY WEIGHT	235300.		
STRUCTURE	135378.	STRUCTURE	29.86
WING	48191.		
ROTOR	0.		
TAIL	5743.		
BODY	56550.		
ALIGHTING GEAR	18800.		
ENGINE SECTION AND NACELLE	6094.		
PROPULSION	28896.	PROPULSION	6.37
CRUISE ENGINES	22304.		
LIFT ENGINES	0.		
THRUST REVERSER	4404.		
EXHAUST SYSTEM	0.		
ENGINE CONTROL	197.		
STARTING SYSTEM	532.		
PROPELLERS	0.		
LUBRICATING SYSTEM	0.		
FUEL SYSTEM	1459.		
DRIVE SYSTEM (POWER TRANS)	0.		
SYSTEMS	71026.		
FLIGHT CONTROLS	5080.		
AUXILIARY POWER PLANT	1116.		
INSTRUMENTS	876.		
HYDRAULIC AND PNEUMATIC	2676.		
ELECTRICAL	5951.		
AVIONICS	2926.	SYSTEMS	15.66
ARMAMENT	0.		
FURNISHINGS AND EQUIPMENT	44293.		
AIR CONDITIONING	7682.		
ANTI-ICING	406.		
PHOTOGRAPHIC	0.		
LOAD AND HANDLING	0.		
		TOTAL	(100.)

RLG with RSS

COST SUMMARY

RDT AND E

	TOTAL *
DEVELOPMENT - NONRECURRING	
ENGINEERING	1123.15
TOOLING	730.30
TEST ARTICLES	80.48
DATA	0.0
SYSTEMS ENG/MNGMT	0.0
CRUISE ENGINE	0.0
LIFT ENGINE	0.0
FAN	0.0
AVIONICS	23.70
OTHER SYSTEMS	0.0
FACILITIES	0.0
TOTAL AIR VEHICLE	1965.64
INTEGR LOGISTICS SUPPORT	
PLANNING	9.97
TRAINING	3.39
HANDBOOKS	22.87
SSE	4.83
TOTAL ILS	41.10
TOTAL DVLPMNT-NONREC	2006.74
DEVELOPMENT - RECUR(PROTOTYPES)	
AIR VEHICLE	836.46
SPARES	215.61
TOTAL DVLPMNT-RECUR	1052.06
GOVMNT DVLPMNT COST	0.0
TOTAL DVLPMNT COST	3058.81

RLG with RSS

PRODUCTION

	MATERIAL	LABOR	TOTAL PER PROD A/C**
STRUCTURE	5530.34	15913.72	21444.06
WING	2490.95	3261.31	5752.26
ROTOR	0.0	0.0	0.0
TAIL	247.64	504.82	752.45
BODY	1658.32	10957.88	12616.20
ALIGHTING GEAR	812.03	37.73	849.76
ENG SECT + NACELLE	321.40	1151.99	1473.39
ENG SECTION	0.0	0.0	0.0
NACELLE	241.74	1045.45	1287.19
AIR INDUCTION	79.67	106.54	186.21
PROPULSION	155.03	144.63	299.65
ENGINE INSTALL	0.0	34.74	34.74
THRUST REVERSER	0.0	6.86	6.86
EXHAUST SYSTEM	0.0	0.0	0.0
ENGINE CONTROLS	4.55	6.47	11.02
STARTING SYSTEM	70.57	11.99	82.56
PROPELLER INSTALL	0.0	0.0	0.0
LUBRICATING SYSTEM	0.0	0.0	0.0
FUEL SYSTEM	79.90	84.56	164.47
DRIVE SYS(PWR TRN)	0.0	0.0	0.0
SYSTEMS	3772.55	9127.12	12899.68
FLIGHT CONTROLS	783.55	403.58	1187.13
AUX POWER PLANT	166.86	27.19	194.06
INSTRUMENTS	85.87	75.12	160.98
HYDRAULIC + PNEUM	177.51	430.47	607.98
ELECTRICAL	545.20	1390.45	1935.65
AVIONIC INSTALL	52.38	523.30	575.68
ARMAMENT	0.0	0.0	0.0
FURN AND EQUIP	1399.16	5603.39	7002.55
AIR CONDITIONING	533.84	639.82	1173.66
ANTI-ICING	28.20	33.79	61.99
PHOTOGRAPHIC	0.0	0.0	0.0
LOAD AND HANDLING	0.0	0.0	0.0
SYSTEMS INTEGR	743.28	706.87	1450.15
TOTAL COST	10201.21	25892.27	36093.47
TOTAL HRS **		776.38	776.38
ENG CHANGE ORDERS			1183.78
SUSTAINING ENG COST			2094.41
PROD TOOLING COST			2187.45
QUALITY ASSURANCE			3482.07
MISCELLANEOUS ***			789.77
TOTAL AIRFRAME COST			45830.93
ENGINE COST			5212.85
AVIONICS COST			851.67
TOTAL MANUFACTURING COST			51895.44
WARRANTY			278.32
TOTAL PRODUCTION COST			52173.74

PROCUREMENT

	PER PROD A/C**
TOTAL PRODUCTION	52173.74
INTEGR LOGISTICS SUPPORT	
PLANNING	30.51
TRAINING	10.37
TRAINERS	360.68
HANDBOOKS	45.48
FACILITIES	0.0
SSE - CFE	26.09
SSE - GFE	751.07
TOTAL ILS	1224.19
INITIAL SPARES COST	7104.93
PRODUCTION DEVELOPMENT	
ENGINEERING	366.99
TOOLING	-183.58
ENGINES	0.0
TOTAL PROD DEV	183.41
TOTAL PROCUREMENT	60686.25

* - MILLIONS OF DOLLARS

** -1000 OF DOLLARS OR HOURS PER PROD A/C

*** - INCLUDES PROD DATA, SYSTEMS ENGR AND OTHER SYSTEMS

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)

	C/SM***	PERCENT
FLIGHT CREW	0.22561	13.85665
FUEL AND OIL	0.48834	29.99339
INSURANCE	0.02521	1.54850
DEPRECIATION	0.55412	34.03387
MAINTENANCE	0.33487	20.56755
TOTAL DOC	1.62814	100.000

INDIRECT OPERATIONAL COST (IOC)

	C/SM***	PERCENT
SYSTEM	0.03046	2.44672
LOCAL	0.07237	5.81262
AIRCRAFT CONTROL	0.00202	0.16219
CABIN ATTENDANT	0.22698	18.23070
FOOD AND BEVERAGE	0.13629	10.94654
PASSENGER HANDLING	0.15707	12.61559
CARGO HANDLING	0.05804	4.66204
OTHER PASSENGER EXPENSE	0.42408	34.06146
OTHER CARGO EXPENSE	0.00853	0.68484
GENERAL + ADMINISTRATION	0.12920	10.37731
TOTAL IOC	1.24504	100.000

MISC. DATA

FLIGHT DISTANCE (N. MI.)	2999.94
BLOCK FUEL (LBS)	80355.56
BLOCK TIME (HRS)	7.23
FLIGHT TIME (HRS)	6.80
AVG STAGE LENGTH (N. MI.)	1144.00
AVG CARGO PER FLIGHT	17413.00
UTILIZATION (HRS PER YR)	3636.00
FLIGHTS PER A/C PER YEAR	502.85
FARE ($)	357.59
FUEL COST ($/LB)	0.09000

*** - CENTS PER SEAT N. MILE

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR $M	CUMULATIVE DEPRECIATION $M	AVERAGE BOOK VALUE OF FLEET $M	REVENUE $M	INTEREST EXPENSE $M	OPERATING EXPENSE $M	CASH FLOW $M	ROI PERCENT
1	6.3	10.0	443.01	26.58	416.43	345.37	42.53	135.44	-88.19	30.31
2	16.3	10.0	1151.84	95.69	1056.15	897.97	103.77	352.16	34.96	30.75
3	20.0	0.0	1417.65	180.75	1236.90	1105.20	115.68	433.42	249.69	31.83
4	20.0	0.0	1417.65	265.91	1151.84	1105.20	102.07	433.42	256.50	33.59
5	20.0	0.0	1417.65	350.87	1066.78	1105.20	88.46	433.42	263.30	35.63
6	20.0	0.0	1417.65	435.93	981.72	1105.20	74.85	433.42	270.11	38.03
7	20.0	0.0	1417.65	520.98	896.66	1105.20	61.24	433.42	276.91	40.87
8	20.0	0.0	1417.65	606.04	811.60	1105.20	47.63	433.42	283.72	44.32
9	20.0	0.0	1417.65	691.10	726.54	1105.20	34.02	433.42	290.52	48.57
10	20.0	0.0	1417.65	776.16	641.49	1105.20	20.41	433.42	297.33	53.95

AVG ROI OVER THE 10 YEAR PERIOD = 37.95 PERCENT

RLG with RSS
Fuel $.60/gal

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)

	C/SM***	PERCENT
FLIGHT CREW	0.22561	8.84710
FUEL AND OIL	1.41025	55.30269
INSURANCE	0.02521	0.98858
DEPRECIATION	0.55412	21.72972
MAINTENANCE	0.33487	13.13184
TOTAL DOC	2.55006	100.000

INDIRECT OPERATIONAL COST (IOC)

	C/SM***	PERCENT
SYSTEM	0.03046	2.34431
LOCAL	0.07237	5.56931
AIRCRAFT CONTROL	0.00202	0.15540
CABIN ATTENDANT	0.22698	17.46758
FOOD AND BEVERAGE	0.13629	10.48833
PASSENGER HANDLING	0.15707	12.08752
CARGO HANDLING	0.05804	4.46690
OTHER PASSENGER EXPENSE	0.42408	32.63570
OTHER CARGO EXPENSE	0.00853	0.65618
GENERAL + ADMINISTRATION	0.18359	14.12881
TOTAL IOC	1.29943	100.000

MISC. DATA

FLIGHT DISTANCE (N. MI.)	2999.94
BLOCK FUEL (LBS)	80355.56
BLOCK TIME (HRS)	7.23
FLIGHT TIME (HRS)	6.80
AVG STAGE LENGTH (N. MI.)	1144.00
AVG CARGO PER FLIGHT	17413.00
UTILIZATION (HRS PER YR)	3636.00
FLIGHTS PER A/C PER YEAR	502.85
FARE ($)	357.59
FUEL COST ($/LB)	0.26000

*** - CENTS PER SEAT N. MILE

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR	CUMULATIVE DEPRECIATION	AVERAGE BOOK VALUE OF FLEET	REVENUE	INTEREST EXPENSE	OPERATING EXPENSE	CASH FLOW	ROI
			$M	$M	$M	$M	$M	$M	$M	PERCENT
1	6.3	10.0	443.01	26.58	416.43	345.37	42.53	181.47	-111.20	24.79
2	16.3	10.0	1151.84	95.69	1056.15	897.97	103.77	471.82	-24.87	25.09
3	20.0	0.0	1417.65	180.75	1236.90	1105.20	115.68	580.70	176.06	25.88
4	20.0	0.0	1417.65	265.81	1151.84	1105.20	102.07	580.70	182.86	27.20
5	20.0	0.0	1417.65	350.87	1066.78	1105.20	83.46	580.70	139.67	28.73
6	20.0	0.0	1417.65	435.93	931.72	1105.20	74.85	580.70	196.47	30.53
7	20.0	0.0	1417.65	520.98	896.66	1105.20	61.24	580.70	203.27	32.66
8	20.0	0.0	1417.65	606.04	811.60	1105.20	47.63	580.70	210.08	35.25
9	20.0	0.0	1417.65	691.10	726.54	1105.20	34.02	580.70	216.88	38.44
10	20.0	0.0	1417.65	776.16	641.49	1105.20	20.41	580.70	223.69	42.47

AVG ROI OVER THE 10 YEAR PERIOD = 30.47 PERCENT

RLG with RSS
Fuel $1.80/gal

SUMMARY ID NO. 1 — A S S E T   P A R A M E T R I C   A N A L Y S I S — MAY 09 1980

AIRCRAFT MODEL -- CL1332-1
I.O.C. DATE --1985
DESIGN SPEED --SUBSONIC

ENGINE I.D. -- 416000
SLS SCALE 1.0 = 40650
NUMBER OF ENGINES = 3.

WING QUARTER CHORD SWEEP = 30.00 DEG
WING TAPER RATIO = 0.300

1 W/S	114.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 T/W	0.255	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 AR	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 T/C	13.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 SWEEP	30.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 FPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 OPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8 TIT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9 NPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 AUG T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11 RADIUS N. MI	3000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 GROSS WEIGHT	453436	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 FUEL WEIGHT	96545	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 OP. WT. EMPTY	256891	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ZERO FUEL WT.	356891	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 ENGINE SCALE	0.944	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17 THRUST/ENGINE	38542	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 WING AREA	3950.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19 WING SPAN	198.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20 H. TAIL AREA	936.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 V. TAIL AREA	564.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22 ENG. LENGTH	10.23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23 ENG. DIAMETER	7.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24 BODY LENGTH	228.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25 WING FUEL LIMIT	3.042	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COST DATA																
26 RDTE - BIL.	3.059	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27 FLYAWAY - MIL.	62.55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 INVESTMNT-BIL.	1.418	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 DOC - C/SM	1.628	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30 IOC - C/SM	1.245	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31 ROI A.T. - 0/0	37.95	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32 DOC - C/SM	2.550	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33 IOC - C/SM	1.299	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34 ROI A.T. - 0/0	30.47	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MISSION PARAMETERS																
35 MISN V1(1,1)	37000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36 MISN V2(1,1)	80356	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSTRAINT OUTPUT																
37 TAKEOFF DST(1)	6970	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38 CLIMB GRAD(1)	0.1140	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39 TAKEOFF DST(2)	6620	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40 CLIMB GRAD(2)	0.0411	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41 CTOL LNDG D(1)	6140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42 AP SPEED-KT(1)	136.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43 SEP(1) - FPS	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44 SEP(2) - FPS	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

RLG with RSS
Fuel \$.60/gal

E**3 AIRCRAFT / 500 PASS / 3000 N MI / M = .80 MISS

T/C=13.00 AR=10.00 W/S=114.80 T/W=0.255

WEIGHT STATEMENT

	WEIGHT(POUNDS)	WEIGHT FRACTION	(PERCENT)
GROSS WEIGHT	(453332.)		
FUEL AVAILABLE	96526.	FUEL	21.29
EXTERNAL	0.		
INTERNAL	96522.		
ZERO FUEL WEIGHT	356806.		
PAYLOAD	100000.	PAYLOAD	22.06
PASSENGERS	05000.		
BAGGAGE	0.		
CARGO	15000.		
STORES	0.		
OPERATIONAL EMPTY WEIGHT	256806.		
OPERATIONAL ITEMS	16186.	OPERATIONAL ITEMS	4.76
STANDARD ITEMS	5405.		
EMPTY WEIGHT	235215.		
STRUCTURE	135353.	STRUCTURE	29.86
WING	43175.		
ROTOR	0.		
TAIL	5741.		
BODY	56547.		
ALIGHTING GEAR	13797.		
ENGINE SECTION AND NACELLE	6093.		
PROPULSION	28939.	PROPULSION	6.37
CRUISE ENGINES	22295.		
LIFT ENGINES	0.		
THRUST REVERSER	4403.		
EXHAUST SYSTEM	0.		
ENGINE CONTROL	197.		
STARTING SYSTEM	532.		
PROPELLERS	0.		
LUBRICATING SYSTEM	0.		
FUEL SYSTEM	1459.		
DRIVE SYSTEM (POWER TRANS)	0.		
SYSTEMS	70974.		
FLIGHT CONTROLS	5090.		
AUXILIARY POWER PLANT	1116.		
INSTRUMENTS	896.		
HYDRAULIC AND PNEUMATIC	2675.		
ELECTRICAL	5551.		
AVIONICS	8875.	SYSTEMS	15.66
ARMAMENT	0.		
FURNISHINGS AND EQUIPMENT	44293.		
AIR CONDITIONING	7682.		
ANTI-ICING	406.		
PHOTOGRAPHIC	0.		
LOAD AND HANDLING	0.		
		TOTAL	(100.)

Integrated Avionics
with RSS

COST SUMMARY

RDT AND E

	TOTAL *
DEVELOPMENT - NONRECURRING	
ENGINEERING	1122.21
TOOLING	730.23
TEST ARTICLES	88.44
DATA	0.0
SYSTEMS ENG/MGMT	0.0
CRUISE ENGINE	0.0
LIFT ENGINE	0.0
FAN	0.0
AVIONICS	19.10
OTHER SYSTEMS	0.0
FACILITIES	0.0
TOTAL AIR VEHICLE	1959.98
INTEGR LOGISTICS SUPPORT	
PLANNING	9.96
TRAINING	3.39
HANDBOOKS	22.66
SSE	4.88
TOTAL ILS	40.89
TOTAL DVLPMNT-NONREC	2000.87
DEVELOPMENT - RECUR(PROTOTYPES)	
AIR VEHICLE	835.84
SPARES	215.53
TOTAL DVLPMNT-RECUR	1051.37
GOVMNT DVLPMNT COST	0.0
TOTAL DVLPMNT COST	3052.24

PRODUCTION

	MATERIAL	LABOR	TOTAL PER PROD A/C**
STRUCTURE	5529.17	15911.92	21441.09
WING	2490.13	3260.34	5750.52
ROTOR	0.0	0.0	0.0
TAIL	247.55	504.65	752.20
BODY	1658.24	10957.49	12615.73
ALIGHTING GEAR	811.89	37.72	849.61
ENG SECT + NACELLE	321.32	1151.71	1473.03
ENG SECTION	0.0	0.0	0.0
NACELLE	241.67	1045.20	1286.87
AIR INDUCTION	79.65	106.51	186.16
PROPULSION	155.01	144.61	299.62
ENGINE INSTALL	0.0	34.73	34.73
THRUST REVERSER	0.0	6.86	6.86
EXHAUST SYSTEM	0.0	0.0	0.0
ENGINE CONTROLS	4.55	6.47	11.02
STARTING SYSTEM	70.57	11.99	82.56
PROPELLER INSTALL	0.0	0.0	0.0
LUBRICATING SYSTEM	0.0	0.0	0.0
FUEL SYSTEM	79.89	84.55	164.45
DRIVE SYS(PWR TRN)	0.0	0.0	0.0
SYSTEMS	3771.55	9115.01	12889.56
FLIGHT CONTROLS	783.51	403.57	1187.08
AUX POWER PLANT	166.87	27.19	194.06
INSTRUMENTS	85.85	75.11	160.96
HYDRAULIC + PNEUM	177.48	430.39	607.87
ELECTRICAL	545.18	1390.43	1935.61
AVIONIC INSTALL	51.46	514.19	565.66
ARMAMENT	0.0	0.0	0.0
FURN AND EQUIP	1399.16	5603.50	7002.67
AIR CONDITIONING	533.84	639.84	1173.68
ANTI-ICING	28.19	33.79	61.98
PHOTOGRAPHIC	0.0	0.0	0.0
LOAD AND HANDLING	0.0	0.0	0.0
SYSTEMS INTEGR	743.02	706.63	1449.65
TOTAL COST	10198.75	25891.10	36079.86
TOTAL HRS **		776.05	776.05
ENG CHANGE ORDERS			1183.33
SUSTAINING ENG COST			2093.33
PROD TOOLING COST			2186.51
QUALITY ASSURANCE			3480.56
MISCELLANEOUS ***			789.43
TOTAL AIRFRAME COST			45812.99
ENGINE COST			5212.09
AVIONICS COST			792.42
TOTAL MANUFACTURING COST			51817.50
WARRANTY			277.98
TOTAL PRODUCTION COST			52095.47

PROCUREMENT

	PER PROD A/C**
TOTAL PRODUCTION	52095.47
INTEGR LOGISTICS SUPPORT	
PLANNING	30.50
TRAINING	10.37
TRAINERS	360.68
HANDBOOKS	45.24
FACILITIES	0.0
SSE - CFE	26.05
SSE - GFE	751.07
TOTAL ILS	1223.90
INITIAL SPARES COST	7096.06
PRODUCTION DEVELOPMENT	
ENGINEERING	366.92
TOOLING	-182.68
ENGINES	0.0
TOTAL PROD DEV	184.24
TOTAL PROCUREMENT	60599.64

* - MILLIONS OF DOLLARS

** -1000 OF DOLLARS OR HOURS PER PROD A/C

*** - INCLUDES PROD DATA, SYSTEMS ENGR AND OTHER SYSTEMS

Integrated-Avionics with RSS

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)

	C/SM***	PERCENT
FLIGHT CREW	0.22561	13.87015
FUEL AND OIL	0.48824	30.01668
INSURANCE	0.02517	1.54755
DEPRECIATION	0.55326	34.01410
MAINTENANCE	0.33423	20.55153
TOTAL DOC	1.62656	100.000

INDIRECT OPERATIONAL COST (IOC)

	C/SM***	PERCENT
SYSTEM	0.03040	2.44156
LOCAL	0.07235	5.81191
AIRCRAFT CONTROL	0.00202	0.16221
CABIN ATTENDANT	0.22698	18.23260
FOOD AND BEVERAGE	0.13629	10.94769
PASSENGER HANDLING	0.15707	12.61693
CARGO HANDLING	0.05804	4.66254
OTHER PASSENGER EXPENSE	0.42408	34.06508
OTHER CARGO EXPENSE	0.00853	0.68492
GENERAL + ADMINISTRATION	0.12915	10.37458
TOTAL IOC	1.24491	100.000

MISC. DATA

FLIGHT DISTANCE (N. MI.)	2999.94
BLOCK FUEL (LBS)	80339.63
BLOCK TIME (HRS)	7.23
FLIGHT TIME (HRS)	6.80
AVG STAGE LENGTH (N. MI.)	1144.00
AVG CARGO PER FLIGHT	17413.00
UTILIZATION (HRS PER YR)	3636.00
FLIGHTS PER A/C PER YEAR	502.85
FARE ($)	357.59
FUEL COST ($/LB)	0.09000

*** - CENTS PER SEAT N. MILE

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR	CUMULATIVE DEPRECIATION	AVERAGE BOOK VALUE OF FLEET	REVENUE	INTEREST EXPENSE	OPERATING EXPENSE	CASH FLOW	ROI
			$M	$M	$M	$M	$M	$M	$M	PERCENT
1	6.3	10.0	442.34	26.54	415.80	345.37	42.46	135.36	-87.85	30.36
2	16.3	10.0	1150.07	95.54	1054.53	897.97	103.61	351.95	35.43	30.80
3	20.0	0.0	1415.48	180.47	1235.00	1105.20	115.50	433.16	249.96	31.88
4	20.0	0.0	1415.48	265.40	1150.07	1105.20	101.91	433.16	256.75	33.65
5	20.0	0.0	1415.48	350.33	1065.15	1105.20	88.33	433.16	263.54	35.69
6	20.0	0.0	1415.48	435.26	980.22	1105.20	74.74	433.16	270.34	38.09
7	20.0	0.0	1415.48	520.19	895.29	1105.20	61.15	433.16	277.13	40.95
8	20.0	0.0	1415.48	605.11	810.36	1105.20	47.56	433.16	283.93	44.40
9	20.0	0.0	1415.48	690.04	725.43	1105.20	33.97	433.16	290.72	48.66
10	20.0	0.0	1415.48	774.97	640.50	1105.20	20.38	433.16	297.52	54.05

AVG ROI OVER THE 10 YEAR PERIOD = 38.02 PERCENT

Integrated Avionics
with RSS
Fuel $.60/gal

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)	C/SM***	PERCENT	INDIRECT OPERATIONAL COST (IOC)	C/SM***	PERCENT
FLIGHT CREW	0.22561	8.85323	SYSTEM	0.03040	2.33937
FUEL AND OIL	1.40997	55.33008	LOCAL	0.07235	5.56865
INSURANCE	0.02517	0.98779	AIRCRAFT CONTROL	0.00202	0.15542
DEPRECIATION	0.55326	21.71100	CABIN ATTENDANT	0.22698	17.46948
MAINTENANCE	0.33428	13.11792	FOOD AND BEVERAGE	0.13629	10.48947
			PASSENGER HANDLING	0.15707	12.08884
TOTAL DOC	2.54829	100.000	CARGO HANDLING	0.05804	4.46738
			OTHER PASSENGER EXPENSE	0.42408	32.63927
			OTHER CARGO EXPENSE	0.00853	0.65625
			GENERAL + ADMINISTRATION	0.18354	14.12586
			TOTAL IOC	1.29929	100.000

MISC. DATA	
FLIGHT DISTANCE (N. MI.)	2999.94
BLOCK FUEL (LBS)	80339.63
BLOCK TIME (HRS)	7.23
FLIGHT TIME (HRS)	6.80
AVG STAGE LENGTH (N. MI.)	1144.00
AVG CARGO PER FLIGHT	17413.00
UTILIZATION (HRS PER YR)	3636.00
FLIGHTS PER A/C PER YEAR	502.85
FARE ($)	357.59
FUEL COST ($/LB)	0.26000

*** - CENTS PER SEAT N. MILE

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RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR	CUMULATIVE DEPRECIATION	AVERAGE BOOK VALUE OF FLEET	REVENUE	INTEREST EXPENSE	OPERATING EXPENSE	CASH FLOW	ROI
			$M	$M	$M	$M	$M	$M	$M	PERCENT
1	6.3	10.0	442.34	26.54	415.80	345.37	42.46	181.38	-110.86	24.83
2	16.3	10.0	1150.07	95.54	1054.53	897.97	103.61	471.58	-24.39	25.13
3	20.0	0.0	1415.48	180.47	1235.00	1105.20	115.50	580.41	176.33	25.92
4	20.0	0.0	1415.48	265.40	1150.07	1105.20	101.91	580.41	183.13	27.25
5	20.0	0.0	1415.48	350.33	1065.15	1105.20	88.33	580.41	189.92	28.78
6	20.0	0.0	1415.48	435.26	980.22	1105.20	74.74	580.41	196.72	30.58
7	20.0	0.0	1415.48	520.19	895.29	1105.20	61.15	580.41	203.51	32.72
8	20.0	0.0	1415.48	605.11	810.36	1105.20	47.56	580.41	210.30	35.31
9	20.0	0.0	1415.48	690.04	725.43	1105.20	33.97	580.41	217.10	38.51
10	20.0	0.0	1415.48	774.97	640.50	1105.20	20.38	580.41	223.89	42.56

AVG ROI OVER THE 10 YEAR PERIOD = 30.53 PERCENT

Integrated Avionics
with RSS
Fuel $1.80/gal

SUMMARY ID NO. 1 A S S E T P A R A M E T R I C A N A L Y S I S MAY 09 1980

AIRCRAFT MODEL -- CL1332-1
I.O.C. DATE --1985
DESIGN SPEED --SUBSONIC

ENGINE I.D. -- 416000
SLS SCALE 1.0 = 40650
NUMBER OF ENGINES = 3.

WING QUARTER CHORD SWEEP = 30.00 DEG
WING TAPER RATIO = 0.300

1 W/S	114.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 T/W	0.255	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 AR	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 T/C	13.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 SWEEP	30.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 FPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 OPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8 TIT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9 NPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 AUG T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11 RADIUS N. MI	3000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 GROSS WEIGHT	453332	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 FUEL WEIGHT	96526	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 OP. WT. EMPTY	256806	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ZERO FUEL WT.	356806	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 ENGINE SCALE	0.943	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17 THRUST/ENGINE	38533	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 WING AREA	3949.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19 WING SPAN	198.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20 H. TAIL AREA	906.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 V. TAIL AREA	564.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22 ENG. LENGTH	10.23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23 ENG. DIAMETER	7.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24 BODY LENGTH	228.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25 WING FUEL LIMIT	3.041	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COST DATA																
26 RDTE - BIL.	3.052	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27 FLYAWAY - MIL.	62.45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 INVESTMNT-BIL.	1.415	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 DOC - C/SM	1.627	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30 IOC - C/SM	1.245	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31 ROI A.T. - 0/0	38.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32 DOC - C/SM	2.543	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33 IOC - C/SM	1.299	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34 ROI A.T. - 0/0	30.53	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MISSION PARAMETERS																
35 MISN V1(1,1)	37000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36 MISN V2(1,1)	80340	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSTRAINT OUTPUT																
37 TAKEOFF DST(1)	6970	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38 CLIMB GRAD(1)	0.1140	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39 TAKEOFF DST(2)	6620	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40 CLIMB GRAD(2)	0.0411	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41 CTOL LNDG D(1)	6140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42 AP SPEED-KT(1)	136.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43 SEP(1) - FPS	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44 SEP(2) - FPS	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Integrated Avionics

E**3 AIRCRAFT / 500 PASS / 3000 N MI / M = .80 MISS

T/C=13.00 AR=10.00 W/S=114.80 T/W=0.255

W E I G H T   S T A T E M E N T

	WEIGHT(POUNDS)	WEIGHT FRACTION	(PERCENT)
GROSS WEIGHT	(435978.)		
FUEL AVAILABLE	90471.	FUEL	20.75
EXTERNAL	0.		
INTERNAL	90467.		
ZERO FUEL WEIGHT	345506.		
PAYLOAD	100000.	PAYLOAD	22.94
PASSENGERS	85000.		
BAGGAGE	0.		
CARGO	15000.		
STORES	0.		
OPERATIONAL EMPTY WEIGHT	245506.		
OPERATIONAL ITEMS	16182.	OPERATIONAL ITEMS	4.95
STANDARD ITEMS	5396.		
EMPTY WEIGHT	223929.		
STRUCTURE	130982.	STRUCTURE	30.04
WING	45889.		
ROTOR	0.		
TAIL	5400.		
BODY	56063.		
ALIGHTING GEAR	17053.		
ENGINE SECTION AND NACELLE	5778.		
PROPULSION	26614.	PROPULSION	6.10
CRUISE ENGINES	21049.		
LIFT ENGINES	0.		
THRUST REVERSER	4201.		
EXHAUST SYSTEM	0.		
ENGINE CONTROL	189.		
STARTING SYSTEM	503.		
PROPELLERS	0.		
LUBRICATING SYSTEM	0.		
FUEL SYSTEM	1410.		
DRIVE SYSTEM (POWER TRANS)	0.		
SYSTEMS	66333.		
FLIGHT CONTROLS	5056.		
AUXILIARY POWER PLANT	1116.		
INSTRUMENTS	875.		
HYDRAULIC AND PNEUMATIC	0.		
ELECTRICAL	5474.		
AVIONICS	2875.	SYSTEMS	15.21
ARMAMENT	0.		
FURNISHINGS AND EQUIPMENT	44293.		
AIR CONDITIONING	6177.		
ANTI-ICING	466.		
PHOTOGRAPHIC	0.		
LOAD AND HANDLING	0.		
		TOTAL	(100.)

All Electric
with RSS

COST SUMMARY

RDT AND E

	TOTAL *
DEVELOPMENT - NONRECURRING	
ENGINEERING	1046.13
TOOLING	702.58
TEST ARTICLES	85.09
DATA	0.0
SYSTEMS ENG/MNGMT	0.0
CRUISE ENGINE	0.0
LIFT ENGINE	0.0
FAN	0.0
AVIONICS	23.18
OTHER SYSTEMS	0.0
FACILITIES	0.0
TOTAL AIR VEHICLE	1856.97
INTEGR LOGISTICS SUPPORT	
PLANNING	9.75
TRAINING	3.31
HANDBOOKS	20.37
SSE	4.77
TOTAL ILS	38.20
TOTAL DVLPMNT-NONREC	1895.18
DEVELOPMENT - RECUR(PROTOTYPES)	
AIR VEHICLE	807.45
SPARES	207.88
TOTAL DVLPMNT-RECUR	1015.33
GOVMNT DVLPMNT COST	0.0
TOTAL DVLPMNT COST	2910.51

PRODUCTION

	MATERIAL	LABOR	TOTAL PER PROD A/C**
STRUCTURE	5328.17	15613.59	20941.74
WING	2373.70	3114.63	5488.33
ROTOR	0.0	0.0	0.0
TAIL	233.00	476.03	709.03
BODY	1645.22	10895.22	12540.44
ALIGHTING GEAR	771.66	35.93	807.59
ENG SECT + NACELLE	304.59	1091.77	1396.36
ENG SECTION	0.0	0.0	0.0
NACELLE	228.30	989.52	1217.82
AIR INDUCTION	76.29	102.25	178.55
PROPULSION	148.39	138.99	287.39
ENGINE INSTALL	0.0	32.88	32.88
THRUST REVERSER	0.0	6.56	6.56
EXHAUST SYSTEM	0.0	0.0	0.0
ENGINE CONTROLS	4.38	6.24	10.62
STARTING SYSTEM	66.76	11.37	78.12
PROPELLER INSTALL	0.0	0.0	0.0
LUBRICATING SYSTEM	0.0	0.0	0.0
FUEL SYSTEM	77.26	81.94	159.20
DRIVE SYS(PWR TRN)	0.0	0.0	0.0
SYSTEMS	3511.18	8509.47	12020.65
FLIGHT CONTROLS	844.78	435.58	1280.36
AUX POWER PLANT	166.98	27.27	194.26
INSTRUMENTS	83.92	73.58	157.50
HYDRAULIC + PNEUM	0.0	0.0	0.0
ELECTRICAL	501.82	1282.64	1784.45
AVIONIC INSTALL	51.50	515.68	567.18
ARMAMENT	0.0	0.0	0.0
FURN AND EQUIP	1400.16	5619.76	7019.92
AIR CONDITIONING	429.58	516.00	945.58
ANTI-ICING	32.44	38.97	71.41
PHOTOGRAPHIC	0.0	0.0	0.0
LOAD AND HANDLING	0.0	0.0	0.0
SYSTEMS INTEGR	707.87	674.68	1382.55
TOTAL COST	9695.61	24936.67	34632.27
TOTAL HRS **		747.73	747.73
ENG CHANGE ORDERS			1136.22
SUSTAINING ENG COST			2001.13
PROD TOOLING COST			2106.72
QUALITY ASSURANCE			3353.55
MISCELLANEOUS ***			760.62
TOTAL AIRFRAME COST			43990.49
ENGINE COST			5097.36
AVIONICS COST			1099.55
TOTAL MANUFACTURING COST			50187.41
WARRANTY			268.25
TOTAL PRODUCTION COST			50455.64

PROCUREMENT

	PER PROD A/C**
TOTAL PRODUCTION	50455.64
INTEGR LOGISTICS SUPPORT	
PLANNING	29.98
TRAINING	10.19
TRAINERS	360.68
HANDBOOKS	42.99
FACILITIES	0.0
SSE - CFE	25.23
SSE - GFE	751.07
TOTAL ILS	1220.13
INITIAL SPARES COST	6877.81
PRODUCTION DEVELOPMENT	
ENGINEERING	360.65
TOOLING	-134.30
ENGINES	0.0
TOTAL PROD DEV	226.34
TOTAL PROCUREMENT	58779.92

* - MILLIONS OF DOLLARS

** -1000 OF DOLLARS OR HOURS PER PROD A/C

*** - INCLUDES PROD DATA, SYSTEMS ENGR AND OTHER SYSTEMS

All Electric with RSS

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)	C/SM***	PERCENT
FLIGHT CREW	0.22561	14.46255
FUEL AND OIL	0.45773	29.34248
INSURANCE	0.02434	1.56016
DEPRECIATION	0.53506	34.29990
MAINTENANCE	0.31721	20.33492
TOTAL DOC	1.55995	100.000

INDIRECT OPERATIONAL COST (IOC)	C/SM***	PERCENT
SYSTEM	0.02852	2.30518
LOCAL	0.06958	5.62454
AIRCRAFT CONTROL	0.00202	0.16323
CABIN ATTENDANT	0.22698	18.34734
FOOD AND BEVERAGE	0.13629	11.01658
PASSENGER HANDLING	0.15707	12.69623
CARGO HANDLING	0.05804	4.69184
OTHER PASSENGER EXPENSE	0.42408	34.27911
OTHER CARGO EXPENSE	0.00853	0.68922
GENERAL + ADMINISTRATION	0.12602	10.18674
TOTAL IOC	1.23714	100.000

MISC. DATA	
FLIGHT DISTANCE (N. MI.)	2999.94
BLOCK FUEL (LBS)	75316.19
BLOCK TIME (HRS)	7.23
FLIGHT TIME (HRS)	6.80
AVG STAGE LENGTH (N. MI.)	1144.00
AVG CARGO PER FLIGHT	17413.00
UTILIZATION (HRS PER YR)	3636.00
FLIGHTS PER A/C PER YEAR	502.84
FARE ($)	357.59
FUEL COST ($/LB)	0.09000

*** - CENTS PER SEAT N. MILE

- -

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR $M	CUMULATIVE DEPRECIATION $M	AVERAGE BOOK VALUE OF FLEET $M	REVENUE $M	INTEREST EXPENSE $M	OPERATING EXPENSE $M	CASH FLOW $M	ROI PERCENT
1	6.3	10.0	428.01	25.68	402.33	345.37	41.09	131.86	-79.85	31.64
2	16.3	10.0	1112.83	92.45	1020.38	897.96	100.26	342.83	47.68	32.12
3	20.0	0.0	1369.63	174.63	1195.00	1105.19	111.76	421.94	258.35	33.26
4	20.0	0.0	1369.63	256.01	1112.83	1105.19	98.61	421.94	264.92	35.13
5	20.0	0.0	1369.63	338.98	1030.65	1105.19	85.46	421.94	271.50	37.29
6	20.0	0.0	1369.63	421.16	948.47	1105.19	72.32	421.94	278.07	39.83
7	20.0	0.0	1369.63	503.34	866.29	1105.19	59.17	421.94	284.65	42.85
8	20.0	0.0	1369.63	585.52	784.12	1105.19	46.02	421.94	291.22	46.50
9	20.0	0.0	1369.63	667.69	701.94	1105.19	32.87	421.94	297.80	51.01
10	20.0	0.0	1369.63	749.87	619.76	1105.19	19.72	421.94	304.37	56.71

AVG ROI OVER THE 10 YEAR PERIOD = 39.75 PERCENT

All Electric
with RSS
Fuel $.60/gal

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)

	C/SM***	PERCENT
FLIGHT CREW	0.22561	9.30709
FUEL AND OIL	1.32183	54.52972
INSURANCE	0.02434	1.00401
DEPRECIATION	0.53506	22.07301
MAINTENANCE	0.31721	13.08613
TOTAL DOC	2.42405	100.000

INDIRECT OPERATIONAL COST (IOC)

	C/SM***	PERCENT
SYSTEM	0.02852	2.21394
LOCAL	0.06958	5.40193
AIRCRAFT CONTROL	0.00202	0.15677
CABIN ATTENDANT	0.22698	17.62119
FOOD AND BEVERAGE	0.13629	10.58057
PASSENGER HANDLING	0.15707	12.19373
CARGO HANDLING	0.05804	4.50614
OTHER PASSENGER EXPENSE	0.42408	32.92241
OTHER CARGO EXPENSE	0.00853	0.66194
GENERAL + ADMINISTRATION	0.17701	13.74142
TOTAL IOC	1.28812	100.000

MISC. DATA

FLIGHT DISTANCE (N. MI.)	2999.94
BLOCK FUEL (LBS)	75316.19
BLOCK TIME (HRS)	7.23
FLIGHT TIME (HRS)	6.80
AVG STAGE LENGTH (N. MI.)	1144.00
AVG CARGO PER FLIGHT	17413.00
UTILIZATION (HRS PER YR)	3636.00
FLIGHTS PER A/C PER YEAR	502.84
FARE ($)	357.59
FUEL COST ($/LB)	0.26000

*** - CENTS PER SEAT N. MILE

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR	CUMULATIVE DEPRECIATION	AVERAGE BOOK VALUE OF FLEET	REVENUE	INTEREST EXPENSE	OPERATING EXPENSE	CASH FLOW	ROI
			$M	$M	$M	$M	$M	$M	$M	PERCENT
1	6.3	10.0	428.01	25.68	402.33	345.37	41.09	174.99	-101.42	26.28
2	16.3	10.0	1112.83	92.45	1020.38	897.96	100.26	454.98	-8.40	26.62
3	20.0	0.0	1369.63	174.63	1195.00	1105.19	111.76	559.98	189.33	27.49
4	20.0	0.0	1369.63	256.81	1112.83	1105.19	98.61	559.98	195.90	28.93
5	20.0	0.0	1369.63	338.98	1030.65	1105.19	85.46	559.98	202.48	30.60
6	20.0	0.0	1369.63	421.16	948.47	1105.19	72.32	559.98	209.05	32.55
7	20.0	0.0	1369.63	503.34	866.29	1105.19	59.17	559.98	215.63	34.88
8	20.0	0.0	1369.63	585.52	784.12	1105.19	46.02	559.98	222.20	37.70
9	20.0	0.0	1369.63	667.69	701.94	1105.19	32.87	559.98	228.78	41.18
10	20.0	0.0	1369.63	749.87	619.76	1105.19	19.72	559.98	235.35	45.58

AVG ROI OVER THE 10 YEAR PERIOD = 32.50 PERCENT

All Electric
with RSS
Fuel #1.80/gal

SUMMARY ID NO. 1 A S S E T P A R A M E T R I C A N A L Y S I S MAY 09 1980

AIRCRAFT MODEL -- CL1332-1
I.O.C. DATE --1985
DESIGN SPEED --SUBSONIC

ENGINE I.D. -- 416000
SLS SCALE 1.0 = 40850
NUMBER OF ENGINES = 3.

WING QUARTER CHORD SWEEP = 30.00 DEG
WING TAPER RATIO = 0.300

1 W/S	114.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 T/W	0.255	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 AR	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 T/C	13.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 SWEEP	30.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 FPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 OPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8 TIT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9 NPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 AUG T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11 RADIUS N. MI	3000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 GROSS WEIGHT	435978	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 FUEL WEIGHT	90471	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 OP. WT. EMPTY	245506	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ZERO FUEL WT.	345506	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 ENGINE SCALE	0.907	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17 THRUST/ENGINE	37058	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 WING AREA	3798.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19 WING SPAN	194.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20 H. TAIL AREA	852.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 V. TAIL AREA	530.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22 ENG. LENGTH	10.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23 ENG. DIAMETER	6.89	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24 BODY LENGTH	228.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25 WING FUEL LIMIT	3.056	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COST DATA																
26 RDTE - BIL.	2.911	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27 FLYAWAY - MIL.	60.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 INVESTMNT-BIL.	1.370	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 DOC - C/SM	1.560	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30 IOC - C/SM	1.237	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31 ROI A.T. - O/O	39.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32 DOC - C/SM	2.424	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33 IOC - C/SM	1.288	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34 ROI A.T. - O/O	32.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MISSION PARAMETERS																
35 MISN V1(1,1)	37000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36 MISN V2(1,1)	75316	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSTRAINT OUTPUT																
37 TAKEOFF DST(1)	6979	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38 CLIMB GRAD(1)	0.1140	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39 TAKEOFF DST(2)	6631	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40 CLIMB GRAD(2)	0.0411	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41 CTOL LNDG D(1)	6163	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42 AP SPEED-KT(1)	136.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43 SEP(1) - FPS	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44 SEP(2) - FPS	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

All Electric
with RSS
Fuel \$.60/gal

COMMUTER --- 50 PASS -- 600 NMI --- M = 0.70 MISS

T/C=16.00 AR=10.00 W/S= 80.00 T/W=0.344

W E I G H T S T A T E M E N T

	WEIGHT(POUNDS)	WEIGHT FRACTION	(PERCENT)
GROSS WEIGHT	(41370.)	FUEL	10.50
FUEL AVAILABLE	4344.		
EXTERNAL	0.		
INTERNAL	4347.		
ZERO FUEL WEIGHT	37026.	PAYLOAD	24.17
PAYLOAD	10000.		
PASSENGERS	8500.		
BAGGAGE	1500.		
CARGO	0.		
STORES	0.		
OPERATIONAL EMPTY WEIGHT	27026.	OPERATIONAL ITEMS	2.84
OPERATIONAL ITEMS	929.		
STANDARD ITEMS	244.		
EMPTY WEIGHT	25853.	STRUCTURE	27.29
STRUCTURE	11290.		
WING	2997.		
ROTOR	0.		
TAIL	524.		
BODY	5263.		
ALIGHTING GEAR	1641.		
ENGINE SECTION AND NACELLE	865.	PROPULSION	11.64
PROPULSION	4815.		
CRUISE ENGINES	2408.		
LIFT ENGINES	0.		
THRUST REVERSER	0.		
EXHAUST SYSTEM	0.		
ENGINE CONTROL	151.		
STARTING SYSTEM	80.		
PROPELLERS	1921.		
LUBRICATING SYSTEM	0.		
FUEL SYSTEM	255.		
DRIVE SYSTEM (POWER TRANS)	0.		
SYSTEMS	9748.		
FLIGHT CONTROLS	1190.		
AUXILIARY POWER PLANT	0.		
INSTRUMENTS	200.		
HYDRAULIC AND PNEUMATIC	269.		
ELECTRICAL	1355.	SYSTEMS	23.56
AVIONICS	598.		
ARMAMENT	0.		
FURNISHINGS AND EQUIPMENT	4735.		
AIR CONDITIONING	1149.		
ANTI-ICING	254.		
PHOTOGRAPHIC	0.		
LOAD AND HANDLING	0.	TOTAL	(100.)

CONVENTIONAL
50 PASSENGER

COST SUMMARY

RDT AND E

	TOTAL *
DEVELOPMENT - NONRECURRING	
ENGINEERING	86.45
TOOLING	68.75
TEST ARTICLES	6.48
DATA	0.0
SYSTEMS ENG/MGMT	0.0
CRUISE ENGINE	0.0
LIFT ENGINE	0.0
FAN	0.0
AVIONICS	0.0
OTHER SYSTEMS	0.0
FACILITIES	0.0
TOTAL AIR VEHICLE	161.68
INTEGR LOGISTICS SUPPORT	
PLANNING	0.93
TRAINING	0.32
HANDBOOKS	4.36
SSE	0.0
TOTAL ILS	5.61
TOTAL DVLPMNT-NONREC	167.30
DEVELOPMENT - RECUR(PROTOTYPES)	
AIR VEHICLE	48.23
SPARES	0.0
TOTAL DVLPMNT-RECUR	48.23
GOVMNT DVLPMNT COST	0.0
TOTAL DVLPMNT COST	215.53

CONVENTIONAL
50 PASSENGER

PRODUCTION

	MATERIAL	LABOR	TOTAL PER PROD A/C**
STRUCTURE	330.02	817.63	1147.65
WING	74.95	177.95	252.90
ROTOR	0.0	0.0	0.0
TAIL	10.49	37.37	47.87
BODY	110.58	500.08	610.66
ALIGHTING GEAR	82.08	9.74	91.82
ENG SECT + NACELLE	51.93	92.48	144.41
ENG SECTION	0.0	0.0	0.0
NACELLE	51.93	92.48	144.41
AIR INDUCTION	0.0	0.0	0.0
PROPULSION	42.76	69.12	111.88
ENGINE INSTALL	0.0	45.76	45.76
THRUST REVERSER	0.0	0.0	0.0
EXHAUST SYSTEM	0.0	0.0	0.0
ENGINE CONTROLS	6.04	5.38	11.41
STARTING SYSTEM	8.16	2.85	11.01
PROPELLER INSTALL	0.0	0.0	0.0
LUBRICATING SYSTEM	0.0	0.0	0.0
FUEL SYSTEM	28.56	15.14	43.70
DRIVE SYS(PWR TRN)	0.0	0.0	0.0
SYSTEMS	530.11	615.46	1145.57
FLIGHT CONTROLS	111.91	113.07	224.98
AUX POWER PLANT	0.0	0.0	0.0
INSTRUMENTS	35.15	16.12	51.28
HYDRAULIC + PNEUM	33.59	23.93	57.52
ELECTRICAL	88.10	144.82	232.93
AVIONIC INSTALL	8.97	45.46	54.43
ARMAMENT	0.0	0.0	0.0
FURN AND EQUIP	118.42	191.19	309.61
AIR CONDITIONING	114.91	68.21	183.12
ANTI-ICING	19.05	12.66	31.71
PHOTOGRAPHIC	0.0	0.0	0.0
LOAD AND HANDLING	0.0	0.0	0.0
SYSTEMS INTEGR	51.73	153.53	205.26
TOTAL COST	954.62	1655.75	2610.37
TOTAL HRS **		49.65	49.65
ENG CHANGE ORDERS			84.77
SUSTAINING ENG COST			242.11
PROD TOOLING COST			299.75
QUALITY ASSURANCE			222.67
MISCELLANEOUS ***			50.50
TOTAL AIRFRAME COST			3510.17
ENGINE COST			1077.01
AVIONICS COST			150.00
TOTAL MANUFACTURING COST			4737.17
WARRANTY			0.0
TOTAL PRODUCTION COST			4737.17

PROCUREMENT

	PER PROD A/C**
TOTAL PRODUCTION	4737.17
INTEGR LOGISTICS SUPPORT	
PLANNING	5.11
TRAINING	1.74
TRAINERS	0.0
HANDBOOKS	21.26
FACILITIES	0.0
SSE - CFE	0.0
SSE - GFE	0.0
TOTAL ILS	28.10
INITIAL SPARES COST	566.86
PRODUCTION DEVELOPMENT	
ENGINEERING	51.87
TOOLING	48.62
ENGINES	0.0
TOTAL PROD DEV	100.49
TOTAL PROCUREMENT	5432.63

* - MILLIONS OF DOLLARS

** -1000 OF DOLLARS OR HOURS PER PROD A/C

*** - INCLUDES PROD DATA, SYSTEMS ENGR AND OTHER SYSTEMS

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)

	C/SM***	PERCENT
FLIGHT CREW	0.74642	18.68742
FUEL AND OIL	1.47588	36.95045
INSURANCE	0.18233	4.56488
DEPRECIATION	0.94664	23.70026
MAINTENANCE	0.64295	16.09695
TOTAL DOC	3.99422	100.000

INDIRECT OPERATIONAL COST (IOC)

	C/SM***	PERCENT
SYSTEM	0.09818	5.37425
LOCAL	0.28686	15.70201
AIRCRAFT CONTROL	0.08551	4.68052
CABIN ATTENDANT	0.20959	11.47257
FOOD AND BEVERAGE	0.0	0.0
PASSENGER HANDLING	0.62582	34.25557
CARGO HANDLING	0.0	0.0
OTHER PASSENGER EXPENSE	0.31372	17.17212
OTHER CARGO EXPENSE	0.0	0.0
GENERAL + ADMINISTRATION	0.20723	11.34298
TOTAL IOC	1.82691	100.000

MISC. DATA

FLIGHT DISTANCE (N. MI.)	599.94
BLOCK FUEL (LBS)	2975.85
BLOCK TIME (HRS)	1.79
FLIGHT TIME (HRS)	1.62
AVG STAGE LENGTH (N. MI.)	100.00
AVG CARGO PER FLIGHT	0.0
UTILIZATION (HRS PER YR)	2800.00
FLIGHTS PER A/C PER YEAR	1563.19
FARE ($)	72.25
FUEL COST ($/LB)	0.14680

*** - CENTS PER SEAT N. MILE

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR	CUMULATIVE DEPRECIATION	AVERAGE BOOK VALUE OF FLEET	REVENUE	INTEREST EXPENSE	OPERATING EXPENSE	CASH FLOW	ROI
			$M	$M	$M	$M	$M	$M	$M	PERCENT
1	3.1	5.0	19.67	1.39	18.28	8.41	2.12	8.53	-6.83	-0.65
2	11.3	10.0	70.82	6.41	64.41	30.28	7.31	30.71	-17.51	-0.66
3	15.0	0.0	94.42	13.10	81.32	40.37	8.84	40.94	-11.22	-0.70
4	15.0	0.0	94.42	19.79	74.64	40.37	7.82	40.94	-10.20	-0.76
5	15.0	0.0	94.42	26.47	67.95	40.37	6.80	40.94	-9.18	-0.84
6	15.0	0.0	94.42	33.16	61.26	40.37	5.78	40.94	-8.16	-0.93
7	15.0	0.0	94.42	39.85	54.57	40.37	4.76	40.94	-7.14	-1.04
8	15.0	0.0	94.42	46.54	47.83	40.37	3.74	40.94	-6.12	-1.19
9	15.0	0.0	94.42	53.23	41.19	40.37	2.72	40.94	-5.10	-1.38
10	15.0	0.0	94.42	59.91	34.51	40.37	1.70	40.94	-4.08	-1.65

AVG ROI OVER THE 10 YEAR PERIOD = -0.93 PERCENT

CONVENTIONAL

50 PASSENGER

SUMMARY ID NO. 1 — A S S E T   P A R A M E T R I C   A N A L Y S I S — JUNE 16 1980

AIRCRAFT MODEL --CL1374-1-1
I.O.C. DATE --1990
DESIGN SPEED --SUBSONIC

ENGINE I.D. -- 526000
SLS SCALE 1.0 = 5792
NUMBER OF ENGINES = 2.

WING QUARTER CHORD SWEEP = 5.38 DEG
WING TAPER RATIO = 0.300

1 W/S	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 T/W	0.344	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 AR	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 T/C	16.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 SWEEP	5.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 FPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 OPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8 TIT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9 NPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 AUG T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11 RADIUS N. MI	600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 GROSS WEIGHT	41370	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 FUEL WEIGHT	4344	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 OP. WT. EMPTY	27026	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ZERO FUEL WT.	37026	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 ENGINE SCALE	1.229	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17 THRUST/ENGINE	7116	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 SHP/ENGINE	4914	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 WING AREA	517.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20 WING SPAN	71.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 H. TAIL AREA	86.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22 V. TAIL AREA	69.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23 ENG. LENGTH	8.73	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24 ENG. DIAMETER	2.63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25 BODY LENGTH	74.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26 WING FUEL LIMIT	2.350	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COST DATA																
27 PDTE - BIL.	0.216	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 FLYAWAY - MIL.	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 INVESTMNT-BIL.	0.094	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30 DOC - C/SM	3.626	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31 IOC - C/SM	1.811	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32 ROI A.T. - 0/0	3.47	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33 DOC - C/SM	3.994	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34 IOC - C/SM	1.827	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35 ROI A.T. - 0/0	-0.93	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36 DOC - C/SM	4.734	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37 IOC - C/SM	1.860	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38 ROI A.T. - 0/0	-9.85	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MISSION PARAMETERS																
39 MISN V1(1,1)	36482	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40 MISN V2(1,1)	2849.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41 MISN V1(2,1)	15000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42 MISN V2(2,1)	1060.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CONSTRAINT OUTPUT																
43 TAKEOFF DST(1)	3451	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44 CLIMB GRAD(1)	0.2199	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45 TAKEOFF DST(2)	3989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46 CLIMB GRAD(2)	0.0449	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47 CTOL LDG D(1)	3998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48 AP SPEED-KT(1)	109.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49 SEP(1) - FPS	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50 SEP(2) - FPS	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CONVENTIONAL
50
PASSENGER

COMMUTER --- 50 PASS -- 600 NMI --- M = 0.70 MISS

T/C=16.00 AR=10.00 W/S= 80.00 T/W=0.344

W E I G H T   S T A T E M E N T

	WEIGHT(POUNDS)	WEIGHT FRACTION	(PERCENT)
GROSS WEIGHT	(41547.)		
FUEL AVAILABLE	4358.	FUEL	10.49
EXTERNAL	0.		
INTERNAL	4361.		
ZERO FUEL WEIGHT	37190.		
PAYLOAD	10000.	PAYLOAD	24.07
PASSENGERS	8500.		
BAGGAGE	1500.		
CARGO	0.		
STORES	0.		
OPERATIONAL EMPTY WEIGHT	27190.		
OPERATIONAL ITEMS	929.	OPERATIONAL ITEMS	2.82
STANDARD ITEMS	244.		
EMPTY WEIGHT	26016.		
STRUCTURE	11323.	STRUCTURE	27.25
WING	3012.		
ROTOR	0.		
TAIL	528.		
BODY	5270.		
ALIGHTING GEAR	1646.		
ENGINE SECTION AND NACELLE	867.		
PROPULSION	4830.	PROPULSION	11.63
CRUISE ENGINES	2413.		
LIFT ENGINES	0.		
THRUST REVERSER	0.		
EXHAUST SYSTEM	0.		
ENGINE CONTROL	151.		
STARTING SYSTEM	80.		
PROPELLERS	1929.		
LUBRICATING SYSTEM	0.		
FUEL SYSTEM	255.		
DRIVE SYSTEM (POWER TRANS)	0.		
SYSTEMS	9863.		
FLIGHT CONTROLS	1221.		
AUXILIARY POWER PLANT	0.		
INSTRUMENTS	200.		
HYDRAULIC AND PNEUMATIC	347.		
ELECTRICAL	1356.		
AVIONICS	598.	SYSTEMS	23.74
ARMAMENT	0.		
FURNISHINGS AND EQUIPMENT	4739.		
AIR CONDITIONING	1149.		
ANTI-ICING	254.		
PHOTOGRAPHIC	0.		
LOAD AND HANDLING	0.		
		TOTAL	(100.)

FBW
50 PASSENGER

COST SUMMARY

RDT AND E

DEVELOPMENT - NONRECURRING	TOTAL *
ENGINEERING	91.82
TOOLING	69.02
TEST ARTICLES	6.77
DATA	0.0
SYSTEMS ENG/MGMT	0.0
CRUISE ENGINE	0.0
LIFT ENGINE	0.0
FAN	0.0
AVIONICS	0.0
OTHER SYSTEMS	0.0
FACILITIES	0.0
TOTAL AIR VEHICLE	167.61
INTEGR LOGISTICS SUPPORT	
PLANNING	0.94
TRAINING	0.32
HANDBOCKS	4.40
SSE	0.0
TOTAL ILS	5.66
TOTAL DVLPMNT-NONREC	173.28
DEVELOPMENT - RECUR(PROTOTYPES)	
AIR VEHICLE	49.80
SPARES	0.0
TOTAL DVLPMNT-RECUR	49.80
GOVMNT DVLPMNT COST	0.0
TOTAL DVLPMNT COST	223.08

FBW
50 PASSENGER

PRODUCTION

	MATERIAL	LABOR	TOTAL PER PROD A/C**
STRUCTURE	330.64	819.61	1150.25
WING	75.25	178.87	254.13
ROTOR	0.0	0.0	0.0
TAIL	10.55	37.62	48.17
BODY	110.59	500.67	611.26
ALIGHTING GEAR	82.26	9.78	92.04
ENG SECT + NACELLE	51.99	92.67	144.66
ENG SECTION	0.0	0.0	0.0
NACELLE	51.99	92.67	144.66
AIR INDUCTION	0.0	0.0	0.0
PROPULSION	42.80	69.28	112.08
ENGINE INSTALL	0.0	45.86	45.86
THRUST REVERSER	0.0	0.0	0.0
EXHAUST SYSTEM	0.0	0.0	0.0
ENGINE CONTROLS	6.06	5.40	11.45
STARTING SYSTEM	8.15	2.85	11.00
PROPELLER INSTALL	0.0	0.0	0.0
LUBRICATING SYSTEM	0.0	0.0	0.0
FUEL SYSTEM	28.59	15.17	43.76
DRIVE SYS(PWR TRN)	0.0	0.0	0.0
SYSTEMS	572.46	685.43	1257.89
FLIGHT CONTROLS	144.75	175.80	320.56
AUX POWER PLANT	0.0	0.0	0.0
INSTRUMENTS	35.15	16.14	51.29
HYDRAULIC + PNEUM	43.31	30.88	74.20
ELECTRICAL	88.08	144.94	233.01
AVIONIC INSTALL	8.96	45.45	54.42
ARMAMENT	0.0	0.0	0.0
FURN AND EQUIP	118.38	191.34	309.72
AIR CONDITIONING	114.78	68.20	182.98
ANTI-ICING	19.04	12.67	31.72
PHOTOGRAPHIC	0.0	0.0	0.0
LOAD AND HANDLING	0.0	0.0	0.0
SYSTEMS INTEGR	52.00	154.49	206.48
TOTAL COST	997.90	1728.81	2726.71
TOTAL HRS **		51.84	51.84
ENG CHANGE ORDERS			88.54
SUSTAINING ENG COST			251.95
PROD TOOLING COST			312.97
QUALITY ASSURANCE			232.50
MISCELLANEOUS ***			52.73
TOTAL AIRFRAME COST			3665.40
ENGINE COST			1080.44
AVIONICS COST			150.00
TOTAL MANUFACTURING COST			4895.84
WARRANTY			0.0
TOTAL PRODUCTION COST			4895.84

PROCUREMENT

	PER PROD A/C**
TOTAL PRODUCTION	4895.84
INTEGR LOGISTICS SUPPORT	
PLANNING	5.14
TRAINING	1.75
TRAINERS	0.0
HANDBOOKS	21.38
FACILITIES	0.0
SSE - CFE	0.0
SSE - GFE	0.0
TOTAL ILS	28.26
INITIAL SPARES COST	585.90
PRODUCTION DEVELOPMENT ENGINEERING	52.17
TOOLING	45.66
ENGINES	0.0
TOTAL PROD DEV	97.83
TOTAL PROCUREMENT	5607.82

* - MILLIONS OF DOLLARS

** -1000 OF DOLLARS OR HOURS PER PROD A/C

*** - INCLUDES PROD DATA, SYSTEMS ENGR AND OTHER SYSTEMS

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)

	C/SM***	PERCENT
FLIGHT CREW	0.74645	18.48193
FUEL AND OIL	1.47998	36.64406
INSURANCE	0.18830	4.66218
DEPRECIATION	0.97769	24.20734
MAINTENANCE	0.64639	16.00443
TOTAL DOC	4.03880	100.000

INDIRECT OPERATIONAL COST (IOC)

	C/SM***	PERCENT
SYSTEM	0.09830	5.37460
LOCAL	0.28809	15.75193
AIRCRAFT CONTROL	0.08551	4.67536
CABIN ATTENDANT	0.20960	11.46043
FOOD AND BEVERAGE	0.0	0.0
PASSENGER HANDLING	0.62582	34.21779
CARGO HANDLING	0.0	0.0
OTHER PASSENGER EXPENSE	0.31372	17.15321
OTHER CARGO EXPENSE	0.0	0.0
GENERAL + ADMINISTRATION	0.20789	11.36663
TOTAL IOC	1.82893	100.000

MISC. DATA

FLIGHT DISTANCE (N. MI.)	599.94
BLOCK FUEL (LBS)	2984.13
BLOCK TIME (HRS)	1.79
FLIGHT TIME (HRS)	1.62
AVG STAGE LENGTH (N. MI.)	100.00
AVG CARGO PER FLIGHT	0.0
UTILIZATION (HRS PER YR)	2800.00
FLIGHTS PER A/C PER YEAR	1563.12
FARE ($)	72.25
FUEL COST ($/LB)	0.14680

*** - CENTS PER SEAT N. MILE

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR $M	CUMULATIVE DEPRECIATION $M	AVERAGE BOOK VALUE OF FLEET $M	REVENUE $M	INTEREST EXPENSE $M	OPERATING EXPENSE $M	CASH FLOW $M	ROI PERCENT
1	3.1	5.0	20.31	1.44	18.87	8.41	2.19	8.60	-7.12	-0.99
2	11.3	10.0	73.13	6.62	66.51	30.28	7.55	30.95	-18.31	-1.01
3	15.0	0.0	97.50	13.52	83.98	40.37	9.13	41.27	-11.89	-1.07
4	15.0	0.0	97.50	20.43	77.07	40.37	8.07	41.27	-10.84	-1.16
5	15.0	0.0	97.50	27.34	70.16	40.37	7.02	41.27	-9.79	-1.28
6	15.0	0.0	97.50	34.24	63.26	40.37	5.97	41.27	-8.73	-1.42
7	15.0	0.0	97.50	41.15	56.35	40.37	4.91	41.27	-7.68	-1.59
8	15.0	0.0	97.50	48.06	49.45	40.37	3.86	41.27	-6.63	-1.81
9	15.0	0.0	97.50	54.96	42.54	40.37	2.81	41.27	-5.57	-2.11
10	15.0	0.0	97.50	61.87	35.63	40.37	1.76	41.27	-4.52	-2.52

AVG ROI OVER THE 10 YEAR PERIOD = -1.42 PERCENT

FBW

50 PASSENGER

SUMMARY ID NO. 1 — A S S E T   P A R A M E T R I C   A N A L Y S I S — JUNE 16 1980

AIRCRAFT MODEL --CL1374-1-1
I.O.C. DATE --1990
DESIGN SPEED --SUBSONIC

ENGINE I.D. -- 526000
SLS SCALE 1.0 = 5792
NUMBER OF ENGINES = 2.

WING QUARTER CHORD SWEEP = 5.38 DEG
WING TAPER RATIO = 0.300

1 W/S	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 T/W	0.344	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 AR	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 T/C	16.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 SWEEP	5.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 FPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 OPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8 TIT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9 NPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 AUG T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11 RADIUS N. MI	609	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 GROSS WEIGHT	41547	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 FUEL WEIGHT	4358	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 OP. WT. EMPTY	27190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ZERO FUEL WT.	37190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 ENGINE SCALE	1.234	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17 THRUST/ENGINE	7146	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 SHP/ENGINE	4935	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 WING AREA	519.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20 WING SPAN	72.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 H. TAIL AREA	87.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22 V. TAIL AREA	69.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23 ENG. LENGTH	8.74	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24 ENG. DIAMETER	2.83	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25 BODY LENGTH	74.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26 WING FUEL LIMIT	2.357	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COST DATA																
27 PDTE - BIL.	0.223	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 FLYAWAY - MIL.	5.89	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 INVESTMNT-BIL.	0.098	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30 DOC - C/SM	3.669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31 IOC - C/SM	1.813	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32 ROI A.T. - O/O	2.88	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33 DOC - C/SM	4.039	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34 IOC - C/SM	1.829	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35 ROI A.T. - O/O	-1.42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36 DOC - C/SM	4.781	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37 IOC - C/SM	1.862	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38 ROI A.T. - O/O	-10.09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MISSION PARAMETERS																
39 MISN V1(1,1)	36489	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40 MISN V2(1,1)	2857.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41 MISN V1(2,1)	15000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42 MISN V2(2,1)	1063.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CONSTRAINT OUTPUT																
43 TAKEOFF DST(1)	3451	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44 CLIMB GRAD(1)	0.2199	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45 TAKEOFF DST(2)	3983	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46 CLIMB GRAD(2)	0.0449	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47 CTOL LNDG D(1)	3998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48 AP SPEED-KT(1)	109.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49 SEP(1) - FPS	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50 SEP(2) - FPS	18	0	0	0	0	0	0	[illegible]	0	0	0	0	0	0	0	0

FBW
50 PASS

COMMUTER --- 50 PASS -- 600 NMI --- M = 0.70 MISS

T/C=16.00 AR=10.00 W/S= 80.00 T/W=0.344

WEIGHT STATEMENT

	WEIGHT(POUNDS)	WEIGHT FRACTION	(PERCENT)
GROSS WEIGHT	(41732.)		
FUEL AVAILABLE	4372.	FUEL	10.48
EXTERNAL	0.		
INTERNAL	4375.		
ZERO FUEL WEIGHT	37361.		
PAYLOAD	10000.	PAYLOAD	23.96
PASSENGERS	8500.		
BAGGAGE	1500.		
CARGO	0.		
STORES	0.		
OPERATIONAL EMPTY WEIGHT	27361.		
OPERATIONAL ITEMS	929.	OPERATIONAL ITEMS	2.81
STANDARD ITEMS	244.		
EMPTY WEIGHT	26187.		
STRUCTURE	11357.	STRUCTURE	27.21
WING	3029.		
ROTOR	0.		
TAIL	532.		
BODY	5275.		
ALIGHTING GEAR	1652.		
ENGINE SECTION AND NACELLE	869.		
PROPULSION	4846.	PROPULSION	11.61
CRUISE ENGINES	2419.		
LIFT ENGINES	0.		
THRUST REVERSER	0.		
EXHAUST SYSTEM	0.		
ENGINE CONTROL	152.		
STARTING SYSTEM	80.		
PROPELLERS	1938.		
LUBRICATING SYSTEM	0.		
FUEL SYSTEM	256.		
DRIVE SYSTEM (POWER TRANS)	0.		
SYSTEMS	9985.		
FLIGHT CONTROLS	1336.		
AUXILIARY POWER PLANT	0.		
INSTRUMENTS	200.		
HYDRAULIC AND PNEUMATIC	348.		
ELECTRICAL	1357.		
AVIONICS	598.	SYSTEMS	23.93
ARMAMENT	0.		
FURNISHINGS AND EQUIPMENT	4743.		
AIR CONDITIONING	1149.		
ANTI-ICING	254.		
PHOTOGRAPHIC	0.		
LOAD AND HANDLING	0.		
		TOTAL	(100.)

MUX

50 PASSENGER

ORIGINAL PAGE IS
OF POOR QUALITY

C O S T   S U M M A R Y

RDT AND E

	TOTAL *
DEVELOPMENT - NONRECURRING	
ENGINEERING	93.78
TOOLING	69.40
TEST ARTICLES	6.93
DATA	0.0
SYSTEMS ENG/MNGMT	0.0
CRUISE ENGINE	0.0
LIFT ENGINE	0.0
FAN	0.0
AVIONICS	0.0
OTHER SYSTEMS	0.0
FACILITIES	0.0
TOTAL AIR VEHICLE	170.11
INTEGR LOGISTICS SUPPORT	
PLANNING	0.95
TRAINING	0.32
HANDBOOKS	4.45
SSE	0.0
TOTAL ILS	5.72
TOTAL DVLPMNT-NONREC	175.82
DEVELOPMENT - RECUR(PROTOTYPES)	
AIR VEHICLE	50.71
SPARES	0.0
TOTAL DVLPMNT-RECUR	50.71
GOVMNT DVLPMNT COST	0.0
TOTAL DVLPMNT COST	226.54

MUX
50 PASSENGER

PRODUCTION

	MATERIAL	LABOR	TOTAL PER PROD A/C**
STRUCTURE	331.25	821.53	1152.77
WING	75.57	179.83	255.40
ROTOR	0.0	0.0	0.0
TAIL	10.61	37.88	48.49
BODY	110.56	501.13	611.69
ALIGHTING GEAR	82.45	9.81	92.26
ENG SECT + NACELLE	52.04	92.88	144.92
ENG SECTION	0.0	0.0	0.0
NACELLE	52.04	92.88	144.92
AIR INDUCTION	0.0	0.0	0.0
PROPULSION	42.84	69.44	112.29
ENGINE INSTALL	0.0	45.97	45.97
THRUST REVERSER	0.0	0.0	0.0
EXHAUST SYSTEM	0.0	0.0	0.0
ENGINE CONTROLS	6.08	5.42	11.50
STARTING SYSTEM	8.14	2.85	10.99
PROPELLER INSTALL	0.0	0.0	0.0
LUBRICATING SYSTEM	0.0	0.0	0.0
FUEL SYSTEM	28.62	15.20	43.83
DRIVE SYS(PWR TRN)	0.0	0.0	0.0
SYSTEMS	601.87	721.98	1323.85
FLIGHT CONTROLS	174.27	211.94	386.22
AUX POWER PLANT	0.0	0.0	0.0
INSTRUMENTS	35.15	16.16	51.30
HYDRAULIC + PNEUM	43.42	31.00	74.42
ELECTRICAL	88.05	145.05	233.11
AVIONIC INSTALL	8.95	45.45	54.40
ARMAMENT	0.0	0.0	0.0
FURN AND EQUIP	118.34	191.49	309.84
AIR CONDITIONING	114.64	68.20	182.83
ANTI-ICING	19.04	12.69	31.73
PHOTOGRAPHIC	0.0	0.0	0.0
LOAD AND HANDLING	0.0	0.0	0.0
SYSTEMS INTEGR	52.27	155.49	207.76
TOTAL COST	1028.24	1768.43	2796.66
TOTAL HRS **		53.03	53.03
ENG CHANGE ORDERS			90.80
SUSTAINING ENG COST			255.77
PROD TOOLING COST			320.15
QUALITY ASSURANCE			237.82
MISCELLANEOUS ***			53.94
TOTAL AIRFRAME COST			3755.14
ENGINE COST			1084.02
AVIONICS COST			150.00
TOTAL MANUFACTURING COST			4989.15
WARRANTY			0.0
TOTAL PRODUCTION COST			4989.15

PROCUREMENT

	PER PROD A/C**
TOTAL PRODUCTION	4989.15
INTEGR LOGISTICS SUPPORT	
PLANNING	5.17
TRAINING	1.76
TRAINERS	0.0
HANDBOOKS	21.50
FACILITIES	0.0
SSE - CFE	0.0
SSE - GFE	0.0
TOTAL ILS	28.42
INITIAL SPARES COST	597.10
PRODUCTION DEVELOPMENT	
ENGINEERING	52.48
TOOLING	44.27
ENGINES	0.0
TOTAL PROD DEV	96.75
TOTAL PROCUREMENT	5711.42

* - MILLIONS OF DOLLARS

** -1000 OF DOLLARS OR HOURS PER PROD A/C

*** - INCLUDES PROD DATA, SYSTEMS ENGR AND OTHER SYSTEMS

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)

	C/SM***	PERCENT
FLIGHT CREW	0.74648	18.35268
FUEL AND OIL	1.48426	36.49132
INSURANCE	0.19170	4.71301
DEPRECIATION	0.99545	24.47366
MAINTENANCE	0.64954	15.96936
TOTAL DOC	4.06742	100.000

INDIRECT OPERATIONAL COST (IOC)

	C/SM***	PERCENT
SYSTEM	0.09854	5.38174
LOCAL	0.28937	15.80400
AIRCRAFT CONTROL	0.08551	4.67003
CABIN ATTENDANT	0.20961	11.44790
FOOD AND BEVERAGE	0.0	0.0
PASSENGER HANDLING	0.62582	34.17880
CARGO HANDLING	0.0	0.0
OTHER PASSENGER EXPENSE	0.31372	17.13371
OTHER CARGO EXPENSE	0.0	0.0
GENERAL + ADMINISTRATION	0.20844	11.38376
TOTAL IOC	1.83101	100.000

MISC. DATA

FLIGHT DISTANCE (N. MI.)	599.94
BLOCK FUEL (LBS)	2992.77
BLOCK TIME (HRS)	1.79
FLIGHT TIME (HRS)	1.62
AVG STAGE LENGTH (N. MI.)	100.00
AVG CARGO PER FLIGHT	0.0
UTILIZATION (HRS PER YR)	2800.00
FLIGHTS PER A/C PER YEAR	1563.05
FARE ($)	72.25
FUEL COST ($/LB)	0.14680

*** - CENTS PER SEAT N. MILE

- -

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR $M	CUMULATIVE DEPRECIATION $M	AVERAGE BOOK VALUE OF FLEET $M	REVENUE $M	INTEREST EXPENSE $M	OPERATING EXPENSE $M	CASH FLOW $M	ROI PERCENT
1	3.1	5.0	20.68	1.46	19.22	8.41	2.23	8.64	-7.29	-1.21
2	11.3	10.0	74.45	6.74	67.71	30.28	7.68	31.11	-18.80	-1.23
3	15.0	0.0	99.26	13.77	85.49	40.37	9.29	41.48	-12.31	-1.30
4	15.0	0.0	99.26	20.80	78.46	40.37	8.22	41.48	-11.23	-1.42
5	15.0	0.0	99.26	27.83	71.43	40.37	7.15	41.48	-10.16	-1.56
6	15.0	0.0	99.26	34.86	64.40	40.37	6.07	41.48	-9.09	-1.73
7	15.0	0.0	99.26	41.89	57.37	40.37	5.00	41.48	-8.02	-1.94
8	15.0	0.0	99.26	48.93	50.34	40.37	3.93	41.48	-6.95	-2.21
9	15.0	0.0	99.26	55.96	43.31	40.37	2.86	41.48	-5.87	-2.57
10	15.0	0.0	99.26	62.99	36.28	40.37	1.79	41.48	-4.80	-3.07

AVG ROI OVER THE 10 YEAR PERIOD = -1.74 PERCENT

MUX

50 PASSENGER

SUMMARY ID NO. 1 — A S S E T   P A R A M E T R I C   A N A L Y S I S — JUNE 16 1980

AIRCRAFT MODEL --CL1374-1-1
I.O.C. DATE --1990
DESIGN SPEED --SUBSONIC

ENGINE I.D. -- 526000
SLS SCALE 1.0 = 5792
NUMBER OF ENGINES = 2.

WING QUARTER CHORD SWEEP = 5.38 DEG
WING TAPER RATIO = 0.300

1 W/S	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 T/W	0.344	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 AR	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 T/C	16.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 SWEEP	5.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 FPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 OPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8 TIT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9 NPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 AUG T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11 RADIUS N. MI	600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 GROSS WEIGHT	41732	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 FUEL WEIGHT	4372	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 OP. WT. EMPTY	27361	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ZERO FUEL WT.	37361	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 ENGINE SCALE	1.239	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17 THRUST/ENGINE	7178	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 SHP/ENGINE	4957	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 WING AREA	522.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20 WING SPAN	72.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 H. TAIL AREA	87.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22 V. TAIL AREA	70.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23 ENG. LENGTH	8.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24 ENG. DIAMETER	2.83	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25 BODY LENGTH	74.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26 WING FUEL LIMIT	2.365	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COST DATA																
27 RDTE - BIL.	0.227	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 FLYAWAY - MIL.	5.99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 INVESTMNT-BIL.	0.099	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30 DCC - C/SM	3.697	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31 IOC - C/SM	1.815	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32 ROI A.T. - 0/0	2.51	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33 DCC - C/SM	4.067	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34 IOC - C/SM	1.831	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35 ROI A.T. - 0/0	-1.74	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36 DCC - C/SM	4.812	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37 IOC - C/SM	1.864	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38 ROI A.T. - 0/0	-10.27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MISSION PARAMETERS																
39 MISN V1(1,1)	36496	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40 MISN V2(1,1)	2865.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41 MISN V1(2,1)	15000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42 MISN V2(2,1)	1067.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CONSTRAINT OUTPUT																
43 TAKEOFF DST(1)	3450	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44 CLIMB GRAD(1)	0.2200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45 TAKEOFF DST(2)	3986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46 CLIMB GRAD(2)	0.0449	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47 CTOL LNDG D(1)	3998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48 AP SPEED-KT(1)	109.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49 SEP(1) - FPS	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50 SEP(2) - FPS	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

MUX
50 PASS

COMMUTER --- 50 PASS -- 600 NMI --- M = 0.70 MISS

T/C=16.00 AR=10.00 W/S= 80.00 T/W=0.344

WEIGHT STATEMENT

	WEIGHT(POUNDS)	WEIGHT FRACTION	(PERCENT)
GROSS WEIGHT	(41708.)		
FUEL AVAILABLE	4370.	FUEL	10 8
EXTERNAL	0.		
INTERNAL	4373.		
ZERO FUEL WEIGHT	37338.		
PAYLOAD	10000.	PAYLOAD	23.98
PASSENGERS	8500.		
BAGGAGE	1500.		
CARGO	0.		
STORES	0.		
OPERATIONAL EMPTY WEIGHT	27338.		
OPERATIONAL ITEMS	929.	OPERATIONAL ITEMS	2.81
STANDARD ITEMS	244.		
EMPTY WEIGHT	26164.		
STRUCTURE	11352.	STRUCTURE	27.22
WING	3026.		
ROTOR	0.		
TAIL	531.		
BODY	5274.		
ALIGHTING GEAR	1651.		
ENGINE SECTION AND NACELLE	869.		
PROPULSION	4843.	PROPULSION	11.61
CRUISE ENGINES	2418.		
LIFT ENGINES	0.		
THRUST REVERSER	0.		
EXHAUST SYSTEM	0.		
ENGINE CONTROL	152.		
STARTING SYSTEM	80.		
PROPELLERS	1937.		
LUBRICATING SYSTEM	0.		
FUEL SYSTEM	256.		
DRIVE SYSTEM (POWER TRANS)	0.		
SYSTEMS	9969.		
FLIGHT CONTROLS	1321.		
AUXILIARY POWER PLANT	0.		
INSTRUMENTS	200.		
HYDRAULIC AND PNEUMATIC	348.		
ELECTRICAL	1357.		
AVIONICS	598.	SYSTEMS	23.90
ARMAMENT	0.		
FURNISHINGS AND EQUIPMENT	4742.		
AIR CONDITIONING	1149.		
ANTI-ICING	254.		
PHOTOGRAPHIC	0.		
LOAD AND HANDLING	0.		
		TOTAL	(100.)

INTEGRATED AVIONICS
50 PASSENGER

COST SUMMARY

RDT AND E

	TOTAL *
DEVELOPMENT - NONRECURRING	
ENGINEERING	94.97
TOOLING	69.32
TEST ARTICLES	6.95
DATA	0.0
SYSTEMS ENG/MNGMT	0.0
CRUISE ENGINE	0.0
LIFT ENGINE	0.0
FAN	0.0
AVIONICS	0.0
OTHER SYSTEMS	0.0
FACILITIES	0.0
TOTAL AIR VEHICLE	171.24
INTEGR LOGISTICS SUPPORT	
PLANNING	0.95
TRAINING	0.32
HANDBOOKS	4.44
SSE	0.0
TOTAL ILS	5.71
TOTAL DVLPMNT-NONREC	176.95
DEVELOPMENT - RECUR(PROTOTYPES)	
AIR VEHICLE	50.80
SPARES	0.0
TOTAL DVLPMNT-RECUR	50.80
GOVMNT DVLPMNT COST	0.0
TOTAL DVLPMNT COST	227.76

PRODUCTION

	MATERIAL	LABOR	TOTAL PER PROD A/C**
STRUCTURE	331.17	821.27	1152.44
WING	75.53	179.70	255.23
ROTOR	0.0	0.0	0.0
TAIL	10.60	37.84	48.45
BODY	110.57	501.07	611.64
ALIGHTING GEAR	82.43	9.81	92.23
ENG SECT + NACELLE	52.04	92.85	144.89
ENG SECTION	0.0	0.0	0.0
NACELLE	52.04	92.85	144.89
AIR INDUCTION	0.0	0.0	0.0
PROPULSION	42.84	69.42	112.26
ENGINE INSTALL	0.0	45.95	45.95
THRUST REVERSER	0.0	0.0	0.0
EXHAUST SYSTEM	0.0	0.0	0.0
ENGINE CONTROLS	6.07	5.42	11.49
STARTING SYSTEM	8.15	2.85	11.00
PROPELLER INSTALL	0.0	0.0	0.0
LUBRICATING SYSTEM	0.0	0.0	0.0
FUEL SYSTEM	28.62	15.20	43.82
DRIVE SYS(PWR TRN)	0.0	0.0	0.0
SYSTEMS	606.11	727.03	1333.14
FLIGHT CONTROLS	178.50	217.05	395.55
AUX POWER PLANT	0.0	0.0	0.0
INSTRUMENTS	35.15	16.15	51.30
HYDRAULIC + PNEUM	43.41	30.98	74.39
ELECTRICAL	88.06	145.04	233.09
AVIONIC INSTALL	8.95	45.45	54.40
ARMAMENT	0.0	0.0	0.0
FURN AND EQUIP	118.35	191.47	309.82
AIR CONDITIONING	114.66	68.20	182.85
ANTI-ICING	19.04	12.69	31.73
PHOTOGRAPHIC	0.0	0.0	0.0
LOAD AND HANDLING	0.0	0.0	0.0
SYSTEMS INTEGR	52.24	155.35	207.59
TOTAL COST	1032.36	1773.07	2805.42
TOTAL HRS **		53.17	53.17
ENG CHANGE ORDERS			91.08
SUSTAINING ENG COST			257.70
PROD TOOLING COST			320.99
QUALITY ASSURANCE			238.45
MISCELLANEOUS ***			54.08
TOTAL AIRFRAME COST			3767.72
ENGINE COST			1083.54
AVIONICS COST			150.00
TOTAL MANUFACTURING COST			5001.25
WARRANTY			0.0
TOTAL PRODUCTION COST			5001.25

PROCUREMENT

	PER PROD A/C**
TOTAL PRODUCTION	5001.25
INTEGR LOGISTICS SUPPORT	
PLANNING	5.16
TRAINING	1.76
TRAINERS	0.0
HANDBOOKS	21.48
FACILITIES	0.0
SSE - CFE	0.0
SSE - GFE	0.0
TOTAL ILS	28.40
INITIAL SPARES COST	598.55
PRODUCTION DEVELOPMENT	
ENGINEERING	52.44
TOOLING	43.99
ENGINES	0.0
TOTAL PROD DEV	96.43
TOTAL PROCUREMENT	5724.63

* - MILLIONS OF DOLLARS

** -1000 OF DOLLARS OR HOURS PER PROD A/C

*** - INCLUDES PROD DATA, SYSTEMS ENGR AND OTHER SYSTEMS

INTEGRATED AVIONICS

50 PASSENGERS

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)

	C/SM***	PERCENT
FLIGHT CREW	0.74648	18.34967
FUEL AND OIL	1.48368	36.47136
INSURANCE	0.19223	4.72534
DEPRECIATION	0.99818	24.53691
MAINTENANCE	0.64751	15.91682
TOTAL DOC	4.06807	100.000

INDIRECT OPERATIONAL COST (IOC)

	C/SM***	PERCENT
SYSTEM	0.09818	5.36406
LOCAL	0.28920	15.80024
AIRCRAFT CONTROL	0.08551	4.67169
CABIN ATTENDANT	0.20961	11.45189
FOOD AND BEVERAGE	0.0	0.0
PASSENGER HANDLING	0.62582	34.19090
CARGO HANDLING	0.0	0.0
OTHER PASSENGER EXPENSE	0.31372	17.13979
OTHER CARGO EXPENSE	0.0	0.0
GENERAL + ADMINISTRATION	0.20832	11.38145
TOTAL IOC	1.83036	100.000

MISC. DATA

FLIGHT DISTANCE (N. MI.)	599.94
BLOCK FUEL (LBS)	2991.61
BLOCK TIME (HRS)	1.79
FLIGHT TIME (HRS)	1.62
AVG STAGE LENGTH (N. MI.)	100.00
AVG CARGO PER FLIGHT	0.0
UTILIZATION (HRS PER YR)	2800.00
FLIGHTS PER A/C PER YEAR	1563.05
FARE ($)	72.25
FUEL COST ($/LB)	0.14680

*** - CENTS PER SEAT N. MILE

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR $M	CUMULATIVE DEPRECIATION $M	AVERAGE BOOK VALUE OF FLEET $M	REVENUE $M	INTEREST EXPENSE $M	OPERATING EXPENSE $M	CASH FLOW $M	ROI PERCENT
1	3.1	5.0	20.74	1.47	19.27	8.41	2.24	8.64	-7.31	-1.20
2	11.3	10.0	74.65	6.76	67.89	30.28	7.70	31.11	-18.84	-1.23
3	15.0	0.0	99.53	13.81	85.73	40.37	9.32	41.48	-12.34	-1.30
4	15.0	0.0	99.53	20.86	78.68	40.37	8.24	41.48	-11.26	-1.41
5	15.0	0.0	99.53	27.91	71.63	40.37	7.17	41.48	-10.19	-1.55
6	15.0	0.0	99.53	34.96	64.58	40.37	6.09	41.48	-9.11	-1.72
7	15.0	0.0	99.53	42.01	57.53	40.37	5.02	41.48	-8.04	-1.93
8	15.0	0.0	99.53	49.06	50.48	40.37	3.94	41.48	-6.96	-2.20
9	15.0	0.0	99.53	56.11	43.43	40.37	2.87	41.48	-5.89	-2.56
10	15.0	0.0	99.53	63.16	36.38	40.37	1.79	41.48	-4.81	-3.06

AVG ROI OVER THE 10 YEAR PERIOD = -1.73 PERCENT

INTEGRATED AVIONICS
50 PASSENGER

SUMMARY ID NO. 1   A S S E T   P A R A M E T R I C   A N A L Y S I S   JUNE 16 1980

AIRCRAFT MODEL --CL1374-1-1
I.O.C. DATE --1990
DESIGN SPEED --SUBSONIC

ENGINE I.D. -- 526000
SLS SCALE 1.0 = 5792
NUMBER OF ENGINES = 2.

WING QUARTER CHORD SWEEP = 5.38 DEG
WING TAPER RATIO = 0.300

1 W/S	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 T/W	0.344	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 AR	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 T/C	16.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 SWEEP	5.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 FPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 OPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8 TIT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9 NPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 AUG T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11 RADIUS N. MI	600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 GROSS WEIGHT	41708	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 FUEL WEIGHT	4370	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 OP. WT. EMPTY	27338	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ZERO FUEL WT.	37338	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 ENGINE SCALE	1.239	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17 THRUST/ENGINE	7174	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 SHP/ENGINE	4954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 WING AREA	521.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20 WING SPAN	72.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 H. TAIL AREA	87.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22 V. TAIL AREA	70.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23 ENG. LENGTH	8.74	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24 ENG. DIAMETER	2.83	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25 BODY LENGTH	74.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26 WING FUEL LIMIT	2.364	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COST DATA																
27 RDTE - BIL.	0.228	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 FLYAWAY - MIL.	6.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 INVESTMNT-BIL.	0.100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30 DOC - C/SM	3.698	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31 IOC - C/SM	1.814	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32 ROI A.T. - 0/0	2.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33 DOC - C/SM	4.068	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34 IOC - C/SM	1.830	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35 ROI A.T. - 0/0	-1.73	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36 DOC - C/SM	4.812	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37 IOC - C/SM	1.863	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38 ROI A.T. - 0/0	-10.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MISSION PARAMETERS																
39 MISN V1(1,1)	36495	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40 MISN V2(1,1)	2864.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41 MISN V1(2,1)	15000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42 MISN V2(2,1)	1067.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CONSTRAINT OUTPUT																
43 TAKEOFF DST(1)	3450	0	0	0	0	0	0	[illegible]	0	0	0	0	0	0	0	0
44 CLIMB GRAD(1)	0.2200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45 TAKEOFF DST(2)	3987	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46 CLIMB GRAD(2)	0.0449	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47 CTOL LNDG D(1)	3998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48 AP SPEED-KT(1)	109.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49 SEP(1) - FPS	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50 SEP([illegible]) - FPS	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

INTEGRATED
AVIONICS
50 PASS.

COMMUTER --- 50 PASS -- 600 NMI --- M = 0.70 MISS

T/C=16.00 AR=10.00 W/S= 80.00 T/W=0.344

W E I G H T S T A T E M E N T

	WEIGHT(POUNDS)	WEIGHT FRACTION	(PERCENT)
GROSS WEIGHT	(41225.)		
FUEL AVAILABLE	4333.	FUEL	10.51
EXTERNAL	0.		
INTERNAL	4336.		
ZERO FUEL WEIGHT	36892.		
PAYLOAD	10000.	PAYLOAD	24.26
PASSENGERS	8500.		
BAGGAGE	1500.		
CARGO	0.		
STORES	0.		
OPERATIONAL EMPTY WEIGHT	26892.		
OPERATIONAL ITEMS	929.	OPERATIONAL ITEMS	2.85
STANDARD ITEMS	244.		
EMPTY WEIGHT	25719.		
STRUCTURE	11245.	STRUCTURE	27.28
WING	2990.		
ROTOR	0.		
TAIL	522.		
BODY	5259.		
ALIGHTING GEAR	1636.		
ENGINE SECTION AND NACELLE	838.		
PROPULSION	4703.	PROPULSION	11.41
CRUISE ENGINES	2303.		
LIFT ENGINES	0.		
THRUST REVERSER	0.		
EXHAUST SYSTEM	0.		
ENGINE CONTROL	150.		
STARTING SYSTEM	80.		
PROPELLERS	1915.		
LUBRICATING SYSTEM	0.		
FUEL SYSTEM	254.		
DRIVE SYSTEM (POWER TRANS)	0.		
SYSTEMS	9772.		
FLIGHT CONTROLS	1332.		
AUXILIARY POWER PLANT	0.		
INSTRUMENTS	199.		
HYDRAULIC AND PNEUMATIC	0.		
ELECTRICAL	1645.		
AVIONICS	598.	SYSTEMS	23.70
ARMAMENT	0.		
FURNISHINGS AND EQUIPMENT	4731.		
AIR CONDITIONING	1012.		
ANTI-ICING	254.		
PHOTOGRAPHIC	0.		
LOAD AND HANDLING	0.		
		TOTAL	(100.)

ALL-ELECTRIC

50 PASSENGER

COST SUMMARY

RDT AND E

	TOTAL *
DEVELOPMENT - NONRECURRING	
ENGINEERING	93.29
TOOLING	68.26
TEST ARTICLES	6.79
DATA	0.0
SYSTEMS ENG/MNGMT	0.0
CRUISE ENGINE	0.0
LIFT ENGINE	0.0
FAN	0.0
AVIONICS	0.0
OTHER SYSTEMS	0.0
FACILITIES	0.0
TOTAL AIR VEHICLE	168.34
INTEGR LOGISTICS SUPPORT	
PLANNING	0.93
TRAINING	0.32
HANDBOOKS	4.35
SSE	0.0
TOTAL ILS	5.59
TOTAL DVLPMNT-NONREC	173.93
DEVELOPMENT - RECUR(PROTOTYPES)	
AIR VEHICLE	49.75
SPARES	0.0
TOTAL DVLPMNT-RECUR	49.75
GOVMNT DVLPMNT COST	0.0
TOTAL DVLPMNT COST	223.68

ALL-ELECTRIC
50 PASSENGER

PRODUCTION

	MATERIAL	LABOR	TOTAL PER PROD A/C**
STRUCTURE	328.17	813.79	1141.96
WING	74.85	177.57	252.42
ROTOR	0.0	0.0	0.0
TAIL	10.45	37.17	47.62
BODY	110.60	499.74	610.34
ALIGHTING GEAR	81.92	9.72	91.64
ENG SECT + NACELLE	50.35	89.59	139.94
ENG SECTION	0.0	0.0	0.0
NACELLE	50.35	89.59	139.94
AIR INDUCTION	0.0	0.0	0.0
PROPULSION	42.73	67.09	109.82
ENGINE INSTALL	0.0	43.78	43.78
THRUST REVERSER	0.0	0.0	0.0
EXHAUST SYSTEM	0.0	0.0	0.0
ENGINE CONTROLS	6.02	5.36	11.38
STARTING SYSTEM	8.17	2.85	11.02
PROPELLER INSTALL	0.0	0.0	0.0
LUBRICATING SYSTEM	0.0	0.0	0.0
FUEL SYSTEM	28.54	15.11	43.65
DRIVE SYS(PWR TRN)	0.0	0.0	0.0
SYSTEMS	562.44	703.54	1265.98
FLIGHT CONTROLS	172.33	202.19	374.52
AUX POWER PLANT	0.0	0.0	0.0
INSTRUMENTS	35.16	16.11	51.27
HYDRAULIC + PNEUM	0.0	0.0	0.0
ELECTRICAL	107.13	175.95	283.08
AVIONIC INSTALL	8.98	45.46	54.44
ARMAMENT	0.0	0.0	0.0
FURN AND EQUIP	118.45	191.07	309.52
AIR CONDITIONING	101.34	60.10	161.44
ANTI-ICING	19.05	12.65	31.70
PHOTOGRAPHIC	0.0	0.0	0.0
LOAD AND HANDLING	0.0	0.0	0.0
SYSTEMS INTEGR	51.51	152.75	204.26
TOTAL COST	984.85	1737.17	2722.02
TOTAL HRS **		52.09	52.09
ENG CHANGE ORDERS			88.44
SUSTAINING ENG COST			253.75
PROD TOOLING COST			314.49
QUALITY ASSURANCE			233.62
MISCELLANEOUS ***			52.99
TOTAL AIRFRAME COST			3665.30
ENGINE COST			1074.21
AVIONICS COST			150.00
TOTAL MANUFACTURING COST			4889.50
WARRANTY			0.0
TOTAL PRODUCTION COST			4889.50

PROCUREMENT

	PER PROD A/C**
TOTAL PRODUCTION	4889.50
INTEGR LOGISTICS SUPPORT	
PLANNING	5.08
TRAINING	1.73
TRAINERS	0.0
HANDBOOKS	21.22
FACILITIES	0.0
SSE - CFE	0.0
SSE - GFE	0.0
TOTAL ILS	28.03
INITIAL SPARES COST	585.14
PRODUCTION DEVELOPMENT	
ENGINEERING	51.62
TOOLING	44.55
ENGINES	0.0
TOTAL PROD DEV	96.16
TOTAL PROCUREMENT	5598.84

* - MILLIONS OF DOLLARS

** -1000 OF DOLLARS OR HOURS PER PROD A/C

*** - INCLUDES PROD DATA, SYSTEMS ENGR AND OTHER SYSTEMS

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)

	C/SM***	PERCENT
FLIGHT CREW	0.74639	18.59442
FUEL AND OIL	1.47253	36.68420
INSURANCE	0.18810	4.68610
DEPRECIATION	0.97665	24.33080
MAINTENANCE	0.63039	15.70450
TOTAL DOC	4.01406	100.000

INDIRECT OPERATIONAL COST (IOC)

	C/SM***	PERCENT
SYSTEM	0.09565	5.24740
LOCAL	0.28586	15.68283
AIRCRAFT CONTROL	0.08551	4.69119
CABIN ATTENDANT	0.20959	11.49830
FOOD AND BEVERAGE	0.0	0.0
PASSENGER HANDLING	0.62582	34.33363
CARGO HANDLING	0.0	0.0
OTHER PASSENGER EXPENSE	0.31372	17.21123
OTHER CARGO EXPENSE	0.0	0.0
GENERAL + ADMINISTRATION	0.20662	11.33540
TOTAL IOC	1.82276	100.000

MISC. DATA

FLIGHT DISTANCE (N. MI.)	599.94
BLOCK FUEL (LBS)	2969.07
BLOCK TIME (HRS)	1.79
FLIGHT TIME (HRS)	1.62
AVG STAGE LENGTH (N. MI.)	100.00
AVG CARGO PER FLIGHT	0.0
UTILIZATION (HRS PER YR)	2800.00
FLIGHTS PER A/C PER YEAR	1563.25
FARE ($)	72.25
FUEL COST ($/LB)	0.14600

*** - CENTS PER SEAT N. MILE

- -

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR $M	CUMULATIVE DEPRECIATION $M	AVERAGE BOOK VALUE OF FLEET $M	REVENUE $M	INTEREST EXPENSE $M	OPERATING EXPENSE $M	CASH FLOW $M	ROI PERCENT
1	3.1	5.0	20.29	1.44	18.85	8.41	2.19	8.55	-7.06	-0.75
2	11.3	10.0	73.05	6.61	66.44	30.28	7.54	30.79	-18.13	-0.77
3	15.0	0.0	97.40	13.51	83.89	40.38	9.12	41.06	-11.66	-0.81
4	15.0	0.0	97.40	20.41	76.99	40.38	8.06	41.06	-10.61	-0.88
5	15.0	0.0	97.40	27.31	70.09	40.38	7.01	41.06	-9.56	-0.97
6	15.0	0.0	97.40	34.21	63.19	40.38	5.96	41.06	-8.51	-1.07
7	15.0	0.0	97.40	41.11	56.29	40.38	4.91	41.06	-7.46	-1.21
8	15.0	0.0	97.40	48.01	49.40	40.38	3.86	41.06	-6.40	-1.37
9	15.0	0.0	97.40	54.91	42.50	40.38	2.81	41.06	-5.35	-1.60
10	15.0	0.0	97.40	61.81	35.60	40.38	1.75	41.06	-4.30	-1.91

AVG ROI OVER THE 10 YEAR PERIOD = -1.08 PERCENT

ALL-ELECTRIC

50 PASSENGER

SUMMARY ID NO. 1   A S S E T   P A R A M E T R I C   A N A L Y S I S   JUNE 16 1980

AIRCRAFT MODEL --CL1374-1-1
I.O.C. DATE --1990
DESIGN SPEED --SUBSONIC

ENGINE I.D. -- 526000
SLS SCALE 1.0 = 5792
NUMBER OF ENGINES = 2.

WING QUARTER CHORD SWEEP = 5.38 DEG
WING TAPER RATIO = 0.300

1 W/S	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 T/W	0.344	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 AR	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 T/C	16.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 SWEEP	5.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 FPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 OPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8 TIT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9 NPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 AUG T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11 RADIUS N. MI	600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 GROSS WEIGHT	41225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 FUEL WEIGHT	4333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 OP. WT. EMPTY	26892	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ZERO FUEL WT.	36892	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 ENGINE SCALE	1.224	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17 THRUST/ENGINE	7091	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 SHP/ENGINE	4897	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 WING AREA	515.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20 WING SPAN	71.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 H. TAIL AREA	86.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22 V. TAIL AREA	68.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23 ENG. LENGTH	8.72	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24 ENG. DIAMETER	2.82	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25 BODY LENGTH	74.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26 WING FUEL LIMIT	2.344	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COST DATA																
27 RDTE - BIL.	0.224	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 FLYAWAY - MIL.	5.88	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 INVESTMNT-BIL.	0.097	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30 DOC - C/SM	3.646	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31 ICC - C/SM	1.806	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32 ROI A.T. - C/0	3.19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33 DOC - C/SM	4.014	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34 ICC - C/SM	1.823	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35 ROI A.T. - 0/0	-1.08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36 DOC - C/SM	4.753	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37 IOC - C/SM	1.856	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38 ROI A.T. - 0/0	-9.71	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MISSION PARAMETERS																
39 MISN V1(1,1)	36477	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40 MISN V2(1,1)	2843.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41 MISN V1(2,1)	15000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42 MISN V2(2,1)	1057.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CONSTRAINT OUTPUT																
43 TAKEOFF DST(1)	3452	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44 CLIMB GRAD(1)	0.2199	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45 TAKEOFF DST(2)	3990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46 CLIMB GRAD(2)	0.0449	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47 CTOL LNDG D(1)	3997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48 AP SPEED-KT(1)	109.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49 SEP(1) - FPS	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50 SEP(2) - FPS	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

ALL-ELECTRIC
50 PASS

COMMUTER --- 30 PASS -- 600 NMI --- M = 0.60 MISS

T/C=16.00 AR=12.00 W/S= 80.00 T/W=0.379

WEIGHT STATEMENT

	WEIGHT(POUNDS)		WEIGHT FRACTION	(PERCENT)
GROSS WEIGHT		(29167.)		
FUEL AVAILABLE		3128.	FUEL	10.72
EXTERNAL	0.			
INTERNAL	3131.			
ZERO FUEL WEIGHT		26039.		
PAYLOAD		6000.	PAYLOAD	20.57
PASSENGERS	5100.			
BAGGAGE	900.			
CARGO	0.			
STORES	0.			
OPERATIONAL EMPTY WEIGHT		20039.		
OPERATIONAL ITEMS	790.		OPERATIONAL ITEMS	3.38
STANDARD ITEMS	197.			
EMPTY WEIGHT		19052.		
STRUCTURE		7940.	STRUCTURE	27.22
WING	2362.			
ROTOR	0.			
TAIL	473.			
BODY	3561.			
ALIGHTING GEAR	1127.			
ENGINE SECTION AND NACELLE	417.			
PROPULSION		3561.	PROPULSION	12.21
CRUISE ENGINES	1651.			
LIFT ENGINES	0.			
THRUST REVERSER	0.			
EXHAUST SYSTEM	0.			
ENGINE CONTROL	117.			
STARTING SYSTEM	80.			
PROPELLERS	1492.			
LUBRICATING SYSTEM	0.			
FUEL SYSTEM	220.			
DRIVE SYSTEM (POWER TRANS)	0.			
SYSTEMS		7552.		
FLIGHT CONTROLS	949.			
AUXILIARY POWER PLANT	0.			
INSTRUMENTS	185.			
HYDRAULIC AND PNEUMATIC	204.			
ELECTRICAL	1077.			
AVIONICS	598.		SYSTEMS	25.89
ARMAMENT	0.			
FURNISHINGS AND EQUIPMENT	3302.			
AIR CONDITIONING	1002.			
ANTI-ICING	236.			
PHOTOGRAPHIC	0.			
LOAD AND HANDLING	0.		TOTAL	(100.)

CONVENTIONAL
30 PASSENGER

COST SUMMARY

RDT AND E

	TOTAL *
DEVELOPMENT - NONRECURRING	
ENGINEERING	68.55
TOOLING	52.90
TEST ARTICLES	4.85
DATA	0.0
SYSTEMS ENG/MNGMT	0.0
CRUISE ENGINE	0.0
LIFT ENGINE	0.0
FAN	0.0
AVIONICS	0.0
OTHER SYSTEMS	0.0
FACILITIES	0.0
TOTAL AIR VEHICLE	126.30
INTEGR LOGISTICS SUPPORT	
PLANNING	0.72
TRAINING	0.24
HANDBOOKS	3.72
SSE	0.0
TOTAL ILS	4.69
TOTAL DVLPMNT-NONREC	130.98
DEVELOPMENT - RECUR(PROTOTYPES)	
AIR VEHICLE	36.52
SPARES	0.0
TOTAL DVLPMNT-RECUR	36.52
GOVMNT DVLPMNT COST	0.0
TOTAL DVLPMNT COST	167.51

CONVENTIONAL
30 PASSENGER

PRODUCTION

	MATERIAL	LABOR	TOTAL PER PROD A/C**
STRUCTURE	237.77	566.08	803.86
WING	62.49	140.87	203.35
ROTOR	0.0	0.0	0.0
TAIL	10.01	33.83	43.84
BODY	79.16	339.90	419.06
ALIGHTING GEAR	59.65	6.72	66.37
ENG SECT + NACELLE	26.47	44.76	71.23
ENG SECTION	0.0	0.0	0.0
NACELLE	26.47	44.76	71.23
AIR INDUCTION	0.0	0.0	0.0
PROPULSION	39.66	51.69	91.36
ENGINE INSTALL	0.0	31.52	31.52
THRUST REVERSER	0.0	0.0	0.0
EXHAUST SYSTEM	0.0	0.0	0.0
ENGINE CONTROLS	4.96	4.19	9.15
STARTING SYSTEM	8.64	2.86	11.50
PROPELLER INSTALL	0.0	0.0	0.0
LUBRICATING SYSTEM	0.0	0.0	0.0
FUEL SYSTEM	26.07	13.12	39.18
DRIVE SYS(PWR TRN)	0.0	0.0	0.0
SYSTEMS	451.55	490.62	942.17
FLIGHT CONTROLS	94.43	90.58	185.01
AUX POWER PLANT	0.0	0.0	0.0
INSTRUMENTS	34.46	15.01	49.47
HYDRAULIC + PNEUM	27.00	18.26	45.27
ELECTRICAL	74.10	115.64	189.74
AVIONIC INSTALL	9.49	45.66	55.15
ARMAMENT	0.0	0.0	0.0
FURN AND EQUIP	87.36	133.92	221.28
AIR CONDITIONING	106.00	59.74	165.74
ANTI-ICING	18.70	11.80	30.51
PHOTOGRAPHIC	0.0	0.0	0.0
LOAD AND HANDLING	0.0	0.0	0.0
SYSTEMS INTEGR	40.33	113.65	153.98
TOTAL COST	769.31	1222.05	1991.36
TOTAL HRS **		36.64	36.64
ENG CHANGE ORDERS			64.51
SUSTAINING ENG COST			199.69
PROD TOOLING COST			221.23
QUALITY ASSURANCE			164.34
MISCELLANEOUS ***			37.28
TOTAL AIRFRAME COST			2678.41
ENGINE COST			687.21
AVIONICS COST			150.00
TOTAL MANUFACTURING COST			3515.62
WARRANTY			0.0
TOTAL PRODUCTION COST			3515.62

PROCUREMENT

	PER PROD A/C**
TOTAL PRODUCTION	3515.62
INTEGR LOGISTICS SUPPORT	
PLANNING	4.17
TRAINING	1.42
TRAINERS	0.0
HANDBOOKS	19.45
FACILITIES	0.0
SSE - CFE	0.0
SSE - GFE	0.0
TOTAL ILS	25.03
INITIAL SPARES COST	280.18
PRODUCTION DEVELOPMENT	
ENGINEERING	42.35
TOOLING	51.21
ENGINES	0.0
TOTAL PROD DEV	93.56
TOTAL PROCUREMENT	3914.39

* - MILLIONS OF DOLLARS

** -1000 OF DOLLARS OR HOURS PER PROD A/C

*** - INCLUDES PROD DATA, SYSTEMS ENGR AND OTHER SYSTEMS

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)

	C/SM***	PERCENT
FLIGHT CREW	0.83460	16.52048
FUEL AND OIL	1.78308	35.29529
INSURANCE	0.25510	5.04960
DEPRECIATION	1.28351	25.40665
MAINTENANCE	0.89560	17.72795
TOTAL DOC	5.05188	100.000

INDIRECT OPERATIONAL COST (IOC)

	C/SM***	PERCENT
SYSTEM	0.15335	6.91587
LOCAL	0.33704	15.19949
AIRCRAFT CONTROL	0.14250	6.42638
CABIN ATTENDANT	0.39059	17.61458
FOOD AND BEVERAGE	0.0	0.0
PASSENGER HANDLING	0.62575	28.21983
CARGO HANDLING	0.0	0.0
OTHER PASSENGER EXPENSE	0.31372	14.14791
OTHER CARGO EXPENSE	0.0	0.0
GENERAL + ADMINISTRATION	0.25447	11.47595
TOTAL IOC	2.21743	100.000

MISC. DATA

FLIGHT DISTANCE (N. MI.)	600.00
BLOCK FUEL (LBS)	2156.08
BLOCK TIME (HRS)	2.00
FLIGHT TIME (HRS)	1.84
AVG STAGE LENGTH (N. MI.)	100.00
AVG CARGO PER FLIGHT	0.0
UTILIZATION (HRS PER YR)	2800.00
FLIGHTS PER A/C PER YEAR	1397.88
FARE ($)	72.26
FUEL COST ($/LB)	0.14680

*** - CENTS PER SEAT N. MILE

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR	CUMULATIVE DEPRECIATION	AVERAGE BOOK VALUE OF FLEET	REVENUE	INTEREST EXPENSE	OPERATING EXPENSE	CASH FLOW	ROI
			$M	$M	$M	$M	$M	$M	$M	PERCENT
1	3.1	5.0	14.33	1.01	13.31	4.51	1.55	5.72	-6.09	-9.03
2	11.3	10.0	51.57	4.67	46.91	16.25	5.32	20.58	-16.77	-9.23
3	15.0	0.0	68.77	9.54	59.23	21.66	6.44	27.44	-13.53	-9.74
4	15.0	0.0	68.77	14.41	54.36	21.66	5.69	27.44	-12.78	-10.62
5	15.0	0.0	68.77	19.28	49.49	21.66	4.95	27.44	-12.04	-11.66
6	15.0	0.0	68.77	24.15	44.61	21.66	4.21	27.44	-11.30	-12.94
7	15.0	0.0	68.77	29.02	39.74	21.66	3.47	27.44	-10.56	-14.52
8	15.0	0.0	68.77	33.89	34.87	21.66	2.72	27.44	-9.81	-16.55
9	15.0	0.0	68.77	38.76	30.00	21.66	1.98	27.44	-9.07	-19.24
10	15.0	0.0	68.77	43.64	25.13	21.66	1.24	27.44	-8.33	-22.97

AVG ROI OVER THE 10 YEAR PERIOD = -13.00 PERCENT

CONVENTIONAL

30 PASSENGER

SUMMARY ID NO. 1 — ASSET PARAMETRIC ANALYSIS — JUNE 12 1980

AIRCRAFT MODEL --L1373-2-1
I.O.C. DATE --1990
DESIGN SPEED --SUBSONIC

ENGINE I.D. -- 521000
SLS SCALE 1.0 = 4512
NUMBER OF ENGINES = 2.

WING QUARTER CHORD SWEEP = 3.60 DEG
WING TAPER RATIO = 0.300

1 W/S	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 T/W	0.379	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 AR	12.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 T/C	16.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 SWEEP	3.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 FPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 OPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8 TIT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9 NPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 AUG T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11 RADIUS N. MI	600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 GROSS WEIGHT	29167	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 FUEL WEIGHT	3128	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 OP. WT. EMPTY	20039	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ZERO FUEL WT.	26039	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 ENGINE SCALE	1.225	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17 THRUST/ENGINE	5527	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 SHP/ENGINE	2450	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 WING AREA	365.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20 WING SPAN	66.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 H. TAIL AREA	78.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22 V. TAIL AREA	62.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23 ENG. LENGTH	7.54	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24 ENG. DIAMETER	2.36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25 BODY LENGTH	58.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26 WING FUEL LIMIT	2.218	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COST DATA																
27 RDTE - BIL.	0.168	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 FLYAWAY - MIL.	4.28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 INVESTMNT-BIL.	0.069	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30 DOC - C/SM	4.607	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31 IOC - C/SM	2.193	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32 ROI A.T. - 0/0	-9.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33 DOC - C/SM	5.052	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34 IOC - C/SM	2.217	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35 ROI A.T. - 0/0	-13.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36 DOC - C/SM	5.946	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37 IOC - C/SM	2.257	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38 ROI A.T. - 0/0	-20.94	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MISSION PARAMETERS																
39 MISN V1(1,1)	29000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40 MISN V2(1,1)	2156.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41 MISN V1(2,1)	15000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42 MISN V2(2,1)	677.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CONSTRAINT OUTPUT																
43 TAKEOFF DST(1)	3343	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44 CLIMB GRAD(1)	0.1925	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45 TAKEOFF DST(2)	3990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46 CLIMB GRAD(2)	0.0443	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47 CTOL LNDG D(1)	3938	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48 AP SPEED-KT(1)	110.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49 SEP(1) - FPS	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50 SEP(2) - FPS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CONVENTIONAL
30 PASS

COMMUTER --- 30 PASS -- 600 NMI --- M = 0.60 MISS

T/C=16.00 AR=12.00 W/S= 80.00 T/W=0.379

W E I G H T   S T A T E M E N T

	WEIGHT(POUNDS)		WEIGHT FRACTION	(PERCENT)
GROSS WEIGHT		(29512.)		
FUEL AVAILABLE		3167.	FUEL	10.73
EXTERNAL	0.			
INTERNAL	3170.			
ZERO FUEL WEIGHT		26345.		
PAYLOAD		6000.	PAYLOAD	20.33
PASSENGERS	5100.			
BAGGAGE	900.			
CARGO	0.			
STORES	0.			
OPERATIONAL EMPTY WEIGHT		20345.		
OPERATIONAL ITEMS	790.		OPERATIONAL ITEMS	3.35
STANDARD ITEMS	197.			
EMPTY WEIGHT		19358.		
STRUCTURE		8007.	STRUCTURE	27.13
WING	2396.			
ROTOR	0.			
TAIL	402.			
BODY	3572.			
ALIGHTING GEAR	1138.			
ENGINE SECTION AND NACELLE	419.			
PROPULSION		3592.	PROPULSION	12.17
CRUISE ENGINES	1662.			
LIFT ENGINES	0.			
THRUST REVERSER	0.			
EXHAUST SYSTEM	0.			
ENGINE CONTROL	119.			
STARTING SYSTEM	80.			
PROPELLERS	1510.			
LUBRICATING SYSTEM	0.			
FUEL SYSTEM	221.			
DRIVE SYSTEM (POWER TRANS)	0.			
SYSTEMS		7759.		
FLIGHT CONTROLS	1068.			
AUXILIARY POWER PLANT	0.			
INSTRUMENTS	183.			
HYDRAULIC AND PNEUMATIC	283.			
ELECTRICAL	1080.			
AVIONICS	593.		SYSTEMS	26.29
ARMAMENT	0.			
FURNISHINGS AND EQUIPMENT	3307.			
AIR CONDITIONING	1002.			
ANTI-ICING	236.			
PHOTOGRAPHIC	0.			
LOAD AND HANDLING	0.			
			TOTAL	(100.)

FBW
30 PASSENGER

COST SUMMARY

RDT AND E

	TOTAL *
DEVELOPMENT - NONRECURRING	
ENGINEERING	74.53
TOOLING	53.62
TEST ARTICLES	5.14
DATA	0.0
SYSTEMS ENG/MNGMT	0.0
CRUISE ENGINE	0.0
LIFT ENGINE	0.0
FAN	0.0
AVIONICS	0.0
OTHER SYSTEMS	0.0
FACILITIES	0.0
TOTAL AIR VEHICLE	133.28
INTEGR LOGISTICS SUPPORT	
PLANNING	0.73
TRAINING	0.25
HANDBOOKS	3.31
SSE	0.0
TOTAL ILS	4.80
TOTAL DVLPMNT-NONREC	138.08
DEVELOPMENT - RECUR(PROTOTYPES)	
AIR VEHICLE	38.15
SPARES	0.0
TOTAL DVLPMNT-RECUR	38.15
GOVMNT DVLPMNT COST	0.0
TOTAL DVLPMNT COST	176.23

FBW

- 30 PASSENGER

PRODUCTION

	MATERIAL	LABOR	TOTAL PER PROD A/C**
STRUCTURE	239.13	570.00	809.12
WING	63.21	142.87	206.08
ROTOR	0.0	0.0	0.0
TAIL	10.16	34.46	44.62
BODY	79.17	340.86	420.02
ALIGHTING GEAR	60.04	6.79	66.83
ENG SECT + NACELLE	26.56	45.02	71.58
ENG SECTION	0.0	0.0	0.0
NACELLE	26.56	45.02	71.58
AIR INDUCTION	0.0	0.0	0.0
PROPULSION	39.78	52.02	91.80
ENGINE INSTALL	0.0	31.71	31.71
THRUST REVERSER	0.0	0.0	0.0
EXHAUST SYSTEM	0.0	0.0	0.0
ENGINE CONTROLS	5.00	4.24	9.25
STARTING SYSTEM	8.61	2.86	11.47
PROPELLER INSTALL	0.0	0.0	0.0
LUBRICATING SYSTEM	0.0	0.0	0.0
FUEL SYSTEM	26.16	13.20	39.36
DRIVE SYS(PWR TRN)	0.0	0.0	0.0
SYSTEMS	515.61	551.03	1066.64
FLIGHT CONTROLS	148.64	143.42	292.06
AUX POWER PLANT	0.0	0.0	0.0
INSTRUMENTS	34.44	15.04	49.48
HYDRAULIC + PNEUM	37.35	25.33	62.68
ELECTRICAL	74.07	115.91	189.99
AVIONIC INSTALL	9.47	45.65	55.11
ARMAMENT	0.0	0.0	0.0
FURN AND EQUIP	87.26	134.12	221.38
AIR CONDITIONING	105.69	59.73	165.42
ANTI-ICING	18.70	11.83	30.53
PHOTOGRAPHIC	0.0	0.0	0.0
LOAD AND HANDLING	0.0	0.0	0.0
SYSTEMS INTEGR	40.86	115.44	156.30
TOTAL COST	835.37	1288.48	2123.86
TOTAL HRS **		38.64	38.64
ENG CHANGE ORDERS			68.74
SUSTAINING ENG COST			211.78
PROD TOOLING COST			233.26
QUALITY ASSURANCE			173.28
MISCELLANEOUS ***			39.30
TOTAL AIRFRAME COST			2850.21
ENGINE COST			693.34
AVIONICS COST			150.00
TOTAL MANUFACTURING COST			3693.55
WARRANTY			0.0
TOTAL PRODUCTION COST			3693.55

PROCUREMENT

	PER PROD A/C**
TOTAL PRODUCTION	3693.55
INTEGR LOGISTICS SUPPORT	
PLANNING	4.23
TRAINING	1.44
TRAINERS	0.0
HANDBOOKS	19.71
FACILITIES	0.0
SSE - CFE	0.0
SSE - GFE	0.0
TOTAL ILS	25.38
INITIAL SPARES COST	294.42
PRODUCTION DEVELOPMENT	
ENGINEERING	42.98
TOOLING	49.10
ENGINES	0.0
TOTAL PROD DEV	92.08
TOTAL PROCUREMENT	4105.42

* - MILLIONS OF DOLLARS

** -1000 OF DOLLARS OR HOURS PER PROD A/C

*** - INCLUDES PROD DATA, SYSTEMS ENGR AND OTHER SYSTEMS

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)	C/SM***	PERCENT
FLIGHT CREW	0.83466	16.17645
FUEL AND OIL	1.80540	34.99046
INSURANCE	0.26772	5.18864
DEPRECIATION	1.34711	26.10835
MAINTENANCE	0.90481	17.53610
TOTAL DOC	5.15969	100.000

INDIRECT OPERATIONAL COST (IOC)	C/SM***	PERCENT
SYSTEM	0.15392	6.92049
LOCAL	0.34103	15.33278
AIRCRAFT CONTROL	0.14250	6.40685
CABIN ATTENDANT	0.39062	17.56235
FOOD AND BEVERAGE	0.0	0.0
PASSENGER HANDLING	0.62575	28.13408
CARGO HANDLING	0.0	0.0
OTHER PASSENGER EXPENSE	0.31372	14.10493
OTHER CARGO EXPENSE	0.0	0.0
GENERAL + ADMINISTRATION	0.25664	11.53851
TOTAL IOC	2.22418	100.000

MISC. DATA	
FLIGHT DISTANCE (N. MI.)	600.00
BLOCK FUEL (LBS)	2183.13
BLOCK TIME (HRS)	2.00
FLIGHT TIME (HRS)	1.84
AVG STAGE LENGTH (N. MI.)	100.00
AVG CARGO PER FLIGHT	0.0
UTILIZATION (HRS PER YR)	2800.00
FLIGHTS PER A/C PER YEAR	1397.78
FARE ($)	72.26
FUEL COST ($/LB)	0.14680

*** - CENTS PER SEAT N. MILE

- -

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR	CUMULATIVE DEPRECIATION	AVERAGE BOOK VALUE OF FLEET	REVENUE	INTEREST EXPENSE	OPERATING EXPENSE	CASH FLOW	ROI
			$M	$M	$M	$M	$M	$M	$M	PERCENT
1	3.1	5.0	15.03	1.06	13.97	4.51	1.62	5.81	-6.42	-9.25
2	11.3	10.0	54.12	4.90	49.22	16.25	5.58	20.90	-17.71	-9.45
3	15.0	0.0	72.16	10.01	62.15	21.66	6.75	27.87	-14.34	-9.93
4	15.0	0.0	72.16	15.12	57.04	21.66	5.97	27.87	-13.56	-10.88
5	15.0	0.0	72.16	20.23	51.92	21.66	5.20	27.87	-12.78	-11.95
6	15.0	0.0	72.16	25.34	46.81	21.66	4.42	27.87	-12.00	-13.25
7	15.0	0.0	72.16	30.45	41.70	21.66	3.64	27.87	-11.22	-14.88
8	15.0	0.0	72.16	35.56	36.59	21.66	2.86	27.87	-10.44	-16.95
9	15.0	0.0	72.16	40.67	31.48	21.66	2.08	27.87	-9.66	-19.71
10	15.0	0.0	72.16	45.79	26.37	21.66	1.30	27.87	-8.89	-23.53

AVG ROI OVER THE 10 YEAR PERIOD = -13.32 PERCENT

FBW

30 PASSENGER

SUMMARY ID NO. 1 A S S E T P A R A M E T R I C A N A L Y S I S JUNE 12 1980

AIRCRAFT MODEL --L1373-2-1 ENGINE I.D. -- 521000 WING QUARTER CHORD SWEEP = 3.60 DEG
I.O.C. DATE --1990 SLS SCALE 1.0 = 4512 WING TAPER RATIO = 0.300
DESIGN SPEED --SUBSONIC NUMBER OF ENGINES = 2.

1 W/S	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 T/W	0.379	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 AR	12.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 T/C	16.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 SWEEP	3.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 FPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 OPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8 TIT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9 NPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 AUG T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11 RADIUS N. MI	600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 GROSS WEIGHT	29512	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 FUEL WEIGHT	3167	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 OP. WT. EMPTY	20345	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ZERO FUEL WT.	26345	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 ENGINE SCALE	1.239	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17 THRUST/ENGINE	5593	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 SHP/ENGINE	2479	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 WING AREA	369.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20 WING SPAN	66.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 H. TAIL AREA	79.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22 V. TAIL AREA	63.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23 ENG. LENGTH	7.56	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24 ENG. DIAMETER	2.37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25 BODY LENGTH	58.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26 WING FUEL LIMIT	2.230	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COST DATA																
27 RDTE - BIL.	0.176	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 FLYAWAY - MIL.	4.49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 INVESTMNT-BIL.	0.072	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30 DOC - C/SM	4.709	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31 IOC - C/SM	2.204	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32 ROI A.T. - 0/0	-9.51	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33 DOC - C/SM	5.160	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34 IOC - C/SM	2.224	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35 ROI A.T. - 0/0	-13.32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36 DOC - C/SM	6.065	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37 IOC - C/SM	2.264	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38 ROI A.T. - 0/0	-20.98	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MISSION PARAMETERS																
39 MISN V1(1,1)	29000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40 MISN V2(1,1)	2183.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41 MISN V1(2,1)	15000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42 MISN V2(2,1)	683.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CONSTRAINT OUTPUT																
43 TAKEOFF DST(1)	3342	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44 CLIMB GRAD(1)	0.1926	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45 TAKEOFF DST(2)	3986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46 CLIMB GRAD(2)	0.0444	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47 CTOL LNDG D(1)	3938	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48 AP SPEED-KT(1)	110.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49 SEP(1) - FPS	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50 SEP(2) - FPS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FBW
30 PASS.

COMMUTER --- 30 PASS -- 600 NMI --- M = 0.60 MISS

T/C=16.00 AR=12.00 W/S= 80.00 T/W=0.379

W E I G H T   S T A T E M E N T

	WEIGHT(POUNDS)			WEIGHT FRACTION	(PERCENT)
GROSS WEIGHT			(29706.)		
FUEL AVAILABLE			3181.	FUEL	10.71
EXTERNAL		0.			
INTERNAL		3184.			
ZERO FUEL WEIGHT			26524.		
PAYLOAD			6000.	PAYLOAD	20.20
PASSENGERS		5100.			
BAGGAGE		900.			
CARGO		0.			
STORES		0.			
OPERATIONAL EMPTY WEIGHT			20524.		
OPERATIONAL ITEMS		790.		OPERATIONAL ITEMS	3.32
STANDARD ITEMS		197.			
EMPTY WEIGHT			19537.		
STRUCTURE		8044.		STRUCTURE	27.08
WING	2415.				
ROTOR	0.				
TAIL	487.				
BODY	3578.				
ALIGHTING GEAR	1144.				
ENGINE SECTION AND NACELLE	421.				
PROPULSION		3609.		PROPULSION	12.15
CRUISE ENGINES	1668.				
LIFT ENGINES	0.				
THRUST REVERSER	0.				
EXHAUST SYSTEM	0.				
ENGINE CONTROL	119.				
STARTING SYSTEM	80.				
PROPELLERS	1520.				
LUBRICATING SYSTEM	0.				
FUEL SYSTEM	222.				
DRIVE SYSTEM (POWER TRANS)	0.				
SYSTEMS		7884.		SYSTEMS	26.54
FLIGHT CONTROLS	1166.				
AUXILIARY POWER PLANT	0.				
INSTRUMENTS	186.				
HYDRAULIC AND PNEUMATIC	205.				
ELECTRICAL	1031.				
AVIONICS	598.				
ARMAMENT	0.				
FURNISHINGS AND EQUIPMENT	3310.				
AIR CONDITIONING	1002.				
ANTI-ICING	237.				
PHOTOGRAPHIC	0.				
LOAD AND HANDLING	0.				
				TOTAL	(100.)

MUX
30 PASSENGER

COST SUMMARY

RDT AND E

	TOTAL *
DEVELOPMENT - NONRECURRING	
ENGINEERING	76.55
TOOLING	54.05
TEST ARTICLES	5.30
DATA	0.0
SYSTEMS ENG/MNGMT	0.0
CRUISE ENGINE	0.0
LIFT ENGINE	0.0
FAN	0.0
AVIONICS	0.0
OTHER SYSTEMS	0.0
FACILITIES	0.0
TOTAL AIR VEHICLE	135.89
INTEGR LOGISTICS SUPPORT	
PLANNING	0.74
TRAINING	0.25
HANDBOOKS	3.87
SSE	0.0
TOTAL ILS	4.86
TOTAL DVLPMNT-NONREC	140.76
DEVELOPMENT - RECUR(PROTOTYPES)	
AIR VEHICLE	39.05
SPARES	0.0
TOTAL DVLPMNT-RECUR	39.05
GOVMNT DVLPMNT COST	0.0
TOTAL DVLPMNT COST	179.81

MUX
30 PASSENGER

PRODUCTION

	MATERIAL	LABOR	TOTAL PER PROD A/C**
STRUCTURE	239.86	572.13	812.00
WING	63.61	144.01	207.62
ROTOR	0.0	0.0	0.0
TAIL	10.25	34.81	45.07
BODY	79.15	341.32	420.47
ALIGHTING GEAR	60.25	6.82	67.07
ENG SECT + NACELLE	26.60	45.17	71.77
ENG SECTION	0.0	0.0	0.0
NACELLE	26.60	45.17	71.77
AIR INDUCTION	0.0	0.0	0.0
PROPULSION	39.83	52.20	92.03
ENGINE INSTALL	0.0	31.82	31.82
THRUST REVERSER	0.0	0.0	0.0
EXHAUST SYSTEM	0.0	0.0	0.0
ENGINE CONTROLS	5.03	4.27	9.30
STARTING SYSTEM	8.60	2.86	11.46
PROPELLER INSTALL	0.0	0.0	0.0
LUBRICATING SYSTEM	0.0	0.0	0.0
FUEL SYSTEM	26.21	13.24	39.45
DRIVE SYS(PWR TRN)	0.0	0.0	0.0
SYSTEMS	549.69	584.78	1134.47
FLIGHT CONTROLS	182.88	176.76	359.64
AUX POWER PLANT	0.0	0.0	0.0
INSTRUMENTS	34.42	15.05	49.48
HYDRAULIC + PNEUM	37.49	25.46	62.95
ELECTRICAL	74.05	116.07	190.12
AVIONIC INSTALL	9.45	45.64	55.09
ARMAMENT	0.0	0.0	0.0
FURN AND EQUIP	87.19	134.23	221.42
AIR CONDITIONING	105.51	59.72	165.23
ANTI-ICING	18.69	11.85	30.54
PHOTOGRAPHIC	0.0	0.0	0.0
LOAD AND HANDLING	0.0	0.0	0.0
SYSTEMS INTEGR	41.16	116.50	157.66
TOTAL COST	870.55	1325.61	2196.16
TOTAL HRS **		39.75	39.75
ENG CHANGE ORDERS			71.05
SUSTAINING ENG COST			216.01
PROD TOOLING COST			239.98
QUALITY ASSURANCE			178.27
MISCELLANEOUS ***			40.43
TOTAL AIRFRAME COST			2941.91
ENGINE COST			696.77
AVIONICS COST			150.00
TOTAL MANUFACTURING COST			3788.67
WARRANTY			0.0
TOTAL PRODUCTION COST			3788.67

PROCUREMENT

	PER PROD A/C**
TOTAL PRODUCTION	3788.67
INTEGR LOGISTICS SUPPORT	
PLANNING	4.27
TRAINING	1.45
TRAINERS	0.0
HANDBOOKS	19.86
FACILITIES	0.0
SSE - CFE	0.0
SSE - GFE	0.0
TOTAL ILS	25.58
INITIAL SPARES COST	302.03
PRODUCTION DEVELOPMENT	
ENGINEERING	43.35
TOOLING	47.94
ENGINES	0.0
TOTAL PROD DEV	91.29
TOTAL PROCUREMENT	4207.57

* - MILLIONS OF DOLLARS

** -1000 OF DOLLARS OR HOURS PER PROD A/C

*** - INCLUDES PROD DATA, SYSTEMS ENGR AND OTHER SYSTEMS

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)

	C/SM***	PERCENT
FLIGHT CREW	0.83471	16.01546
FUEL AND OIL	1.81260	34.77809
INSURANCE	0.27421	5.26130
DEPRECIATION	1.37993	26.47661
MAINTENANCE	0.91044	17.46843
TOTAL DOC	5.21188	100.000

INDIRECT OPERATIONAL COST (IOC)

	C/SM***	PERCENT
SYSTEM	0.15436	6.92852
LOCAL	0.34327	15.40791
AIRCRAFT CONTROL	0.14250	6.39629
CABIN ATTENDANT	0.39064	17.53447
FOOD AND BEVERAGE	0.0	0.0
PASSENGER HANDLING	0.62575	28.08769
CARGO HANDLING	0.0	0.0
OTHER PASSENGER EXPENSE	0.31372	14.08167
OTHER CARGO EXPENSE	0.0	0.0
GENERAL + ADMINISTRATION	0.25762	11.56345
TOTAL IOC	2.22786	100.000

MISC. DATA

FLIGHT DISTANCE (N. MI.)	600.00
BLOCK FUEL (LBS)	2191.84
BLOCK TIME (HRS)	2.00
FLIGHT TIME (HRS)	1.84
AVG STAGE LENGTH (N. MI.)	100.00
AVG CARGO PER FLIGHT	0.0
UTILIZATION (HRS PER YR)	2600.00
FLIGHTS PER A/C PER YEAR	1397.70
FARE ($)	72.26
FUEL COST ($/LB)	0.14680

*** - CENTS PER SEAT N. MILE

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR	CUMULATIVE DEPRECIATION	AVERAGE BOOK VALUE OF FLEET	REVENUE	INTEREST EXPENSE	OPERATING EXPENSE	CASH FLOW	ROI
			$M	$M	$M	$M	$M	$M	$M	PERCENT
1	3.1	5.0	15.40	1.09	14.31	4.51	1.66	5.85	-6.59	-9.34
2	11.3	10.0	55.43	5.02	50.41	16.25	5.72	21.06	-18.18	-9.54
3	15.0	0.0	73.90	10.25	63.65	21.66	6.92	28.08	-14.75	-10.08
4	15.0	0.0	73.90	15.49	53.42	21.66	6.12	28.08	-13.95	-10.98
5	15.0	0.0	73.90	20.72	53.18	21.66	5.32	28.08	-13.15	-12.06
6	15.0	0.0	73.90	25.96	47.95	21.66	4.52	28.08	-12.35	-13.38
7	15.0	0.0	73.90	31.19	42.71	21.66	3.72	28.08	-11.56	-15.02
8	15.0	0.0	73.90	36.42	37.48	21.66	2.93	28.08	-10.76	-17.11
9	15.0	0.0	73.90	41.66	32.24	21.66	2.13	28.08	-9.96	-19.89
10	15.0	0.0	73.90	46.89	27.01	21.66	1.33	28.08	-9.16	-23.75

AVG ROI OVER THE 10 YEAR PERIOD = -13.45 PERCENT

MUX

30 PASSENGER

SUMMARY ID NO. 1 — A S S E T   P A R A M E T R I C   A N A L Y S I S — JUNE 12 1980

AIRCRAFT MODEL --L1373-2-1
I.O.C. DATE --1990
DESIGN SPEED --SUBSONIC

ENGINE I.D. -- 521000
SLS SCALE 1.0 = 4512
NUMBER OF ENGINES = 2.

WING QUARTER CHORD SWEEP = 3.60 DEG
WING TAPER RATIO = 0.300

1 W/S	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 T/W	0.379	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 AR	12.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 T/C	16.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 SWEEP	3.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 FPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 OPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8 TIT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9 NPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 AUG T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11 RADIUS N. MI	600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 GROSS WEIGHT	29706	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 FUEL WEIGHT	3181	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 OP. WT. EMPTY	20524	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ZERO FUEL WT.	26524	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 ENGINE SCALE	1.248	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17 THRUST/ENGINE	5629	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 SHP/ENGINE	2495	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 WING AREA	371.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20 WING SPAN	66.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 H. TAIL AREA	83.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22 V. TAIL AREA	64.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23 ENG. LENGTH	7.57	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24 ENG. DIAMETER	2.37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25 BODY LENGTH	58.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26 WING FUEL LIMIT	2.242	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COST DATA																
27 RDTE - BIL.	0.180	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 FLYAWAY - MIL.	4.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 INVESTMNT-BIL.	0.374	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30 DOC - C/SM	4.759	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31 IOC - C/SM	2.208	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32 ROI A.T. - 0/0	-9.71	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33 DOC - C/SM	5.212	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34 IOC - C/SM	2.228	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35 ROI A.T. - 0/0	-13.45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36 DOC - C/SM	6.120	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37 IOC - C/SM	2.268	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38 ROI A.T. - 0/0	-20.95	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MISSION PARAMETERS																
39 MISN V1(1,1)	29000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40 MISN V2(1,1)	2191.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41 MISN V1(2,1)	15000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42 MISN V2(2,1)	687.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CONSTRAINT OUTPUT																
43 TAKEOFF DST(1)	3341	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44 CLIMB GRAD(1)	0.1926	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45 TAKEOFF DST(2)	3934	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46 CLIMB GRAD(2)	0.0444	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47 CTOL LNDG D(1)	3939	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48 AP SPEED-KT(1)	110.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49 SEP(1) - FPS	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50 SEP(2) - FPS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

MUX
30 PASS.

COMMUTER --- 30 PASS -- 600 NMI --- M = 0.60 MISS

T/C=16.00 AR=12.00 W/S= 80.00 T/W=0.379

WEIGHT STATEMENT

	WEIGHT(POUNDS)	WEIGHT FRACTION	(PERCENT)
GROSS WEIGHT	(29684.)		
FUEL AVAILABLE	3183.	FUEL	10.71
EXTERNAL	0.		
INTERNAL	3183.		
ZERO FUEL WEIGHT	26504.		
PAYLOAD	6000.	PAYLOAD	20.21
PASSENGERS	5100.		
BAGGAGE	900.		
CARGO	0.		
STORES	0.		
OPERATIONAL EMPTY WEIGHT	20504.		
OPERATIONAL ITEMS	790.	OPERATIONAL ITEMS	3.33
STANDARD ITEMS	197.		
EMPTY WEIGHT	19517.		
STRUCTURE	8040.	STRUCTURE	27.08
WING	2413.		
ROTOR	0.		
TAIL	485.		
BODY	3577.		
ALIGHTING GEAR	1143.		
ENGINE SECTION AND NACELLE	421.		
PROPULSION	3607.	PROPULSION	12.15
CRUISE ENGINES	1667.		
LIFT ENGINES	0.		
THRUST REVERSER	0.		
EXHAUST SYSTEM	0.		
ENGINE CONTROL	119.		
STARTING SYSTEM	80.		
PROPELLERS	1519.		
LUBRICATING SYSTEM	0.		
FUEL SYSTEM	222.		
DRIVE SYSTEM (POWER TRANS)	0.		
SYSTEMS	7870.		
FLIGHT CONTROLS	1173.		
AUXILIARY POWER PLANT	0.		
INSTRUMENTS	186.		
HYDRAULIC AND PNEUMATIC	285.		
ELECTRICAL	1031.		
AVIONICS	598.	SYSTEMS	26.51
ARMAMENT	0.		
FURNISHINGS AND EQUIPMENT	3310.		
AIR CONDITIONING	1032.		
ANTI-ICING	237.		
PHOTOGRAPHIC	0.		
LOAD AND HANDLING	0.	TOTAL	(100.)

INTEGRATED AVIONICS
30 PASSENGER

COST SUMMARY

RDT AND E

DEVELOPMENT - NONRECURRING	TOTAL *
ENGINEERING	77.75
TOOLING	53.98
TEST ARTICLES	5.32
DATA	0.0
SYSTEMS ENG/MNGMT	0.0
CRUISE ENGINE	0.0
LIFT ENGINE	0.0
FAN	0.0
AVIONICS	0.0
OTHER SYSTEMS	0.0
FACILITIES	0.0
TOTAL AIR VEHICLE	137.04
INTEGR LOGISTICS SUPPORT	
PLANNING	0.74
TRAINING	0.25
HANDBOOKS	3.86
SSE	0.0
TOTAL ILS	4.85
TOTAL DVLPMNT-NONREC	141.90
DEVELOPMENT - RECUR(PROTOTYPES)	
AIR VEHICLE	39.15
SPARES	0.0
TOTAL DVLPMNT-RECUR	39.15
GOVMNT DVLPMNT COST	0.0
TOTAL DVLPMNT COST	181.05

INTEGRATED AVIONICS 30 PASS.

PRODUCTION

	MATERIAL	LABOR	TOTAL PER PROD A/C**
STRUCTURE	239.78	571.90	811.68
WING	63.57	143.89	207.45
ROTOR	0.0	0.0	0.0
TAIL	10.24	34.77	45.02
BODY	79.15	341.27	420.42
ALIGHTING GEAR	60.23	6.82	67.04
ENG SECT + NACELLE	26.60	45.15	71.75
ENG SECTION	0.0	0.0	0.0
NACELLE	26.60	45.15	71.75
AIR INDUCTION	0.0	0.0	0.0
PROPULSION	39.82	52.18	92.00
ENGINE INSTALL	0.0	31.81	31.81
THRUST REVERSER	0.0	0.0	0.0
EXHAUST SYSTEM	0.0	0.0	0.0
ENGINE CONTROLS	5.03	4.27	9.29
STARTING SYSTEM	8.60	2.86	11.46
PROPELLER INSTALL	0.0	0.0	0.0
LUBRICATING SYSTEM	0.0	0.0	0.0
FUEL SYSTEM	26.20	13.24	39.44
DRIVE SYS(FWR TRN)	0.0	0.0	0.0
SYSTEMS	554.64	589.78	1144.41
FLIGHT CONTROLS	187.81	181.80	369.61
AUX POWER PLANT	0.0	0.0	0.0
INSTRUMENTS	34.42	15.05	49.48
HYDRAULIC + PNEUM	37.47	25.45	62.92
ELECTRICAL	74.05	116.05	190.10
AVIONIC INSTALL	9.45	45.64	55.09
ARMAMENT	0.0	0.0	0.0
FURN AND EQUIP	87.20	134.22	221.42
AIR CONDITIONING	105.53	59.72	165.25
ANTI-ICING	16.69	11.85	30.54
PHOTOGRAPHIC	0.0	0.0	0.0
LOAD AND HANDLING	0.0	0.0	0.0
SYSTEMS INTEGR	41.13	116.38	157.51
TOTAL COST	875.37	1330.23	2205.60
TOTAL HRS **		39.89	39.89
ENG CHANGE ORDERS			71.36
SUSTAINING ENG COST			218.09
PROD TOOLING COST			240.82
QUALITY ASSURANCE			178.89
MISCELLANEOUS ***			40.57
TOTAL AIRFRAME COST			2955.32
ENGINE COST			696.39
AVIONICS COST			150.00
TOTAL MANUFACTURING COST			3801.70
WARRANTY			0.0
TOTAL PRODUCTION COST			3801.70

PROCUREMENT

	PER PROD A/C**
TOTAL PRODUCTION	3801.70
INTEGR LOGISTICS SUPPORT	
PLANNING	4.26
TRAINING	1.45
TRAINERS	0.0
HANDBOOKS	19.85
FACILITIES	0.0
SSE - CFE	0.0
SSE - GFE	0.0
TOTAL ILS	25.56
INITIAL SPARES COST	303.07
PRODUCTION DEVELOPMENT	
ENGINEERING	43.31
TOOLING	47.66
ENGINES	0.0
TOTAL PROD DEV	90.97
TOTAL PROCUREMENT	4221.30

* - MILLIONS OF DOLLARS

** -1000 OF DOLLARS OR HOURS PER PROD A/C

*** - INCLUDES PROD DATA, SYSTEMS ENGR AND OTHER SYSTEMS

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)

	C/SM***	PERCENT
FLIGHT CREW	0.83470	16.00743
FUEL AND OIL	1.81179	34.74547
INSURANCE	0.27526	5.27886
DEPRECIATION	1.38519	26.56432
MAINTENANCE	0.90752	17.40385
TOTAL DOC	5.21446	100.000

INDIRECT OPERATIONAL COST (IOC)

	C/SM***	PERCENT
SYSTEM	0.15380	6.90651
LOCAL	0.34302	15.40340
AIRCRAFT CONTROL	0.14250	6.39906
CABIN ATTENDANT	0.39064	17.54195
FOOD AND BEVERAGE	0.0	0.0
PASSENGER HANDLING	0.62575	28.09984
CARGO HANDLING	0.0	0.0
OTHER PASSENGER EXPENSE	0.31372	14.08777
OTHER CARGO EXPENSE	0.0	0.0
GENERAL + ADMINISTRATION	0.25746	11.56150
TOTAL IOC	2.22689	100.000

MISC. DATA

FLIGHT DISTANCE (N. MI.)	600.00
BLOCK FUEL (LBS)	2190.86
BLOCK TIME (HRS)	2.00
FLIGHT TIME (HRS)	1.84
AVG STAGE LENGTH (N. MI.)	100.00
AVG CARGO PER FLIGHT	0.0
UTILIZATION (HRS PER YR)	2800.00
FLIGHTS PER A/C PER YEAR	1397.71
FARE ($)	72.26
FUEL COST ($/LB)	0.14680

*** - CENTS PER SEAT N. MILE

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR $M	CUMULATIVE DEPRECIATION $M	AVERAGE BOOK VALUE OF FLEET $M	REVENUE $M	INTEREST EXPENSE $M	OPERATING EXPENSE $M	CASH FLOW $M	ROI PERCENT
1	3.1	5.0	15.45	1.09	14.36	4.51	1.67	5.85	-6.61	-9.31
2	11.3	10.0	55.64	5.04	50.60	16.25	5.74	21.06	-18.24	-9.52
3	15.0	0.0	74.18	10.29	63.89	21.66	6.94	28.08	-14.79	-10.05
4	15.0	0.0	74.18	15.54	58.64	21.66	6.14	28.08	-13.98	-10.95
5	15.0	0.0	74.18	20.80	53.38	21.66	5.34	28.08	-13.18	-12.03
6	15.0	0.0	74.18	26.05	48.13	21.66	4.54	28.08	-12.38	-13.34
7	15.0	0.0	74.18	31.31	42.87	21.66	3.74	28.08	-11.58	-14.97
8	15.0	0.0	74.18	36.56	37.62	21.66	2.94	28.08	-10.78	-17.07
9	15.0	0.0	74.18	41.82	32.36	21.66	2.14	28.08	-9.98	-19.84
10	15.0	0.0	74.18	47.07	27.11	21.66	1.34	28.08	-9.18	-23.68

AVG ROI OVER THE 10 YEAR PERIOD = -13.41 PERCENT

INTEGRATED AVIONICS
30 PASSENGER

SUMMARY ID NO. 1 ASSET PARAMETRIC ANALYSIS JUNE 12 1980

AIRCRAFT MODEL --L1373-2-1
I.O.C. DATE --1990
DESIGN SPEED --SUBSONIC

ENGINE I.D. -- 521000
SLS SCALE 1.0 = 4512
NUMBER OF ENGINES = 2.

WING QUARTER CHORD SWEEP = 3.60 DEG
WING TAPER RATIO = 0.300

1 W/S	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 T/W	0.379	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 AR	12.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 T/C	16.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 SWEEP	3.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 FPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 OPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8 TIT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9 NFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 AUG T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11 RADIUS N. MI	600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 GROSS WEIGHT	29684	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 FUEL WEIGHT	3180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 OP. WT. EMPTY	20504	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ZERO FUEL WT.	26504	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 ENGINE SCALE	1.247	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17 THRUST/ENGINE	5625	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 SHP/ENGINE	2493	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 WING AREA	371.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20 WING SPAN	66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 H. TAIL AREA	80.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22 V. TAIL AREA	63.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23 ENG. LENGTH	7.57	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24 ENG. DIAMETER	2.37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25 BODY LENGTH	58.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26 WING FUEL LIMIT	2.241	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COST DATA																
27 RDTE - BIL.	0.181	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 FLYAWAY - MIL.	4.62	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 INVESTMNT-BIL.	0.074	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30 DOC - C/SM	4.762	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31 IOC - C/SM	2.237	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32 ROI A.T. - 0/0	-9.69	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33 DOC - C/SM	5.214	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34 IOC - C/SM	2.227	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35 ROI A.T. - 0/0	-13.41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36 DOC - C/SM	6.123	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37 IOC - C/SM	2.267	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38 ROI A.T. - 0/0	-20.88	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MISSION PARAMETERS																
39 MISN V1(1,1)	29000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40 MISN V2(1,1)	2190.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41 MISN V1(2,1)	15000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42 MISN V2(2,1)	686.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CONSTRAINT OUTPUT																
43 TAKEOFF DST(1)	3341	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44 CLIMB GRAD(1)	0.1926	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45 TAKEOFF DST(2)	3985	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46 CLIMB GRAD(2)	0.0444	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47 CTOL LNDG D(1)	3939	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48 AP SPEED-KT(1)	110.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49 SEP(1) - FPS	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50 SEP(2) - FPS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

INTEGRATED AVIONICS
30 PASS.

COMMUTER --- 30 PASS -- 600 NMI --- M = 0.60 MISS

T/C=16.00 AR=12.00 W/S= 80.00 T/W=0.379

W E I G H T   S T A T E M E N T

	WEIGHT(POUNDS)	WEIGHT FRACTION	(PERCENT)
GROSS WEIGHT	(29253.)		
FUEL AVAILABLE	3136.	FUEL	10.72
EXTERNAL	0.		
INTERNAL	3139.		
ZERO FUEL WEIGHT	26117.		
PAYLOAD	6000.	PAYLOAD	20.51
PASSENGERS	5100.		
BAGGAGE	900.		
CARGO	0.		
STORES	0.		
OPERATIONAL EMPTY WEIGHT	20117.		
OPERATIONAL ITEMS	790.	OPERATIONAL ITEMS	3.37
STANDARD ITEMS	197.		
EMPTY WEIGHT	19130.		
STRUCTURE	7947.	STRUCTURE	27.17
WING	2377.		
ROTOR	0.		
TAIL	475.		
BODY	3565.		
ALIGHTING GEAR	1130.		
ENGINE SECTION AND NACELLE	400.		
PROPULSION	3468.	PROPULSION	11.86
CRUISE ENGINES	1554.		
LIFT ENGINES	0.		
THRUST REVERSER	0.		
EXHAUST SYSTEM	0.		
ENGINE CONTROL	118.		
STARTING SYSTEM	80.		
PROPELLERS	1497.		
LUBRICATING SYSTEM	0.		
FUEL SYSTEM	220.		
DRIVE SYSTEM (POWER TRANS)	0.		
SYSTEMS	7715.		
FLIGHT CONTROLS	1155.		
AUXILIARY POWER PLANT	0.		
INSTRUMENTS	185.		
HYDRAULIC AND PNEUMATIC	0.		
ELECTRICAL	1303.		
AVIONICS	598.	SYSTEMS	26.37
ARMAMENT	0.		
FURNISHINGS AND EQUIPMENT	3303.		
AIR CONDITIONING	935.		
ANTI-ICING	236.		
PHOTOGRAPHIC	0.		
LOAD AND HANDLING	0.		
		TOTAL	(100.)

ALL-ELECTRIC
30 PASSENGER

COST SUMMARY

RDT AND E

	TOTAL *
DEVELOPMENT - NONRECURRING	
ENGINEERING	76.22
TOOLING	53.04
TEST ARTICLES	5.16
DATA	0.0
SYSTEMS ENG/MNGMT	0.0
CRUISE ENGINE	0.0
LIFT ENGINE	0.0
FAN	0.0
AVIONICS	0.0
OTHER SYSTEMS	0.0
FACILITIES	0.0
TOTAL AIR VEHICLE	134.41
INTEGR LOGISTICS SUPPORT	
PLANNING	0.72
TRAINING	0.25
HANDBOOKS	3.77
SSE	0.0
TOTAL ILS	4.74
TOTAL DVLPMNT-NONREC	139.15
DEVELOPMENT - RECUR(PROTOTYPES)	
AIR VEHICLE	38.18
SPARES	0.0
TOTAL DVLPMNT-RECUR	38.18
GOVMNT DVLPMNT COST	0.0
TOTAL DVLPMNT COST	177.33

ALL-ELECTRIC - 30 PASSENGER

PRODUCTION

	MATERIAL	LABOR	TOTAL PER PROD A/C**
STRUCTURE	237.20	565.68	802.87
WING	62.85	141.77	204.62
ROTOR	0.0	0.0	0.0
TAIL	10.04	33.99	44.03
BODY	79.18	340.23	419.41
ALIGHTING GEAR	59.74	6.74	66.48
ENG SECT + NACELLE	25.38	42.95	68.33
ENG SECTION	0.0	0.0	0.0
NACELLE	25.38	42.95	68.33
AIR INDUCTION	0.0	0.0	0.0
PROPULSION	39.69	49.87	89.56
ENGINE INSTALL	0.0	29.66	29.66
THRUST REVERSER	0.0	0.0	0.0
EXHAUST SYSTEM	0.0	0.0	0.0
ENGINE CONTROLS	4.97	4.21	9.18
STARTING SYSTEM	8.63	2.86	11.49
PROPELLER INSTALL	0.0	0.0	0.0
LUBRICATING SYSTEM	0.0	0.0	0.0
FUEL SYSTEM	26.09	13.14	39.23
DRIVE SYS(PWR TRN)	0.0	0.0	0.0
SYSTEMS	515.55	567.48	1083.03
FLIGHT CONTROLS	177.16	165.37	342.53
AUX POWER PLANT	0.0	0.0	0.0
INSTRUMENTS	34.46	15.02	49.47
HYDRAULIC + PNEUM	0.0	0.0	0.0
ELECTRICAL	89.58	139.91	229.50
AVIONIC INSTALL	9.49	45.66	55.14
ARMAMENT	0.0	0.0	0.0
FURN AND EQUIP	87.33	133.97	221.30
AIR CONDITIONING	98.84	55.74	154.58
ANTI-ICING	18.70	11.81	30.51
PHOTOGRAPHIC	0.0	0.0	0.0
LOAD AND HANDLING	0.0	0.0	0.0
SYSTEMS INTEGR	40.46	114.10	154.57
TOTAL COST	832.91	1297.12	2130.03
TOTAL HRS **		38.89	38.89
ENG CHANGE ORDERS			68.96
SUSTAINING ENG COST			214.33
PROD TOOLING COST			234.82
QUALITY ASSURANCE			174.44
MISCELLANEOUS ***			39.57
TOTAL AIRFRAME COST			2862.15
ENGINE COST			688.75
AVIONICS COST			150.00
TOTAL MANUFACTURING COST			3700.69
WARRANTY			0.0
TOTAL PRODUCTION COST			3700.89

PROCUREMENT

	PER PROD A/C**
TOTAL PRODUCTION	3700.89
INTEGR LOGISTICS SUPPORT	
PLANNING	4.18
TRAINING	1.42
TRAINERS	0.0
HANDBOOKS	19.57
FACILITIES	0.0
SSE - CFE	0.0
SSE - GFE	0.0
TOTAL ILS	25.18
INITIAL SPARES COST	295.00
PRODUCTION DEVELOPMENT	
ENGINEERING	42.51
TOOLING	48.06
ENGINES	0.0
TOTAL PROD DEV	90.57
TOTAL PROCUREMENT	4111.64

* - MILLIONS OF DOLLARS

** -1000 OF DOLLARS OR HOURS PER PROD A/C

*** - INCLUDES PROD DATA, SYSTEMS ENGR AND OTHER SYSTEMS

OPERATIONAL COSTS

DIRECT OPERATIONAL COST (DOC)

	C/SM***	PERCENT
FLIGHT CREW	0.83461	16.29431
FUEL AND OIL	1.78633	34.87511
INSURANCE	0.26831	5.23837
DEPRECIATION	1.35008	26.35809
MAINTENANCE	0.88275	17.23410
TOTAL DOC	5.12208	100.000

INDIRECT OPERATIONAL COST (IOC)

	C/SM***	PERCENT
SYSTEM	0.15011	6.77625
LOCAL	0.33803	15.25945
AIRCRAFT CONTROL	0.14250	6.43270
CABIN ATTENDANT	0.39060	17.63219
FOOD AND BEVERAGE	0.0	0.0
PASSENGER HANDLING	0.62575	28.24757
CARGO HANDLING	0.0	0.0
OTHER PASSENGER EXPENSE	0.31372	14.16182
OTHER CARGO EXPENSE	0.0	0.0
GENERAL + ADMINISTRATION	0.25453	11.49002
TOTAL IOC	2.21525	100.000

MISC. DATA

FLIGHT DISTANCE (N. MI.)	600.00
BLOCK FUEL (LBS)	2160.03
BLOCK TIME (HRS)	2.00
FLIGHT TIME (HRS)	1.84
AVG STAGE LENGTH (N. MI.)	100.00
AVG CARGO PER FLIGHT	0.0
UTILIZATION (HRS PER YR)	2800.00
FLIGHTS PER A/C PER YEAR	1397.86
FARE ($)	72.26
FUEL COST ($/LB)	0.14680

*** - CENTS PER SEAT N. MILE

- -

RATE OF RETURN ON INVESTMENT

YEAR	AVG NO AIRCRAFT DURING YEAR	AIRCRAFT ADDED DURING YEAR	AVERAGE INVESTMENT DURING YEAR $M	CUMULATIVE DEPRECIATION $M	AVERAGE BOOK VALUE OF FLEET $M	REVENUE $M	INTEREST EXPENSE $M	OPERATING EXPENSE $M	CASH FLOW $M	ROI PERCENT
1	3.1	5.0	15.07	1.07	14.00	4.51	1.63	5.77	-6.40	-8.97
2	11.3	10.0	54.24	4.91	49.33	16.25	5.60	20.77	-17.61	-9.17
3	15.0	0.0	72.31	10.03	62.28	21.66	6.77	27.69	-14.18	-9.68
4	15.0	0.0	72.31	15.15	57.16	21.66	5.99	27.69	-13.40	-10.55
5	15.0	0.0	72.31	20.28	52.04	21.66	5.21	27.69	-12.62	-11.58
6	15.0	0.0	72.31	25.40	46.92	21.66	4.43	27.69	-11.84	-12.85
7	15.0	0.0	72.31	30.52	41.79	21.66	3.64	27.69	-11.06	-14.42
8	15.0	0.0	72.31	35.64	36.67	21.66	2.86	27.69	-10.28	-16.44
9	15.0	0.0	72.31	40.76	31.55	21.66	2.08	27.69	-9.50	-19.11
10	15.0	0.0	72.31	45.89	26.43	21.66	1.30	27.69	-8.72	-22.81

AVG ROI OVER THE 10 YEAR PERIOD = -12.91 PERCENT

ALL-ELECTRIC
30 PASSENGER

SUMMARY ID NO. 1 A S S E T   P A R A M E T R I C   A N A L Y S I S JUNE 12 1980

AIRCRAFT MODEL --L1373-2-1 ENGINE I.D. -- 521000 WING QUARTER CHORD SWEEP = 3.60 DEG
I.O.C. DATE --1990 SLS SCALE 1.0 = 4512 WING TAPER RATIO = 0.300
DESIGN SPEED --SUBSONIC NUMBER OF ENGINES = 2.

1 W/S	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 T/W	0.379	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 AR	12.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 T/C	16.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 SWEEP	3.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 FPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 OFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8 TIT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9 NPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 AUG T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11 RADIUS N. MI	600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 GROSS WEIGHT	29253	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 FUEL WEIGHT	3136	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 OP. WT. EMPTY	20117	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ZERO FUEL WT.	26117	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 ENGINE SCALE	1.229	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17 THRUST/ENGINE	5543	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 SHP/ENGINE	2457	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 WING AREA	366.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20 WING SPAN	66.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 H. TAIL AREA	78.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22 V. TAIL AREA	62.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23 ENG. LENGTH	7.55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24 ENG. DIAMETER	2.36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25 BODY LENGTH	58.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26 WING FUEL LIMIT	2.222	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COST DATA																
27 RDTE - BIL.	0.177	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 FLYAWAY - MIL.	4.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 INVESTMNT-BIL.	0.072	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30 DOC - C/SM	4.676	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31 IOC - C/SM	2.195	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32 ROI A.T. - 0/0	-9.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33 DOC - C/SM	5.122	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34 IOC - C/SM	2.215	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35 ROI A.T. - 0/0	-12.91	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36 DOC - C/SM	6.017	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37 IOC - C/SM	2.255	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38 ROI A.T. - 0/0	-20.47	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MISSION PARAMETERS																
39 MISN V1(1,1)	29000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40 MISN V2(1,1)	2160.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41 MISN V1(2,1)	15000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42 MISN V2(2,1)	679.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CONSTRAINT OUTPUT																
43 TAKEOFF DST(1)	3343	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44 CLIMB GRAD(1)	0.1925	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45 TAKEOFF DST(2)	3989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46 CLIMB GRAD(2)	0.0443	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47 CTOL LNDG D(1)	3938	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48 AP SPEED-KT(1)	110.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49 SEP(1) - FPS	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50 SEP(2) - FPS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

ALL
ELECTRIC
30 PASS.

APPENDIX B

SUBSYSTEM DETAILS

ESTIMATED ATA EECS WEIGHTS FOR EACH OF 3 IDENTICAL COOLING PACKAGES

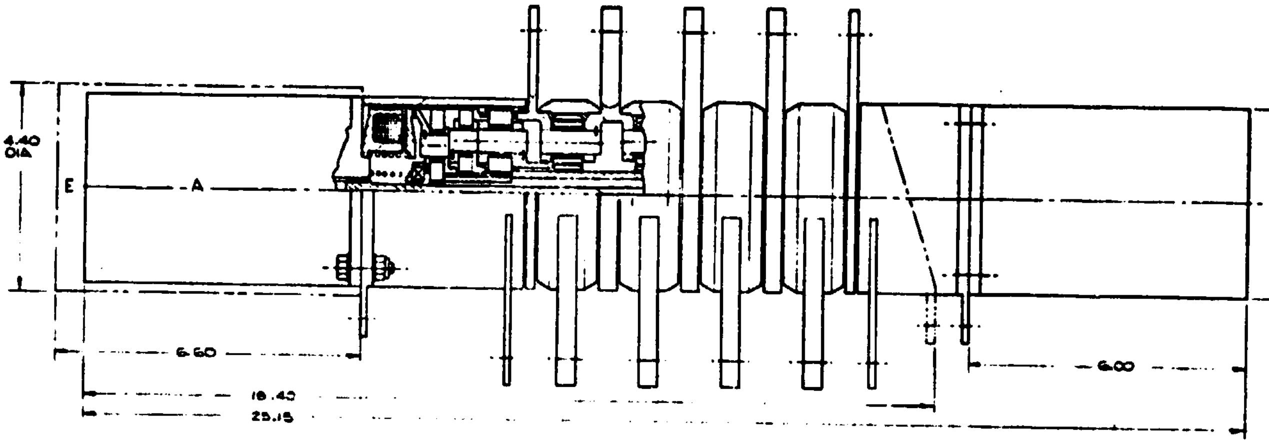
SUBSYSTEM	WEIGHT (LB)
Fresh Air Compressor	
compressor with inlet guide vanes	78
electric drive motor	130
Primary Heat Exchanger	
heat exchanger	65
ground cooling fan and drive motor	27
cooling air louvers	*
Vapor Cycle Refrigeration Unit	677
Cabin Air Recirculation System	
ducting	*
recirculation fan and drive motor	11
electric heaters	*
Controls	*
TOTAL PER PACK	988
TOTAL PER AIRPLANE (3 PACKS)	2,964
*Not estimated	

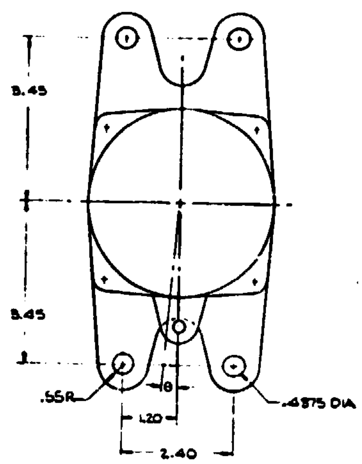
ESTIMATED PERFORMANCE

Table summarizes the estimated performance of the ATA EECS at the four primary design points investigated; high altitude cruise, high altitude descent, and sea level ground static on both hot and cold days. The high altitude cruise and descant conditions considered were at the ATA operating envelope extreme; Mach 0.8 at 42,00 ft. per Reference 2.

ESTIMATED ATA EECS PERFORMANCE
FOR EACH OF 3 IDENTICAL COOLING PACKAGES

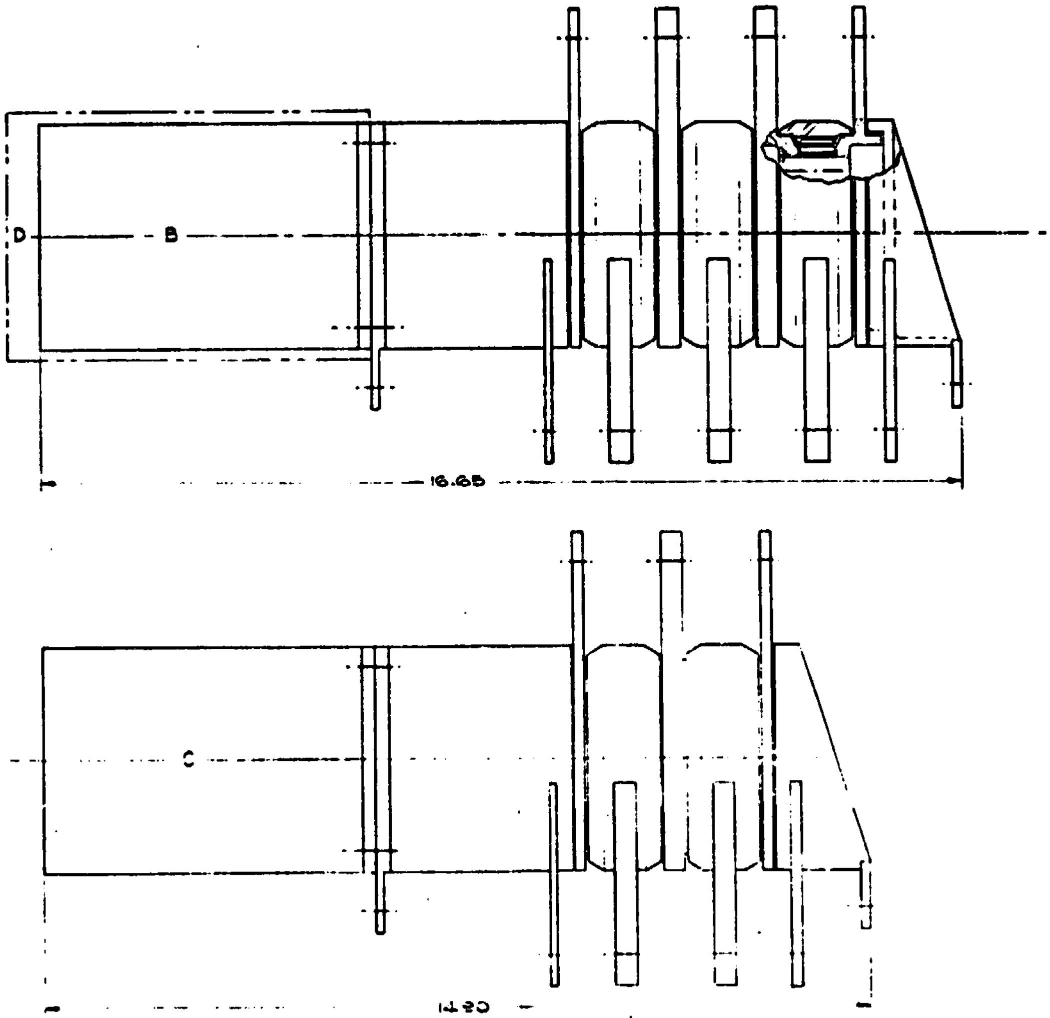
OPERATING CONDITION	SEA LEVEL STATIC HOT DAY	SEA LEVEL STATIC COLD DAY	42,000 ft. CRUISE HOT DAY	42,000 ft. DESCENT HOT DAY
Ambient Pressure, psia	14.70	14.70	2.48	2.48
Ambient Temperature, °F	103	-40	-44	-44
Ambient Humidity, gr/lb.	130	0	0	0
Air Compressor Inlet Pressure, psia	14.65	14.70	3.65	3.65
Air Compressor Inlet Temperature, °F	103	-40	9	9
Cabin Temperature, °F	75	75	75	75
Cabin Heat Load, Btu/Hr.	129,800	-35,900	84,300	84,300
sensible	109,800	-35,900	64,300	64,300
Latent	20,000	0	20,000	20,000
Evaporator Cooling Required, Tons	30.06	0	7.33	3.82
sensible	19.01	0	5.66	2.29
latent	11.05	0	1.67	1.67
Electric Heating Required, kw	0	11	0	0
Cabin Airflow, lb/min	298	136	200	173
fresh	162	0	100	86
recirculated	136	136	100	87
Cooling Airflow, lb/min	1,396	0	456	456
primary heat exchanger	406	0	215	215
condenser	990	0	241	241
Input Electric Power, kw	163	11	168	132
fresh air compressor	68	0	126	98
recirculation fan	5	5	4	4
primary HX fan	10	0	0	0
refrigerant compressor	60	0	38	30
condenser fan	20	0	0	0
heaters	0	6	0	0





Rotary actuators ATA flight control sytem.

AiResearch
Dwg. No. SK 74611



Rotary actuators ATA flight control system.

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COMMON ACTUATORS	A ↓	B ↓		C ↓			D ↓		E ↓
PARAMETERS \ ACTUATORS	SP1	SP2	SP3	SP4	SP5	SP6	IBA	OBA	RUD
MOTOR									
• TYPE	A	A	A	A	A	A	A	A	A
• NUMBER	2	1	1	1	1	1	1	1	1
• [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
• [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
• POWER, η [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BRAKE									
• TYPE	B	B	B	B	B	B	—	—	—
• NUMBER	1	1	1	1	1	1	—	—	—
• HOLDING TORQUE [illegible]	103.0	48.0	[illegible]	[illegible]	[illegible]	26.0	—	—	—
• HOLDING [illegible]	—	—	—	—	—	—	—	—	—
GEAR HEAD									
• TYPE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	D	D	D	D
• NUMBER	2	1	1	1	1	1	1	1	1
• GEAR RATIO	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
• EFFICIENCY [illegible]	92.7	[illegible]	[illegible]	[illegible]	92.7	92.7	92.7	92.7	92.7
DRIVE									
• TYPE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
• [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
• [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
• EFFICIENCY [illegible]	97.5	[illegible]	[illegible]	[illegible]	97.5	97.5	97.5	[illegible]	97.5
ACTUATOR									
• TYPE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
• LENGTH [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17.25	[illegible]	[illegible]
• W [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
• D [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.25	[illegible]	[illegible]
• WEIGHT [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]									
• [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
• [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
• [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PERF[illegible]									
• [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
• [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
• [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
• [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
• [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
• [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

NOTES:

1. η - MOTOR EFFICIENCY
2. θ - OUTPUT ANGLE FROM NULL
3. SPRING RATE - MECHANICAL

A. BRUSHLESS PERMANENT MAGNET, 270 VDC
B. [illegible]
C. PLANETARY, 3 STAGE
D. MULTIPLE SECTION, PLANETARY, 1 STAGE
E. POSITION SERVO WITH TORQUE LIMITING
F. PULSE [illegible] MODULATION WITH CURRENT LIMIT

Rotary actuators ATA flight control system.

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LANDING GEAR DESIGN SUMMARY

ACTUATORS	MLG1	MLG2	MLG3	MLG4	MLG5	NLG1	NLG2
MOTORS							
● TYPE	AC	AC	AC	AC	AC	AC	AC
● NUMBER	1	1	1	1	1	1	1
PERFORMANCE (LINEAR)							
● SYNCHRONOUS SPEED (IPS)	2.5	12.8	2.5	0.06	3.0	2.0	1.4
● DESIGN-LOAD (LB)	70.7×10^3	9.7×10^3	2.8×10^3	2.5×10^3	4.0×10^3	11.8×10^3	0.7
● STROKE (IN)	21.3	32.0	1.4	7.5	6.9	23.0	0.7
DIMENSIONS							
● LENGTH, RETRACTED (IN)	29.0	39.2	8.4	15.2	14.3	30.2	6.8
● WIDTH (IN)	6.0	6.1	3.5	4.5	4.2	4.2	2.0
● DEPTH (IN)	14.0	10.1	5.8	6.8	7.3	7.3	4.0
● WEIGHT (LB)	144	62	10	12	18	49	3