

## 737/CFM56-7 AIRCRAFT ENGINE SYSTEMS

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Seattle, Washington

### ABSTRACT

The configuration of the propulsion system engine externals must meet many airplane requirements such as cost, thrust, weight, range and systems power extraction. On the 737-700 several program requirements also played a major role in the development of the engine externals. These program goals were increased range, same cost as a 1994 737-300, 15% reduction in maintenance costs from the 737-300, and a propulsion package that appeared as if it was designed by one company.. This presentation will show how these requirements shaped the design of the engine externals for the 737-700/CFM56-7B.

Seattle, Washington

ABSTRACT

# Engine Installation



# Boeing

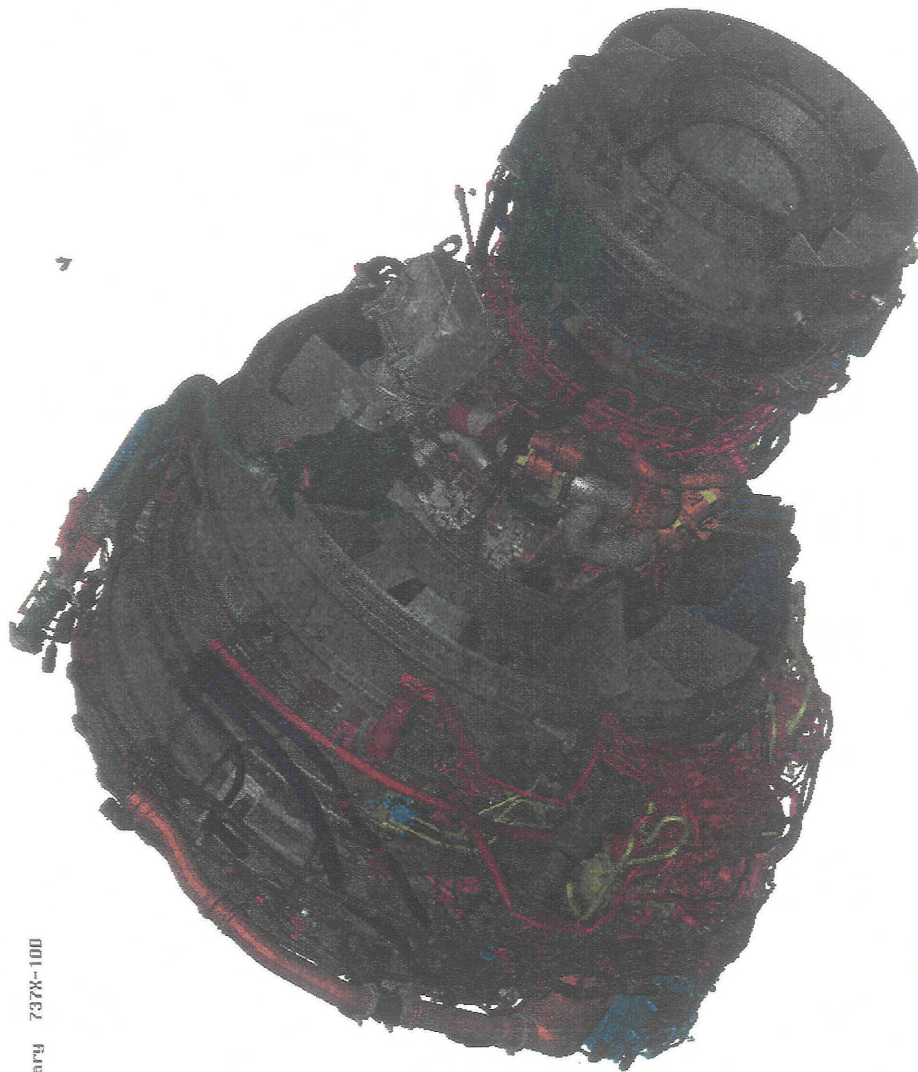


# Boeing Designed Systems

- Pneumatics - ducting, valves, controllers, precooler
- Starting - ducting, valve
- Integrated Drive Generator (IDG) - power feeder cables, cooling
- Cowl Thermal Anti-Ice (CTAI) - ducting, valve, controller
- Fire Protection - fire detectors, drains, extinguishing
- Fuel Line
- Hydraulics - hoses, tubes, case drain filter

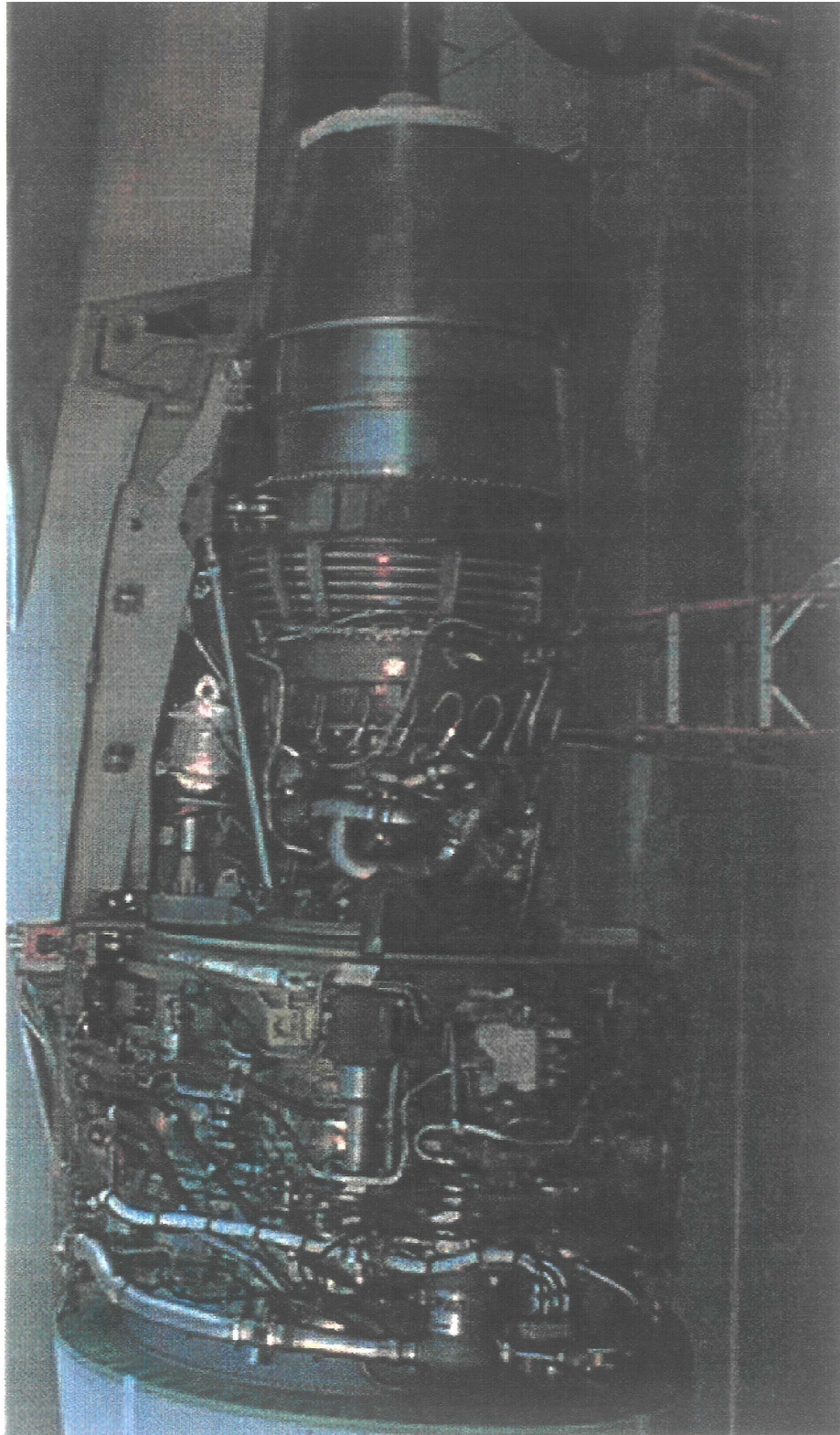


# CFMI and Boeing

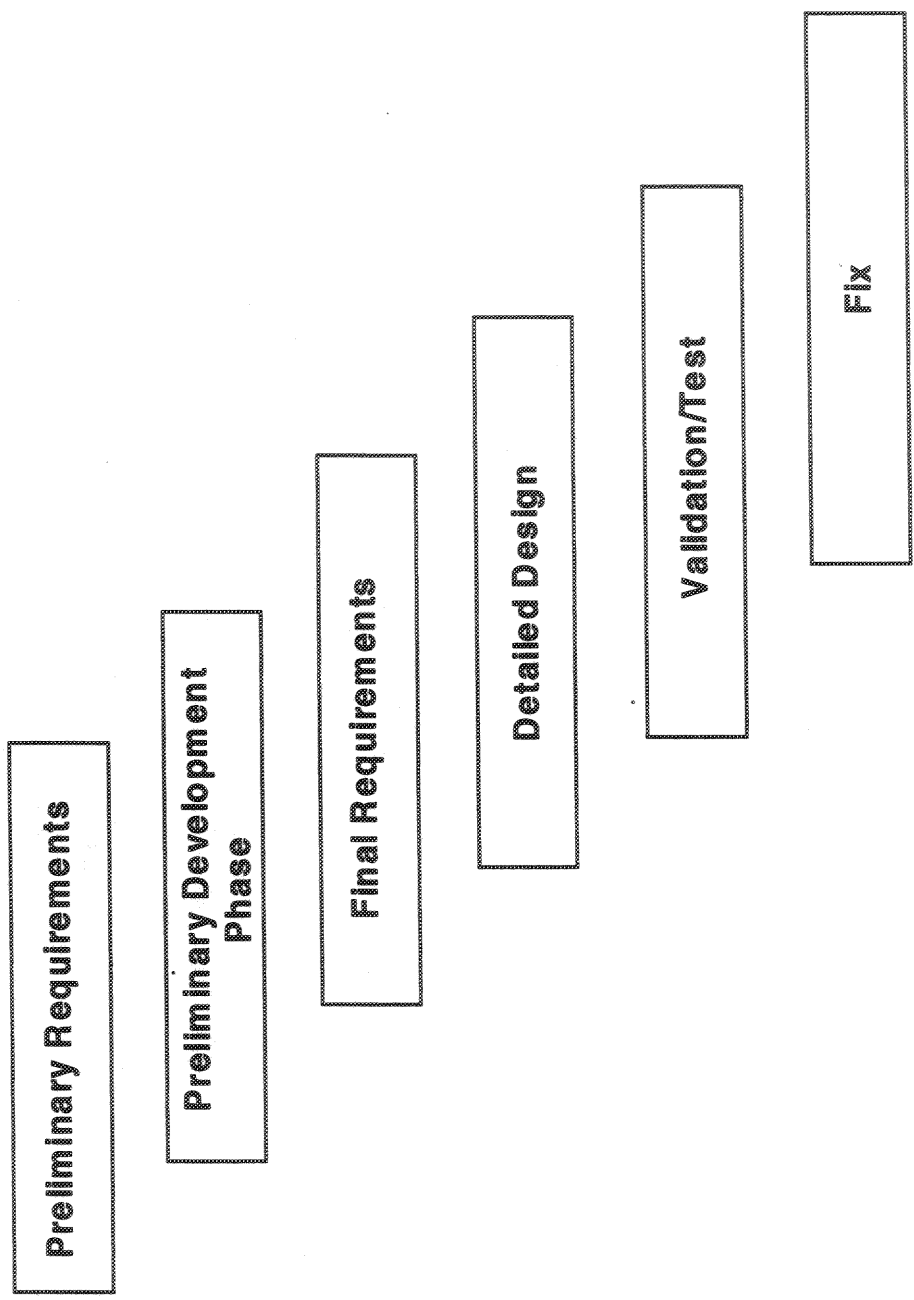


air 737X-100

# Engine Without Cowls

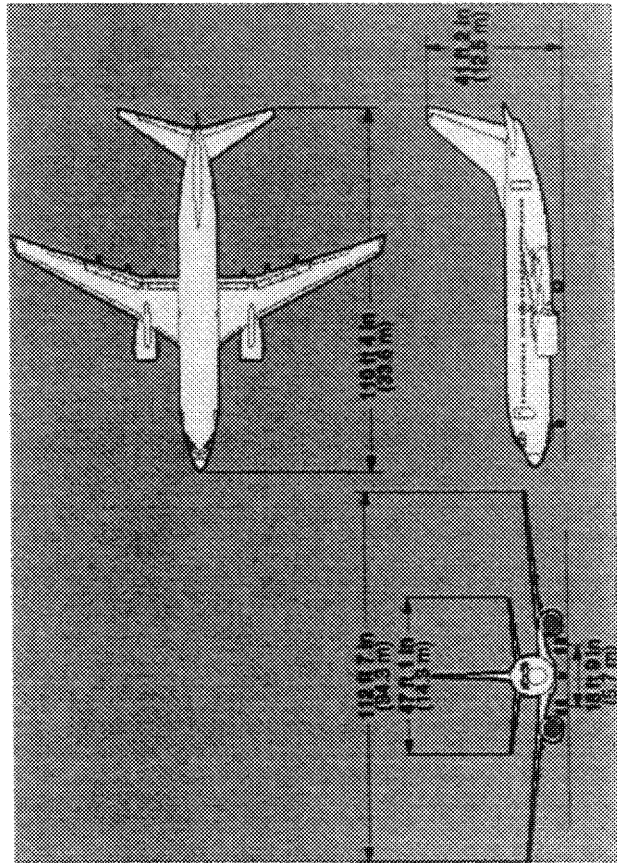
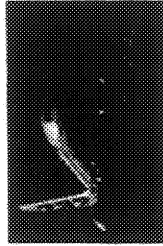
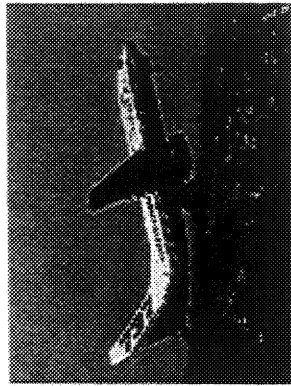
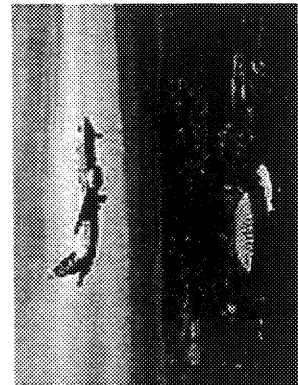


# How We Ended Up With This Configuration



# AIRPLANE

## 737-700





# 737NG AIRPLANE FOCUS

- **Past**
  - **Fly It**
    - **Higher**
    - **Farther**
    - **Faster than competition**
  - **Boeing's Economics**
  
- **Present**
  - **Emphasize Airline's Economics**
  - **And Fly It**
    - **Farther**
    - **Faster**
    - **Higher than current 737**

## **737NG ENGINE FOCUS**

- **Decrease**
  - **Noise - Stage 3 minus 4 db**
  - **Fuel Burn - 7.7% lower SFC than CFM56-3C-1**
  - **Maintenance - 15% less maintenance cost than CFM56-3C-1**
  - **Cost - same price as today's 737**
- **Increase**
  - **Thrust - up to 26,400 lbs**
  - **Reliability/Time on Wing**

## **737NG EBU FOCUS**

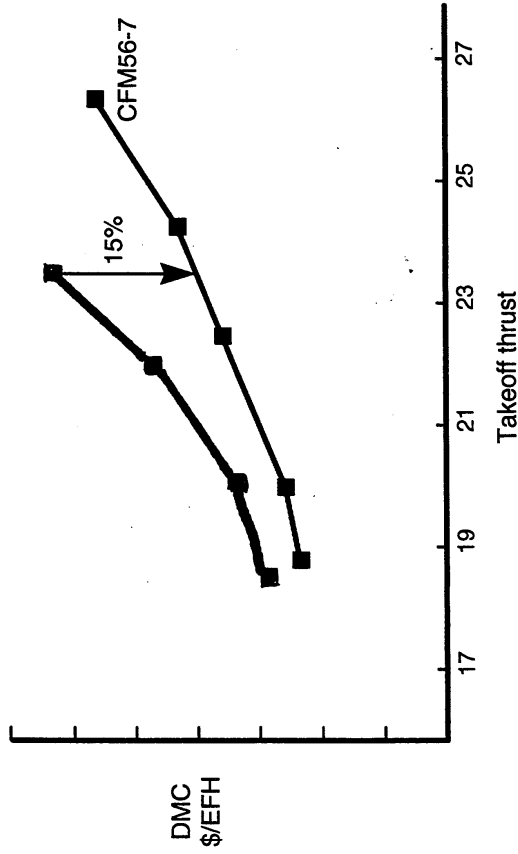
- **Decrease**
  - **Maintenance**
  - **Fuel Burn (indirectly)**
    - Minimize weight, cooling air**
  - **Cost**
    - Recurring and Non-Recurring**
- **Increase**
  - **Reliability/Time on Wing**

**\* RELIABILITY AND MAINTAINABILITY WERE KEY  
DESIGN INFLUENCES**



# Reduced Maintenance

- **15% Reduction in Total Direct Maintenance Cost from 737-300**
- **Get Customer Input Early**
  - **Ease of component removal was a primary focus**
    - Digital verification for all LRU's by design engineers
    - Physical validation by airline mechanics



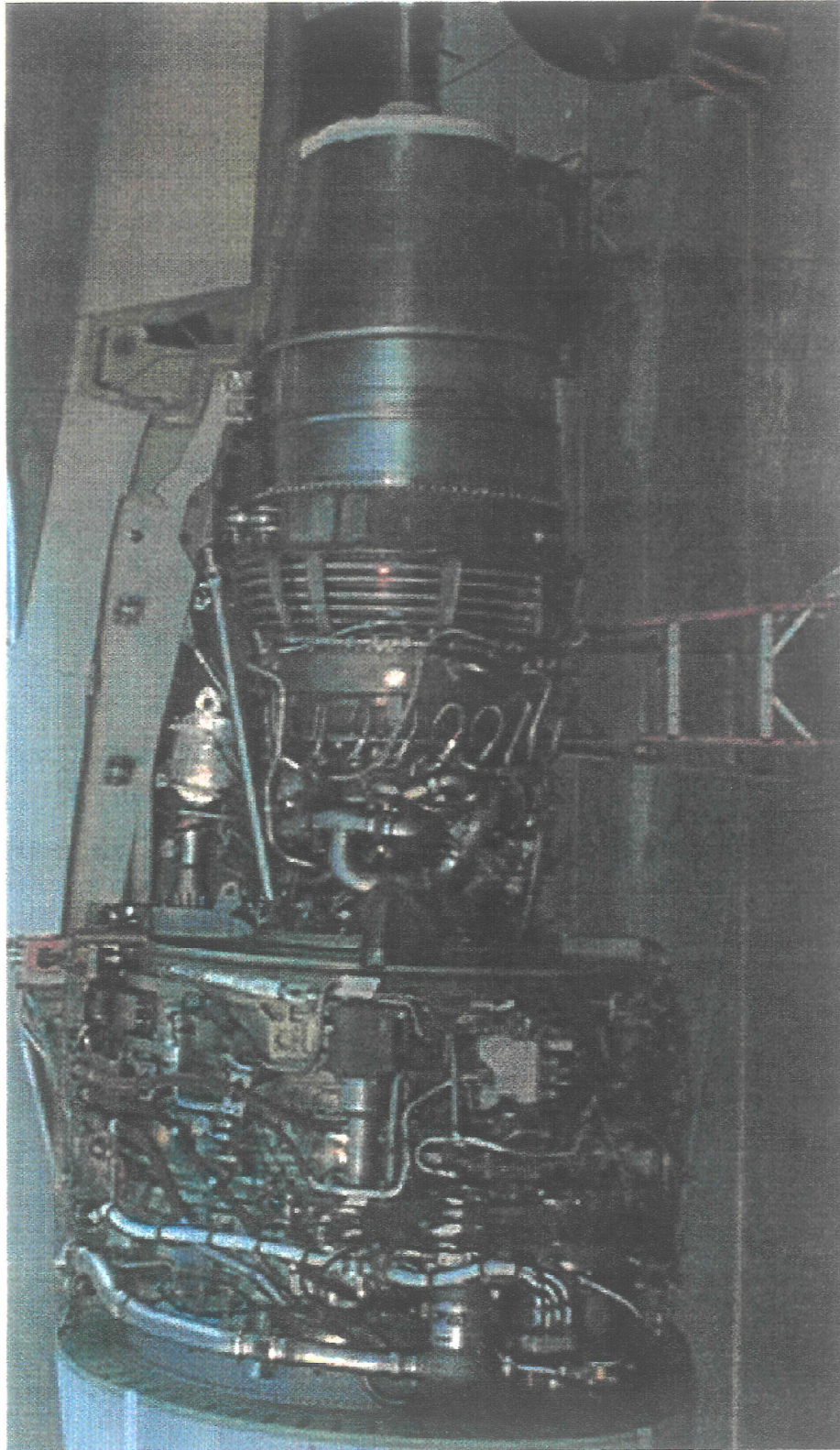
# **Improved Reliability**

- **Use Existing Components if Reliable**
  - **Bleed Air Valves and Regulators**
- **Lessons Learned Incorporated From Other Programs**
  - **CTAI Valve, Starter, IDG, Fire Detectors**
- **New Technologies Must Be Proven Out**
  - **Precooler Control Valve**
- **Extensive Testing to Validate Designs**
  - **Complete EBU package on all engine tests (goal)**

# **INTERNAL EQUIPMENT BASIC REQUIREMENTS**

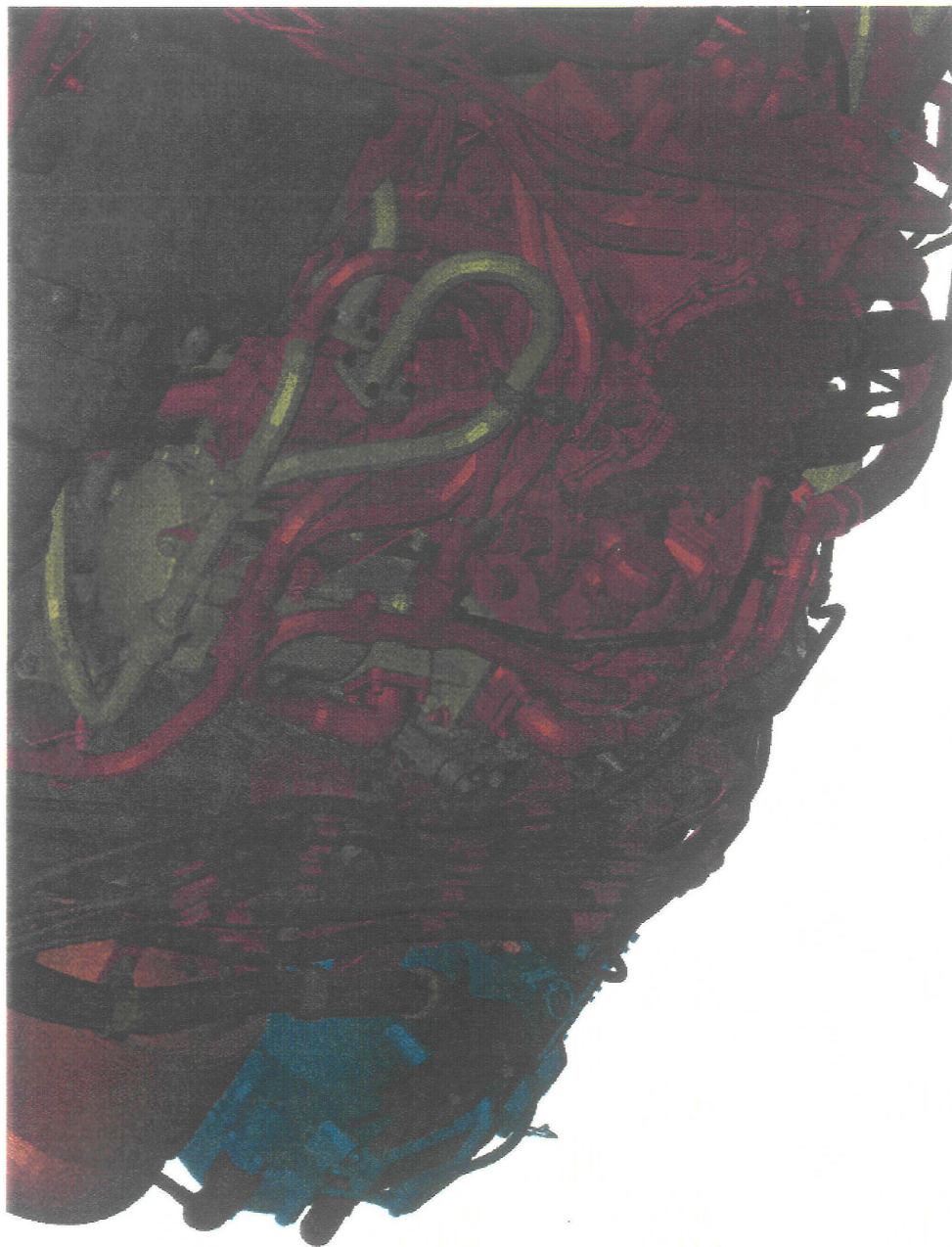
- **PERFORM INTENDED FUNCTION**
- **CAN BE INSTALLED ON THE AIRPLANE**
- **BUILDABLE**
- **WITHSTAND INSTALLATION ENVIRONMENT**
  - **Vibration**
    - **Fatigue - Last the Life of the Airplane**
  - **Temperature**
  - **Fluid Resistance**
- **MEETS FAR'S**

# Engine Without Cowls

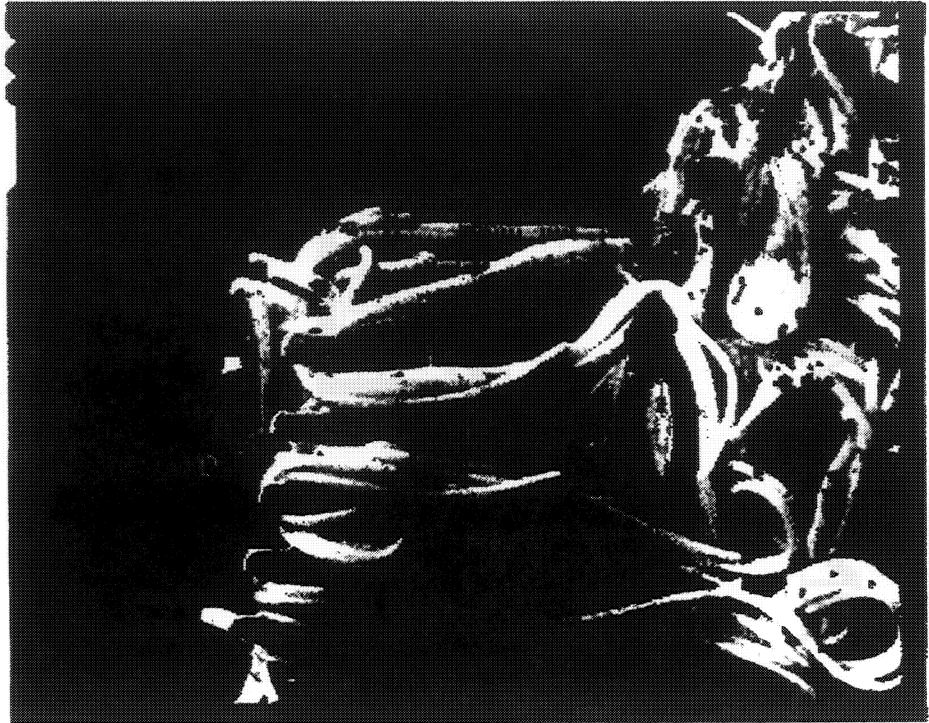




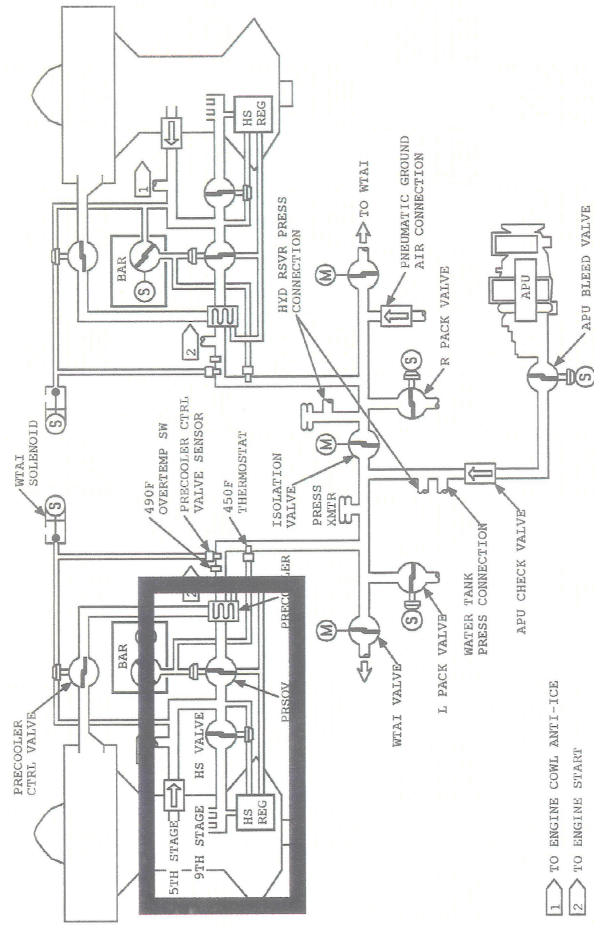
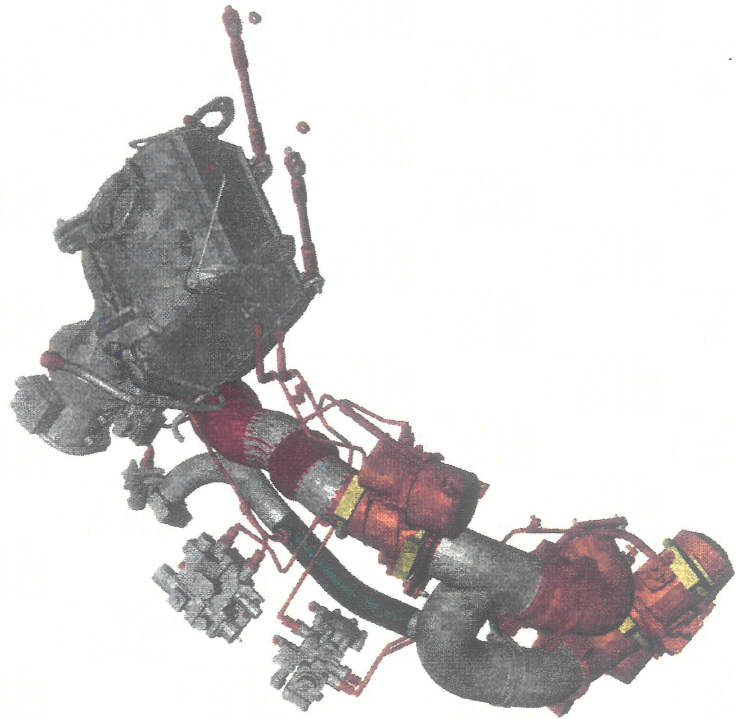
# SPAGHETTI



# SPAGHETTI



# PNEUMATICS

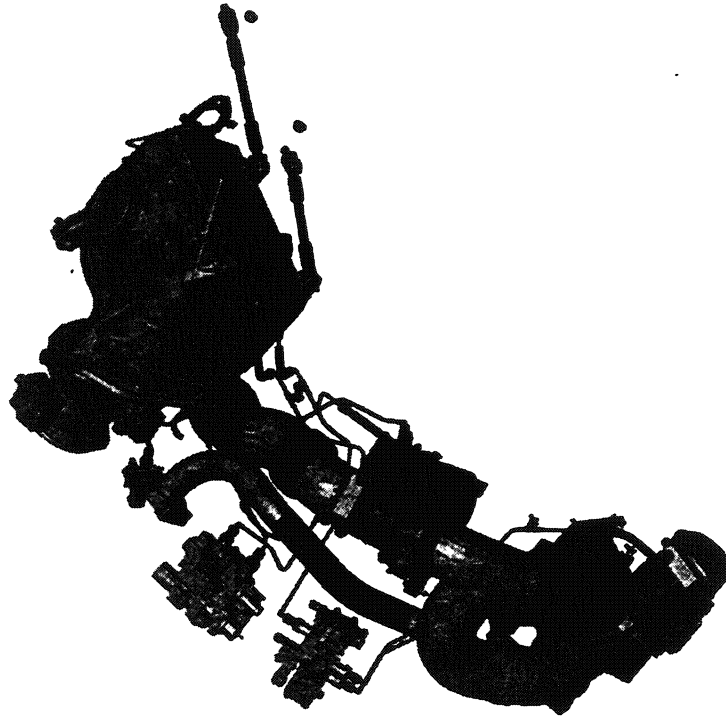


DISTRIBUTION - INTRODUCTION

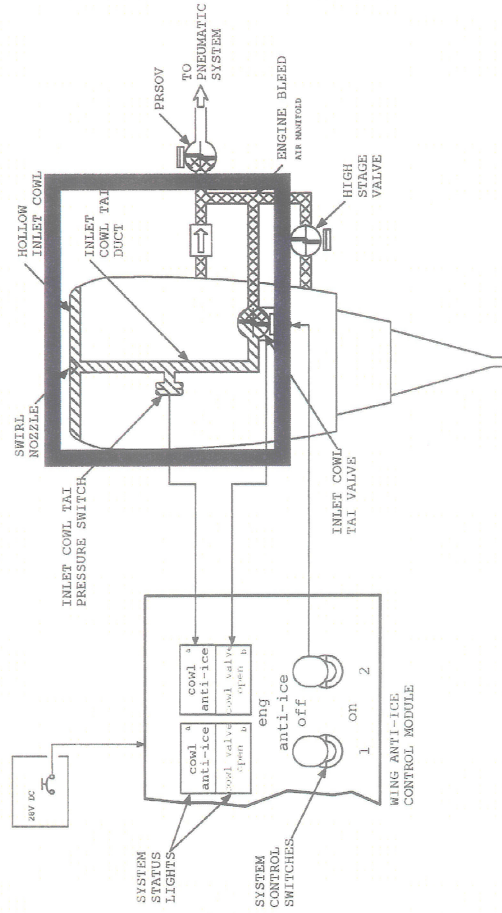


# PNEUMATICS

- Responsibilities
  - Ducting
    - Flex Joints
    - Flanges
  - Valve Installation
  - Controller Installation
  - Precooler Installation
- Requirements
  - Pressurize the Airplane
    - Temperature Control
  - Pressure Relief
  - Nacelle Cooling / Engine Case Distortion
  - Equipment Removals
  - Pressure Loss
  - MTBUR



# CTAI



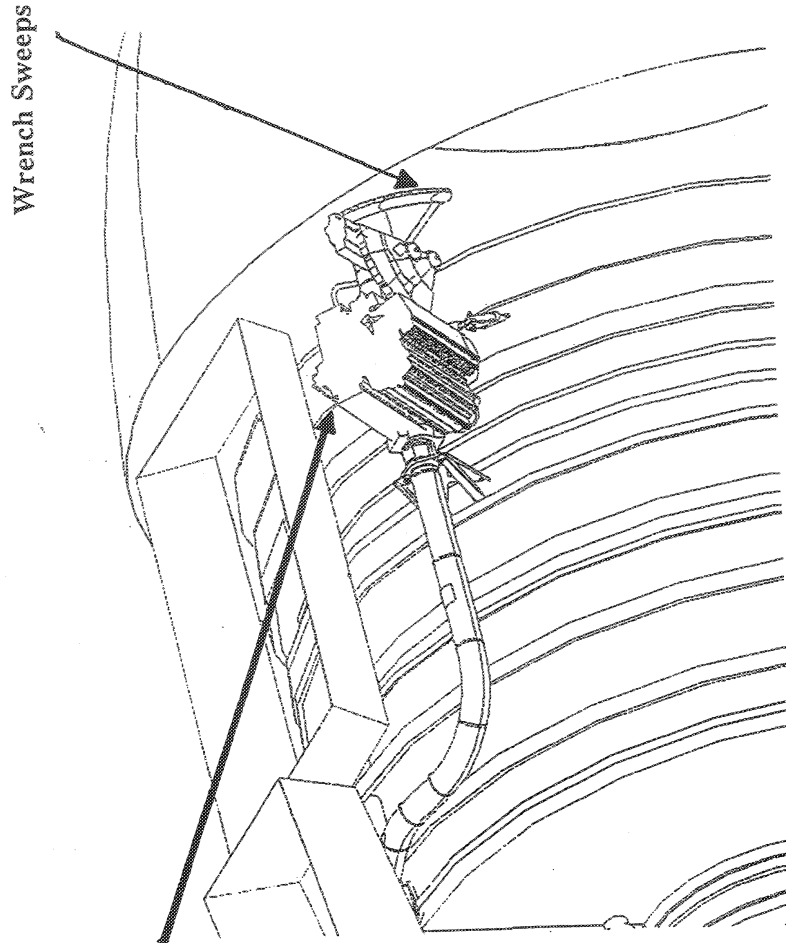
INLET COWL ANTI-ICING SYSTEM - INTRODUCTION

# CTAI

- Responsibilities
  - Ducting
    - Flanges
  - Valve
  - Pressure Sensor Installation
- Requirements
  - Anti-Ice Engine Inlet
  - Pressure Drop
  - Heat Rejection into Fan Compartment
  - Valve Removal
  - MTBUR



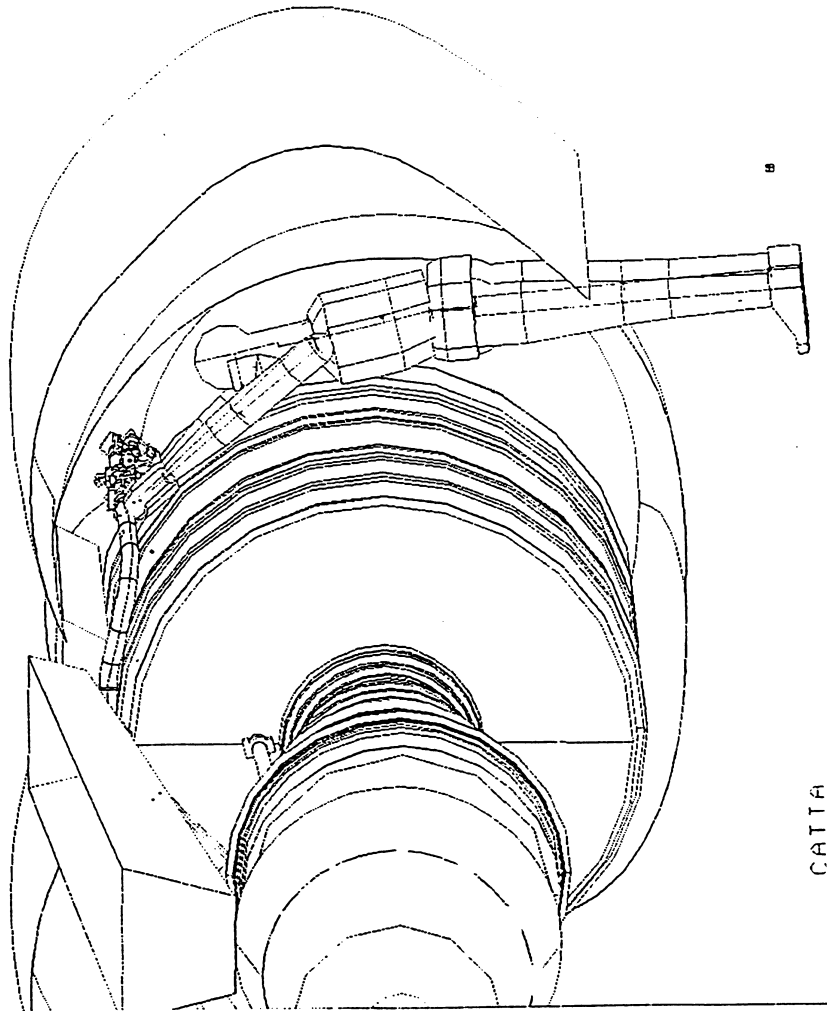
# PNEUMATICS MAINTENANCE



Wrench Sweeps

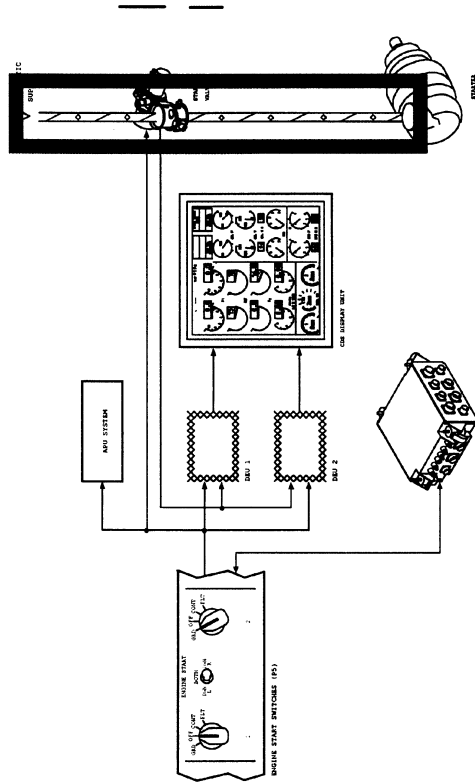
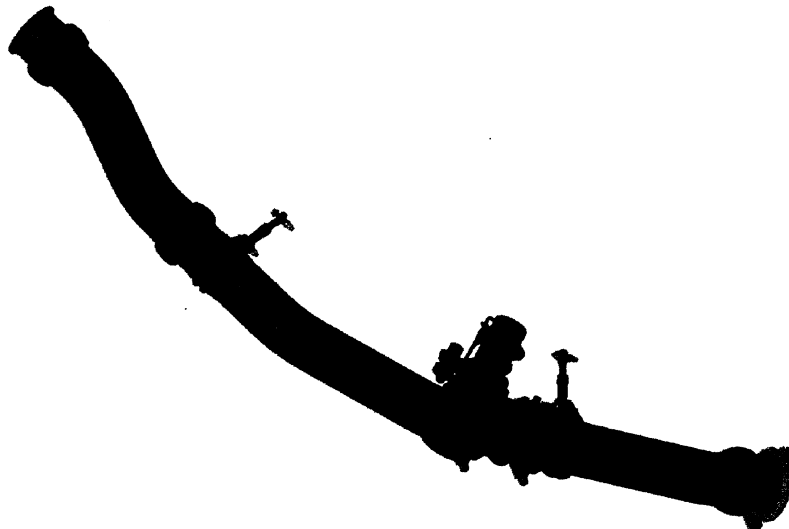
Modeling Removal Path  
Swept Volume Stored in CATIA

# PNEUMATICS MAINTENANCE



CAT 1A

# STARTER

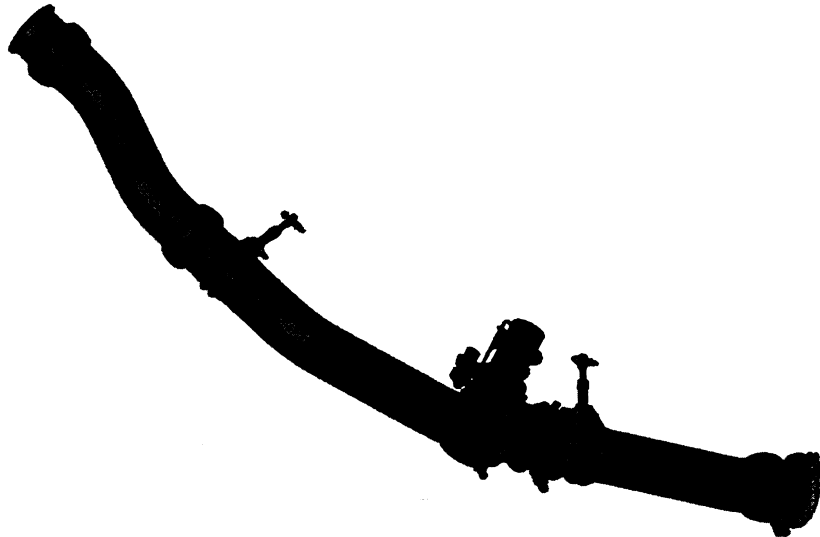


ENGINE STARTING - GENERAL DESCRIPTION

Change identifier in View - Header and Footer

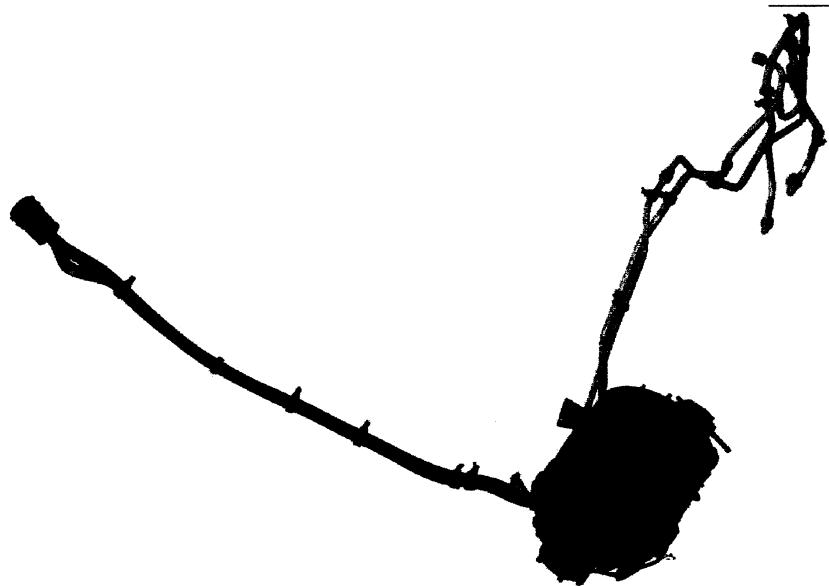
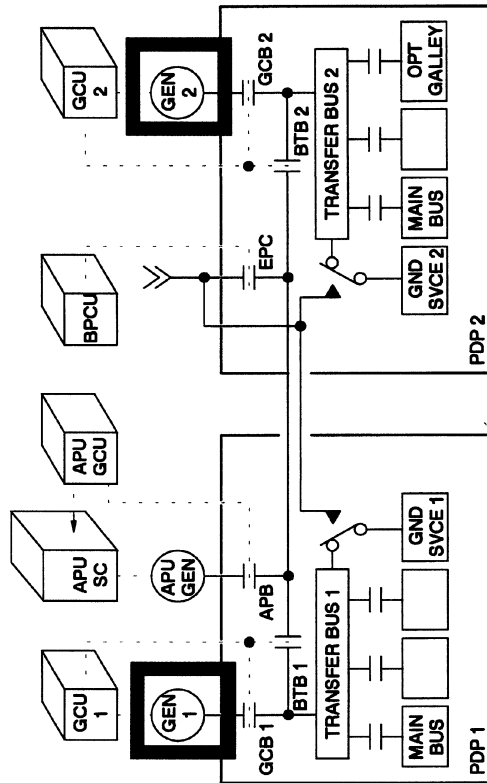
# STARTER

- Responsibilities
  - Ducting
    - Flex Joints
    - Flanges
  - Valve Installation
- Requirements
  - Supply Air to the Starter
  - MTBUR
  - Valve Removal





# IDG



# IDG

- Responsibilities
  - Power Feeder
  - Oil Cooling Lines
  - Air/Oil Cooler
  - IDG Installation
- Requirements
  - Engine/Gearbox Deflections
  - Pressure Drop
  - IDG Retention for Blade Out
  - IDG Removal
  - MTBUR
  - Fire Safety

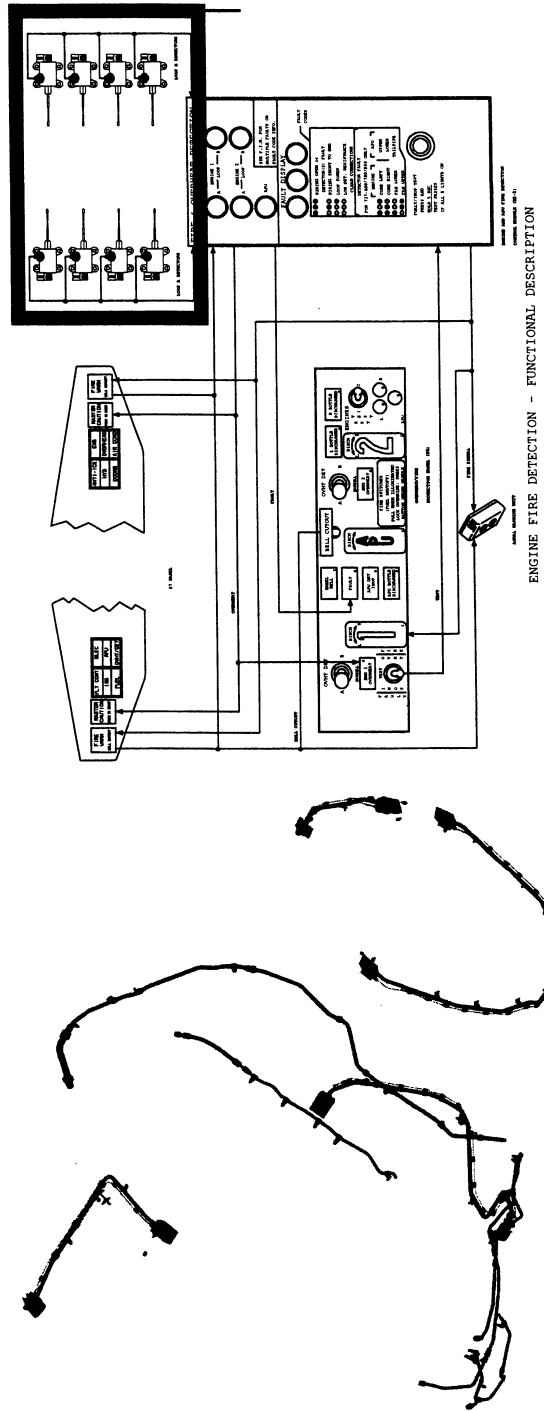


# FIRE PROTECTION

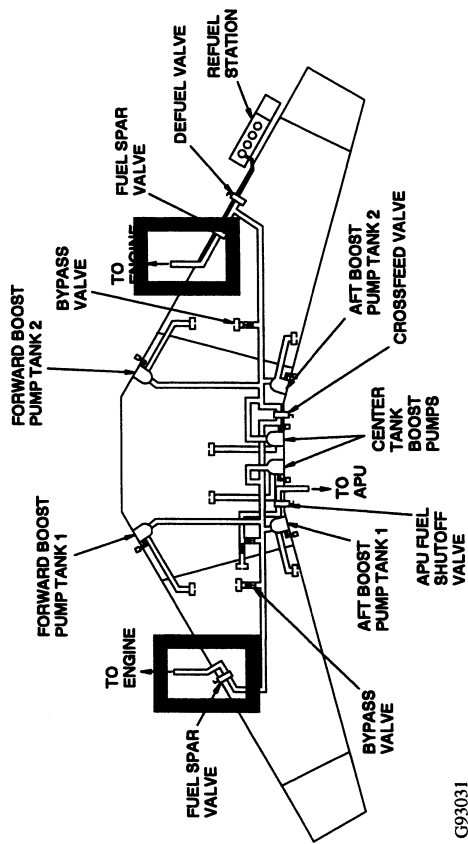
- Responsibilities
  - Fire Detectors
  - Fan Case Drains
  - Firex Tubes
- Requirements
  - Down Hill Drains
  - Overheat Detection
  - Fire Detection
  - Fire Detector Removal
  - MTBUR



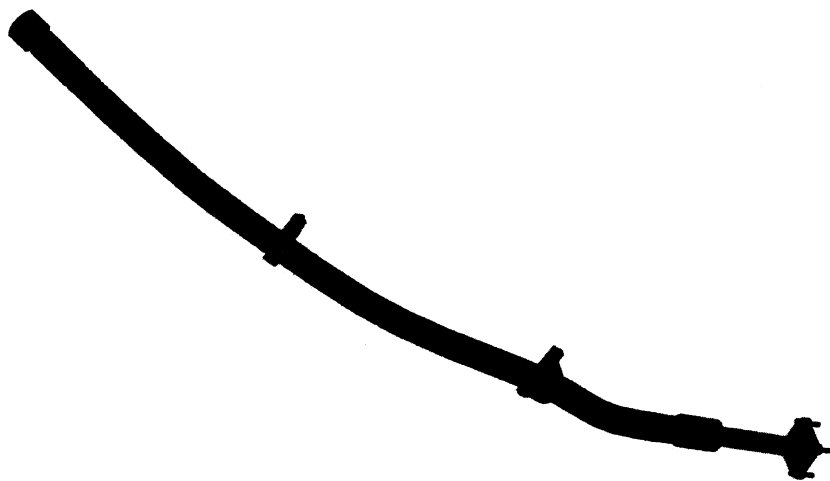
# FIRE PROTECTION



# FUEL



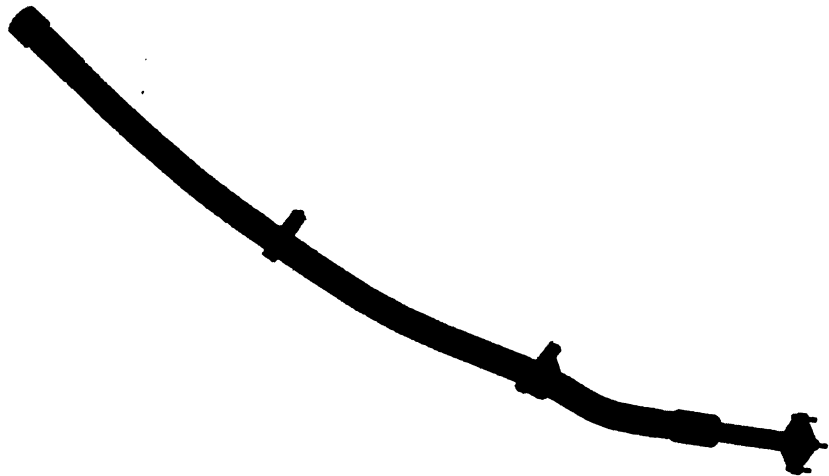
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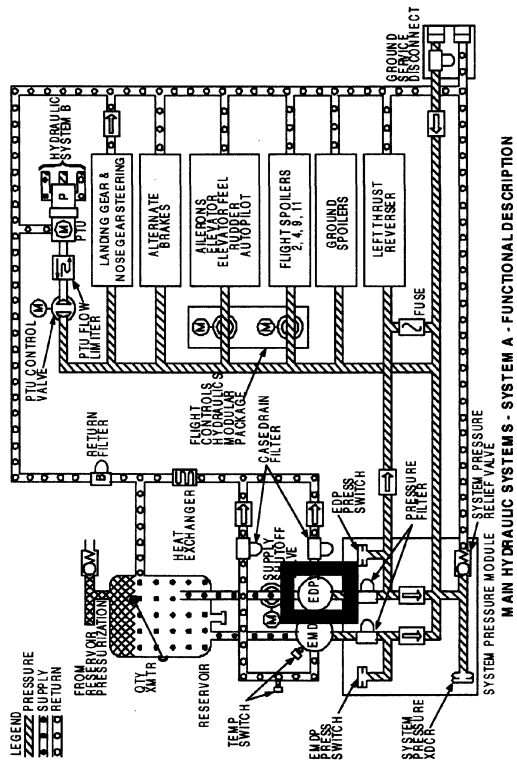
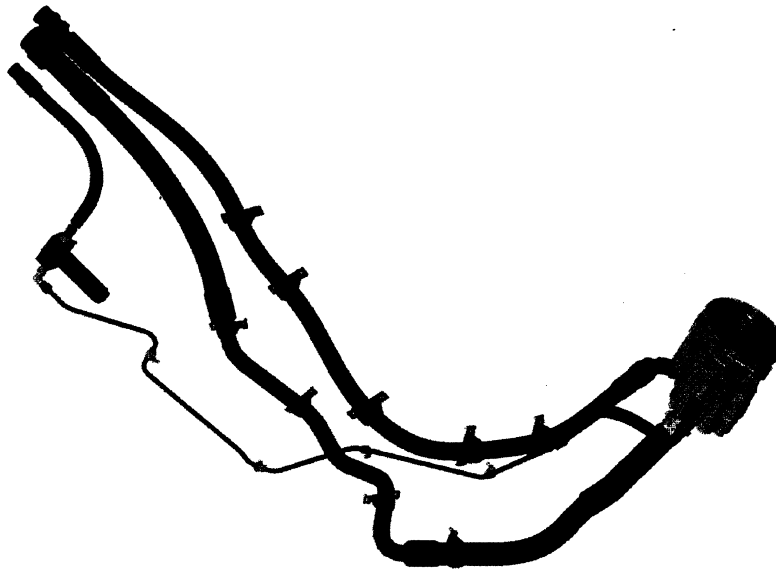
BOEING PROPRIETARY

# FUEL

- Responsibilities
  - Fuel Hose
- Requirements
  - Strut/Engine Deflections
  - Pressure Drop
  - Fire Safety



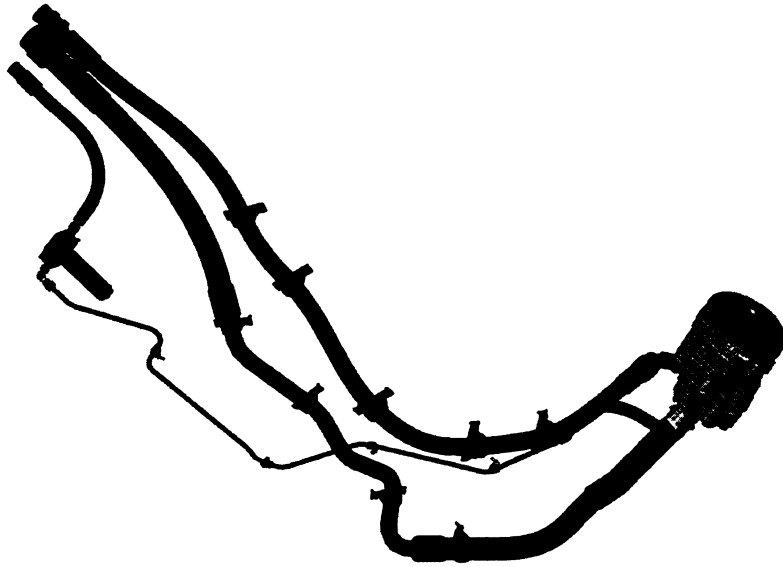
# Hydraulics





# HYDRAULICS

- Responsibilities
  - Hoses
  - Tubes
  - Case Drain Filter Installation
  - Pump Installation
- Requirements
  - Pressure Drop
  - Fire Safety
  - Strut/Engine Deflection
  - Engine/Gearbox Deflection
  - Pump Removal
  - MTBUR



# BRACKETS



# BRACKETS

- Responsibilities
  - Brackets
- Requirements
  - Retain Systems and Components



# NACELLE VENTILATION

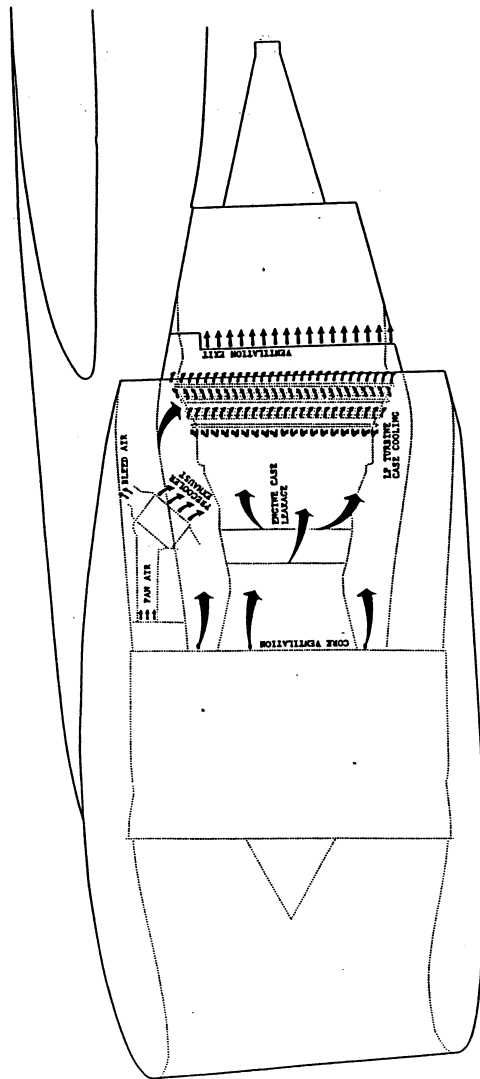
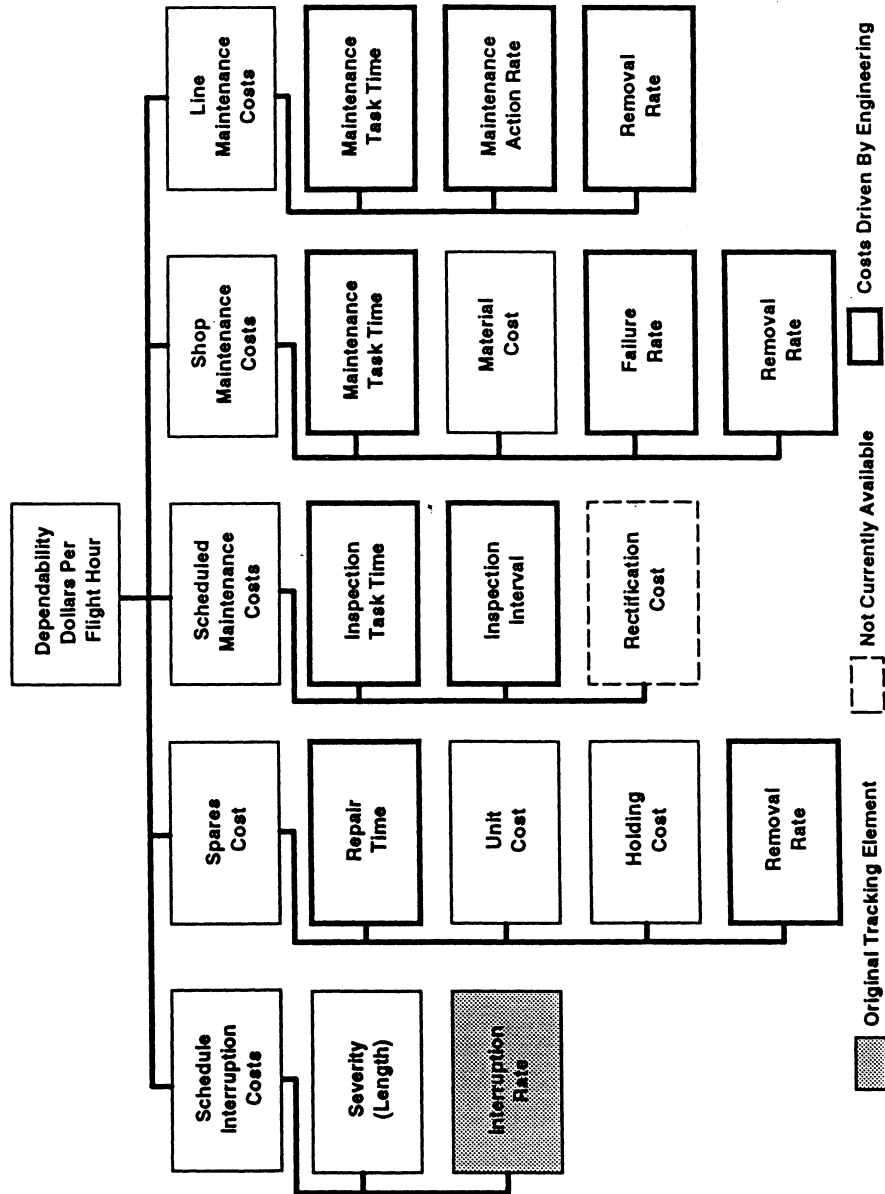


FIGURE 3-9  
CORE COMPARTMENT VENTILATION

# Dependability

## AIPLANE DEPENDABILITY COST ELEMENTS



## **Conclusion**

- **EBU Systems are the Power Source for the Airplane.**
- **Five Basic Requirements Are the Major Focus.**
  - **Function**
  - **Installation**
  - **Production**
  - **Environment**
  - **FAR's**
- **EBU System is a Small Portion of the Airplane Systems.**
- **One System can Effect Numerous Systems.**
- **Each System has Unique Requirements.**