

737/CFM56-7 AIRCRAFT ENGINE SYSTEMS

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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.

Engine Installation



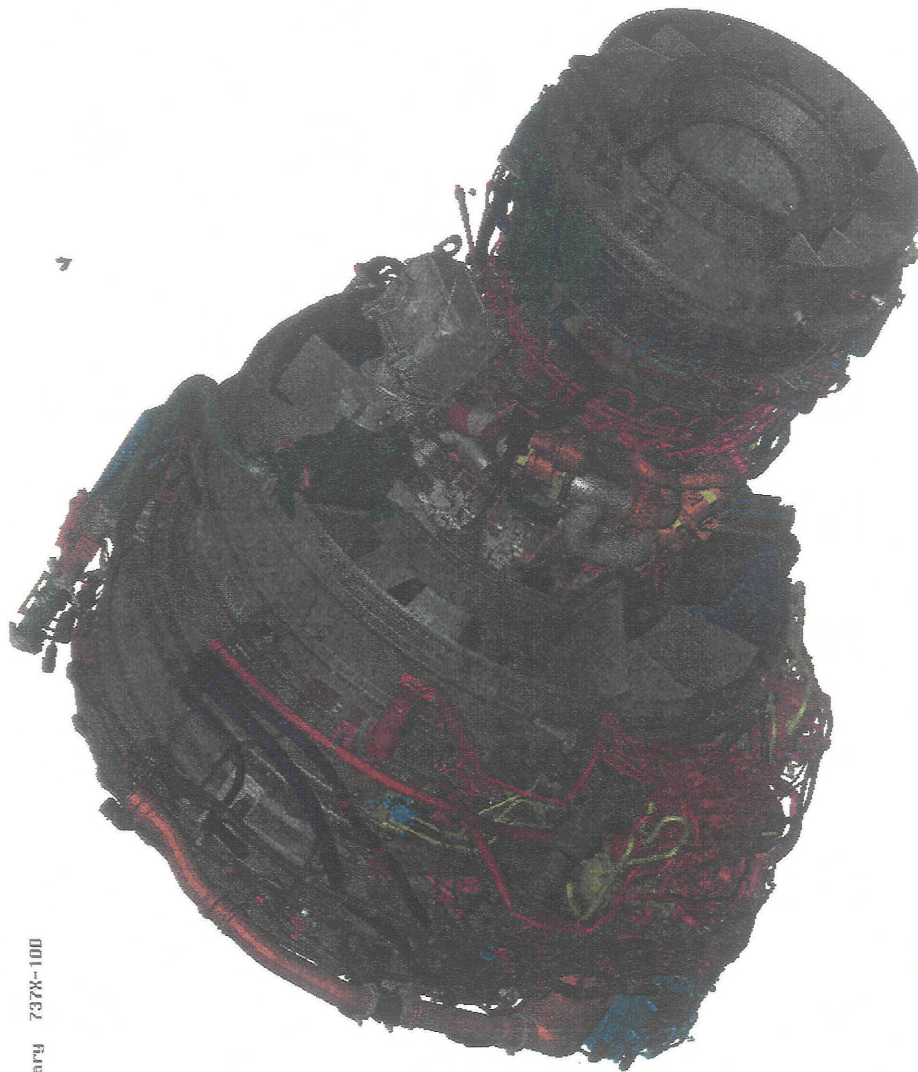
Boeing



Boeing Designed Systems

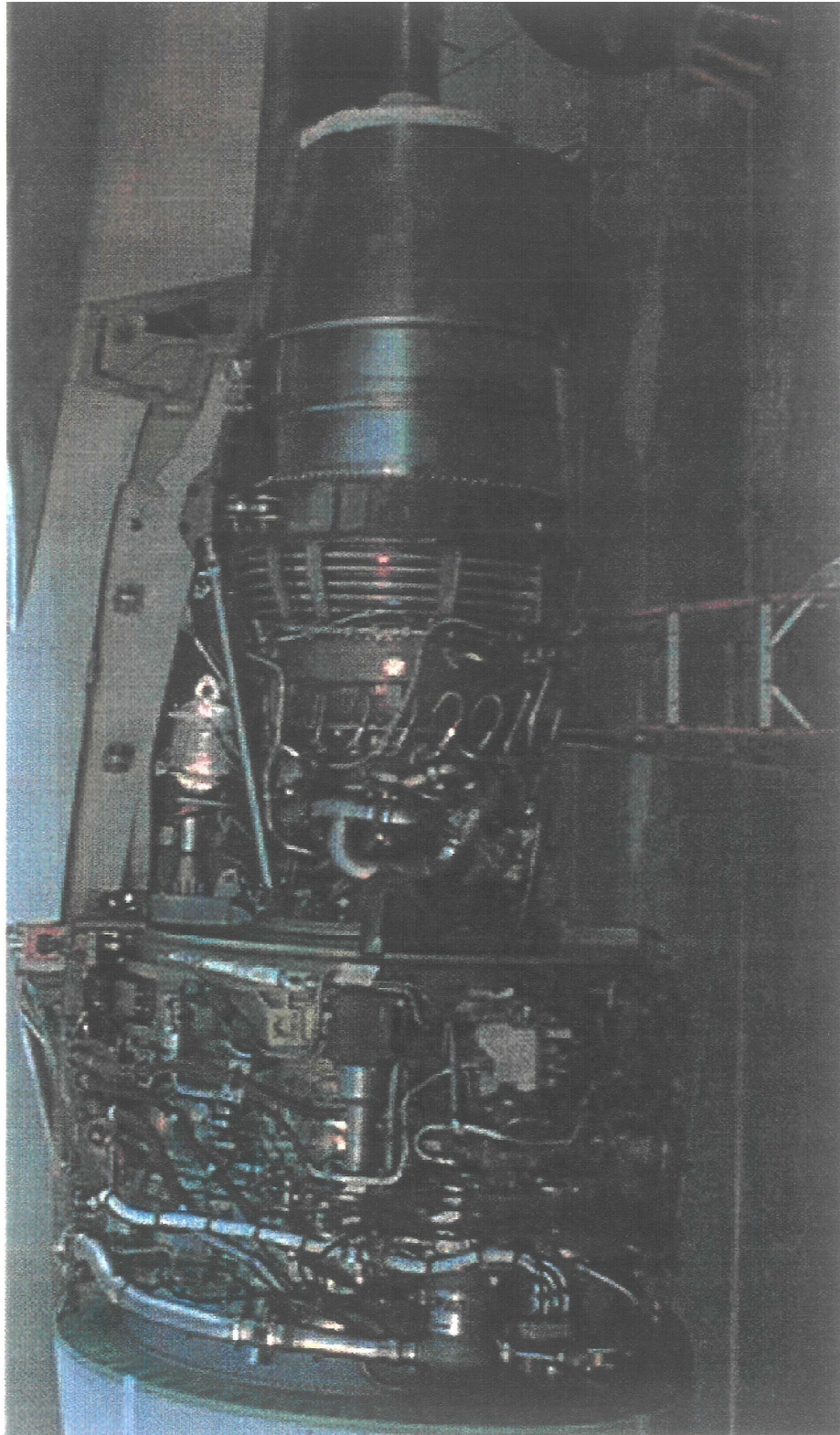
- Pneumatics - ducting, valves, controllers, precooler
- Starting - ducting, valve
- Integrated Drive Generator (IDG) - power feeder cables, cooling
- Cowl Thermal Anti-Ice (CTAI) - ducting, valve, controller
- Fire Protection - fire detectors, drains, extinguishing
- Fuel Line
- Hydraulics - hoses,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

CFMI and Boeing

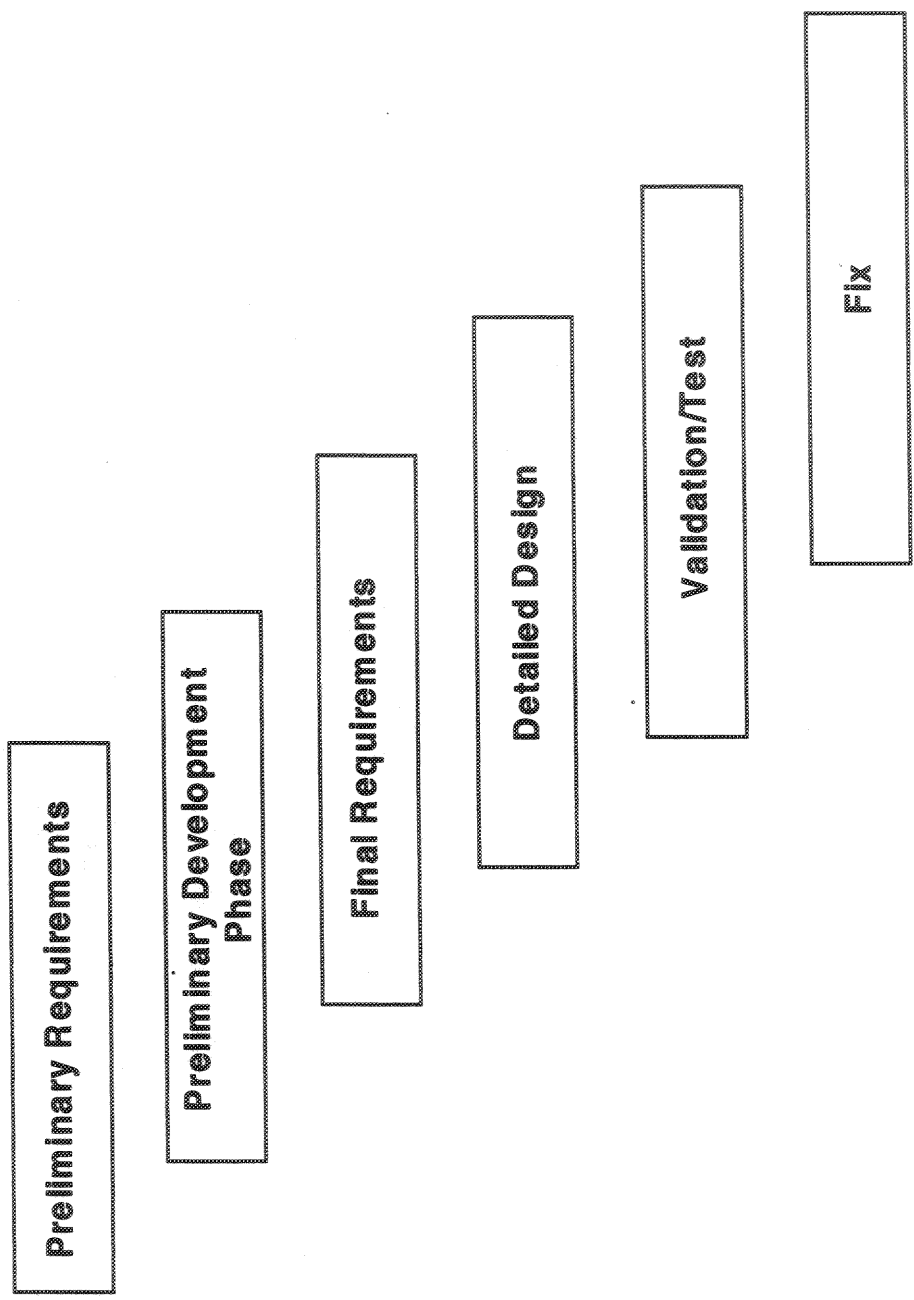


air 737X-100

Engine Without Cowls



How We Ended Up With This Configuration



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**

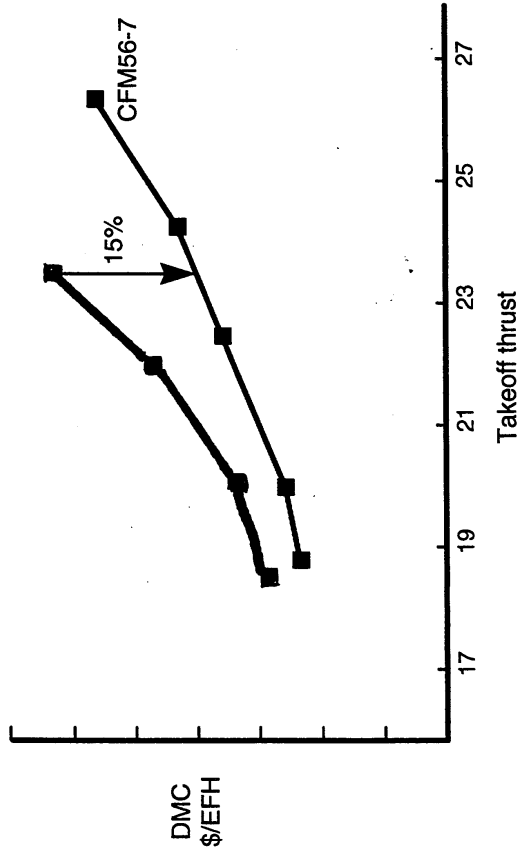
737NG EBU FOCUS

- **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



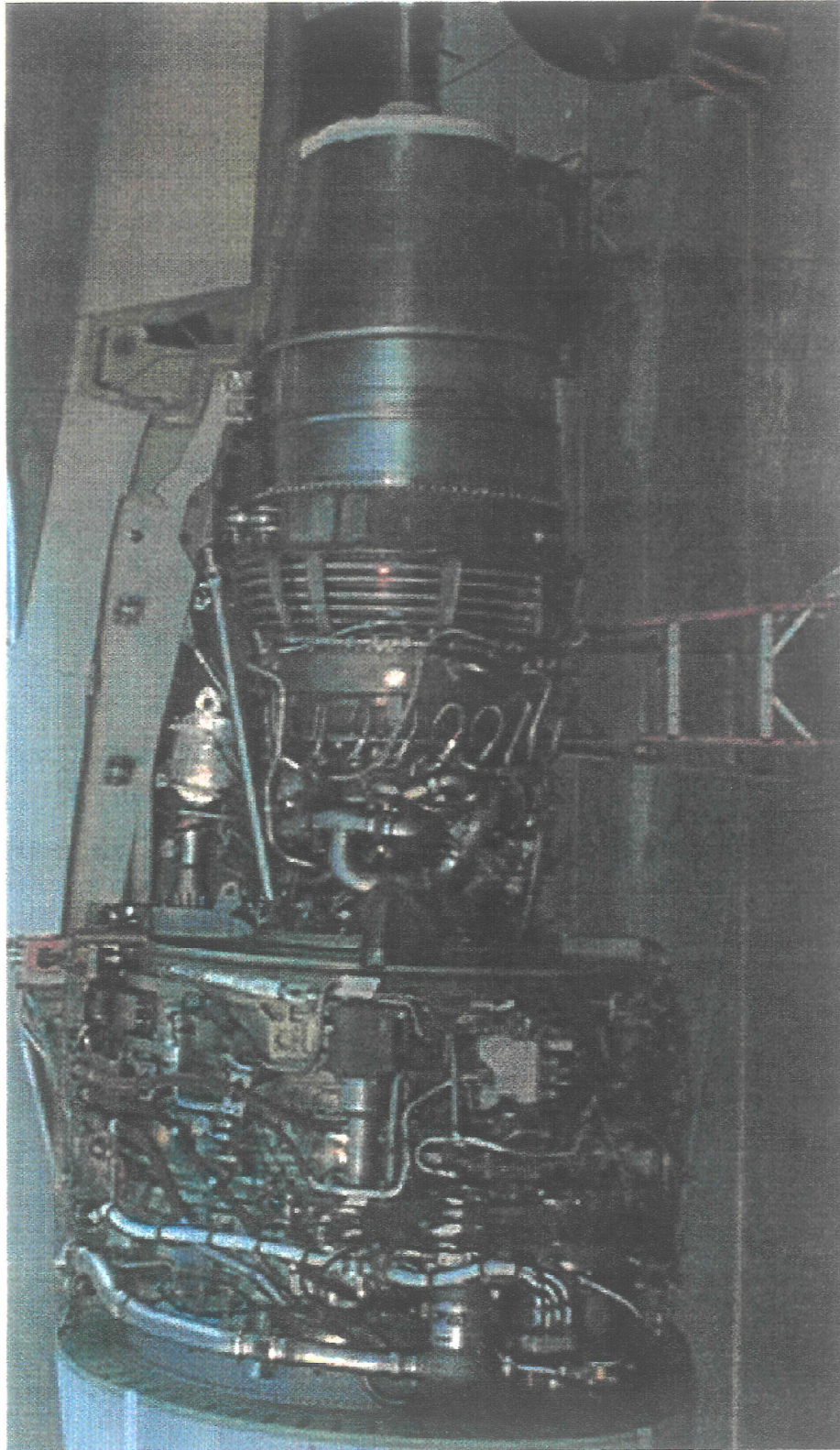
Improved Reliability

- **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)**

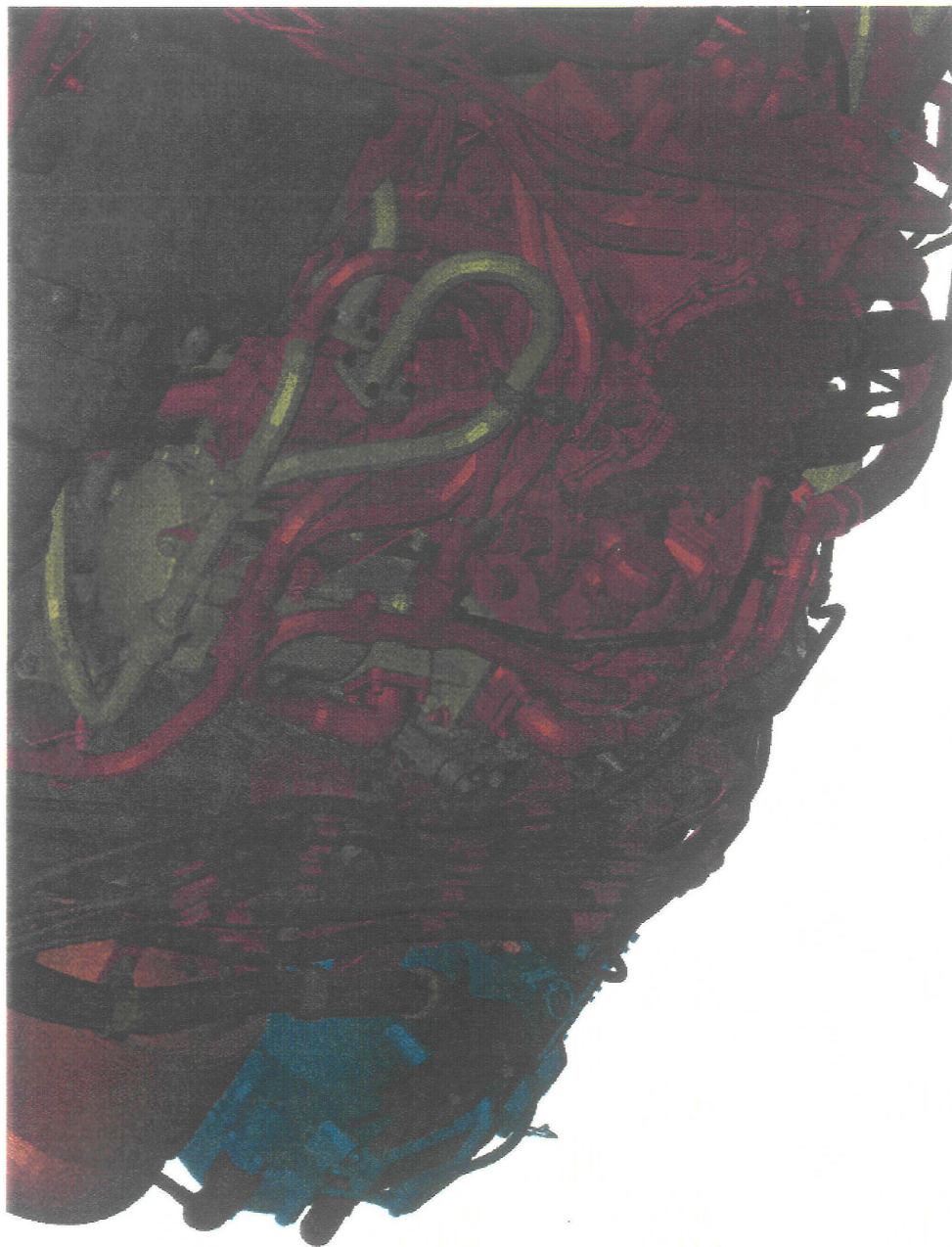
INTERNAL EQUIPMENT BASIC REQUIREMENTS

- **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**

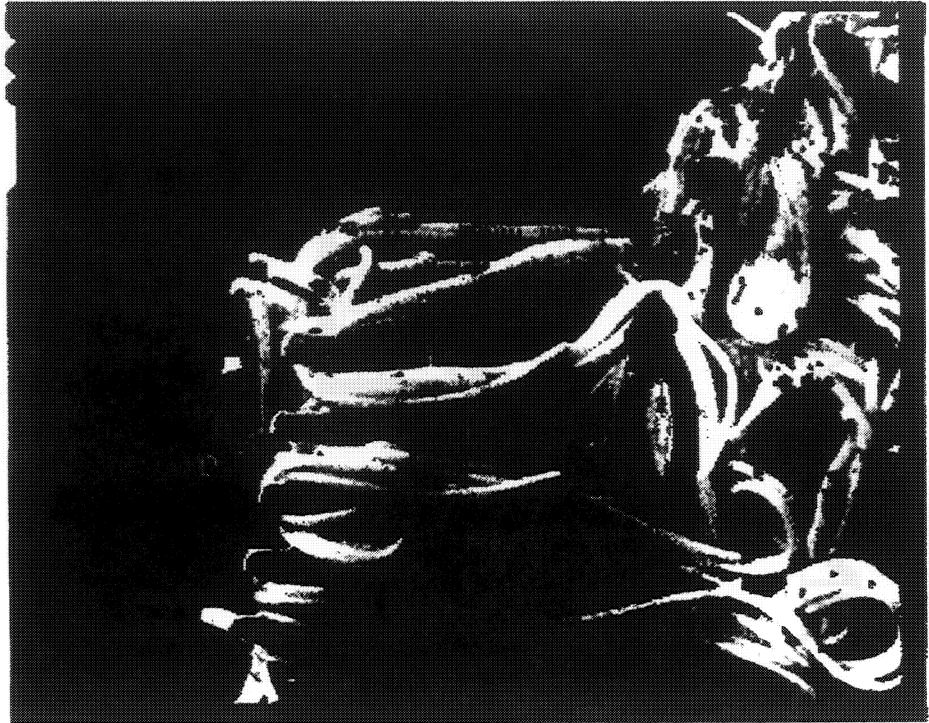
Engine Without Cowls



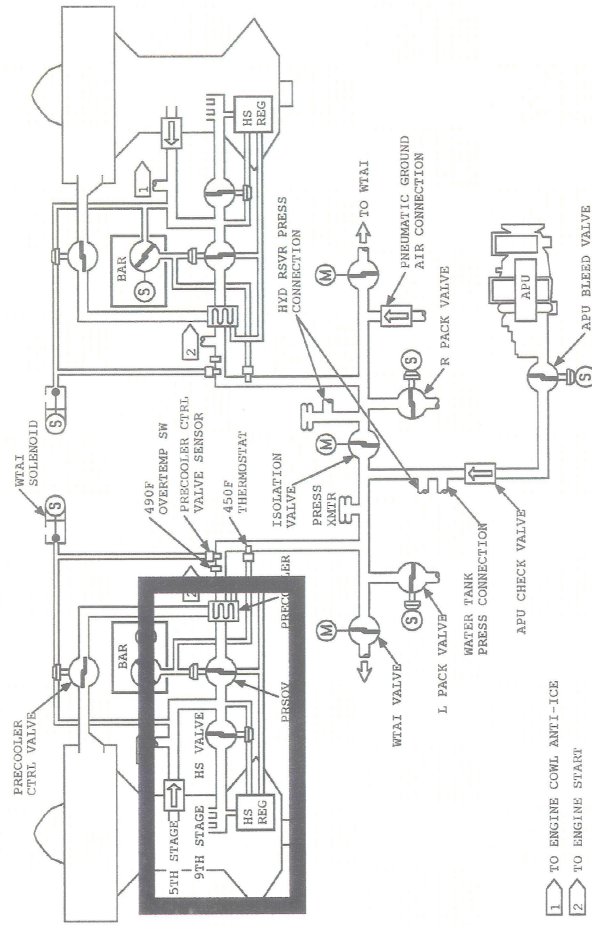
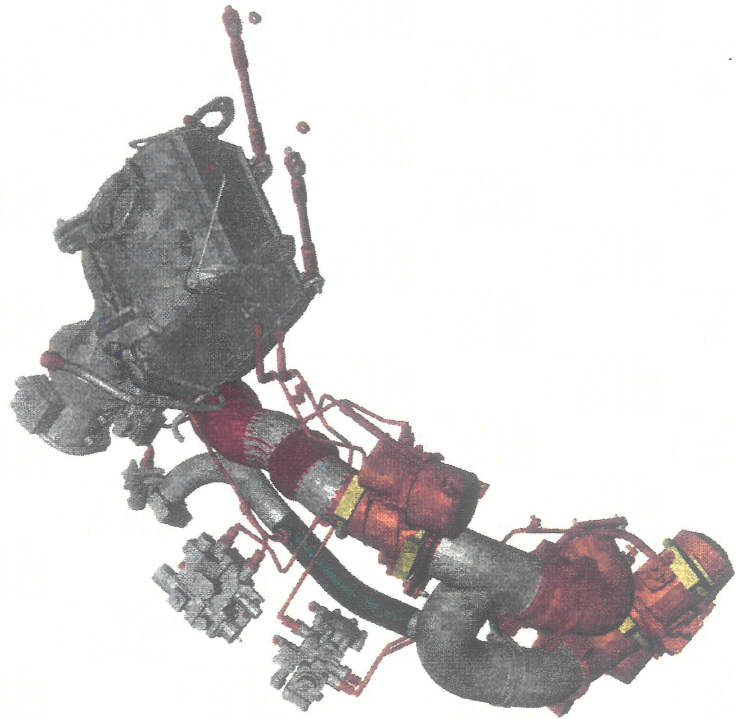
SPAGHETTI



SPAGHETTI



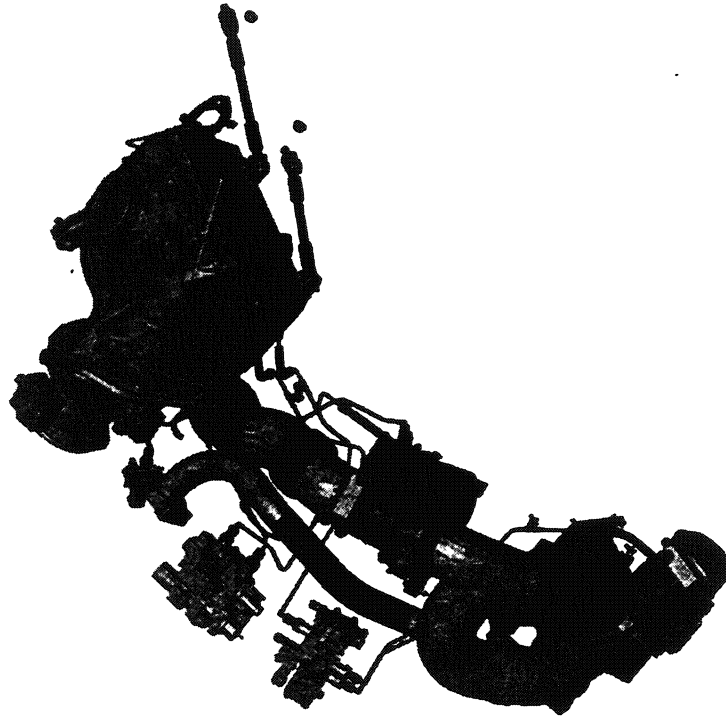
PNEUMATICS



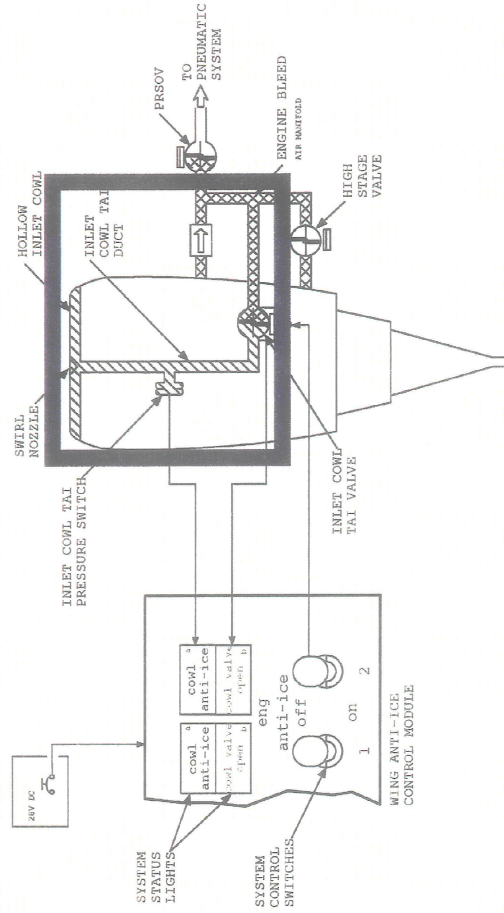
DISTRIBUTION - INTRODUCTION

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



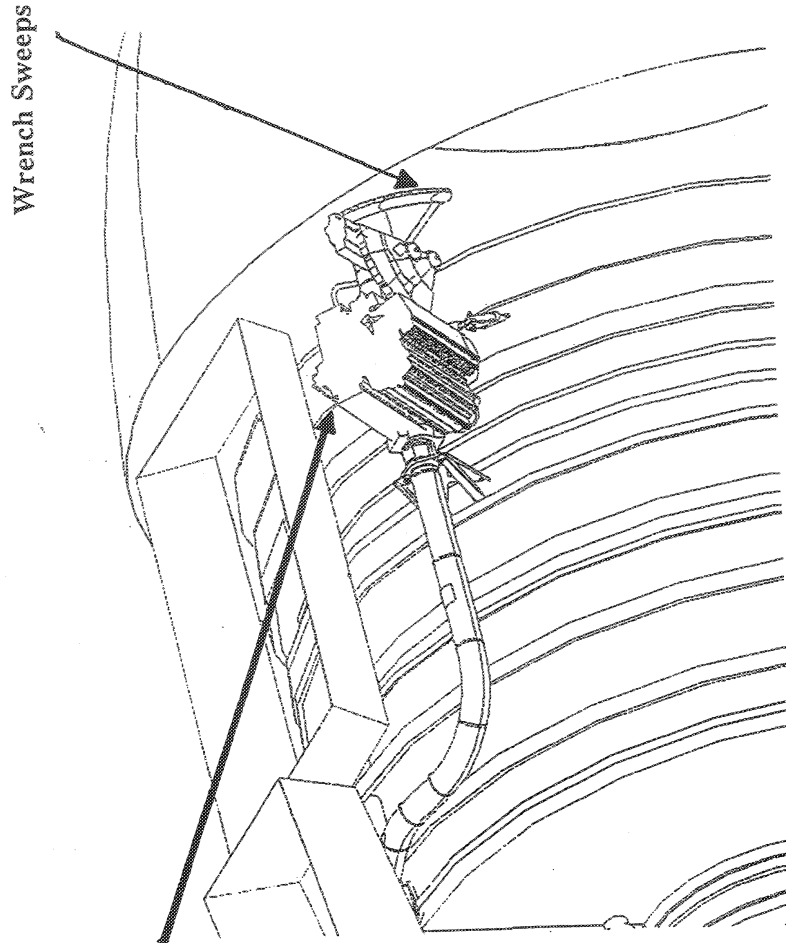
INLET COWL ANTI-ICING SYSTEM - INTRODUCTION

CTAI

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



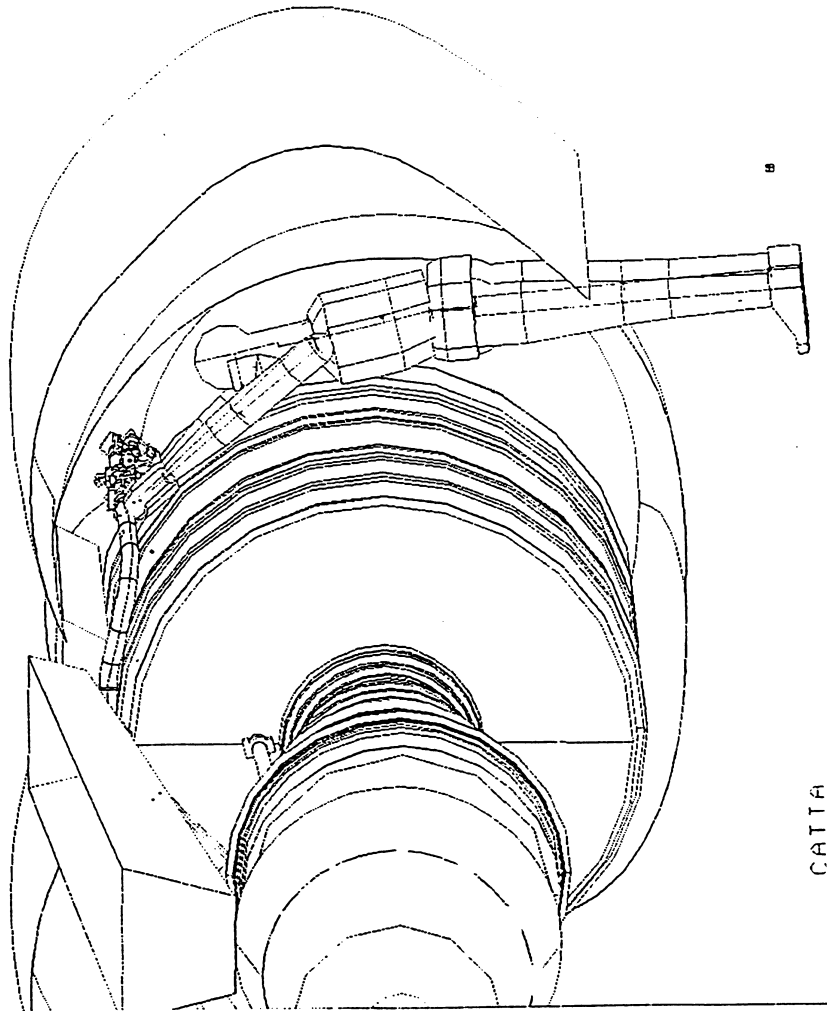
PNEUMATICS MAINTENANCE



Wrench Sweeps

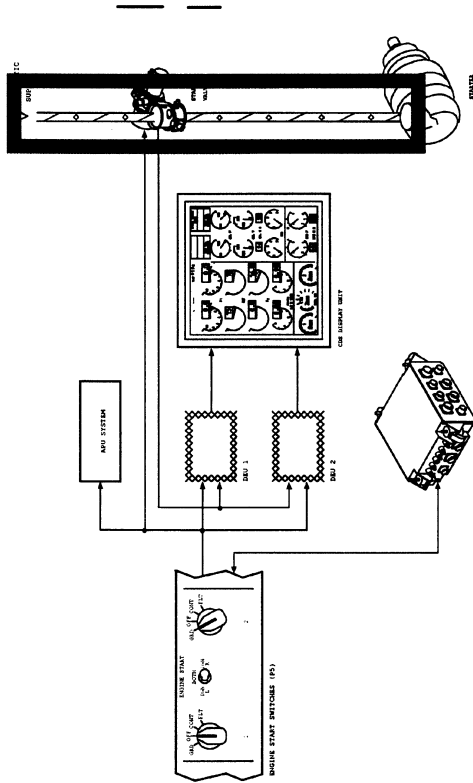
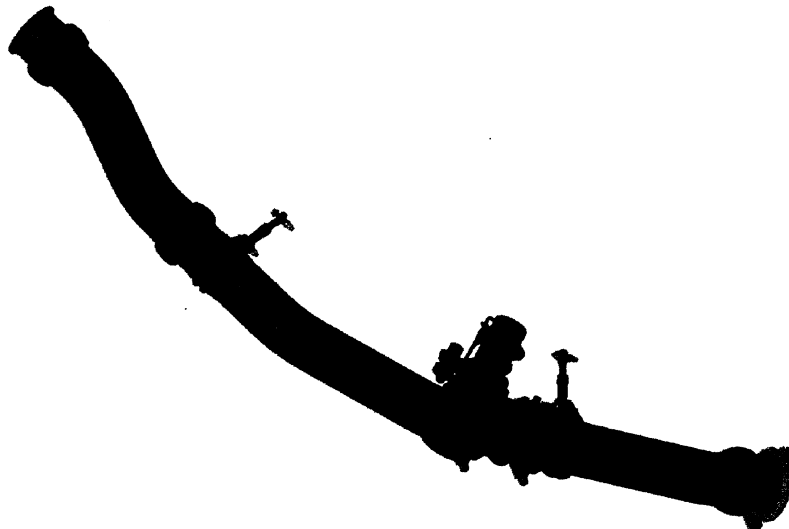
Modeling Removal Path
Swept Volume Stored in CATIA

PNEUMATICS MAINTENANCE



CAT 1A

STARTER

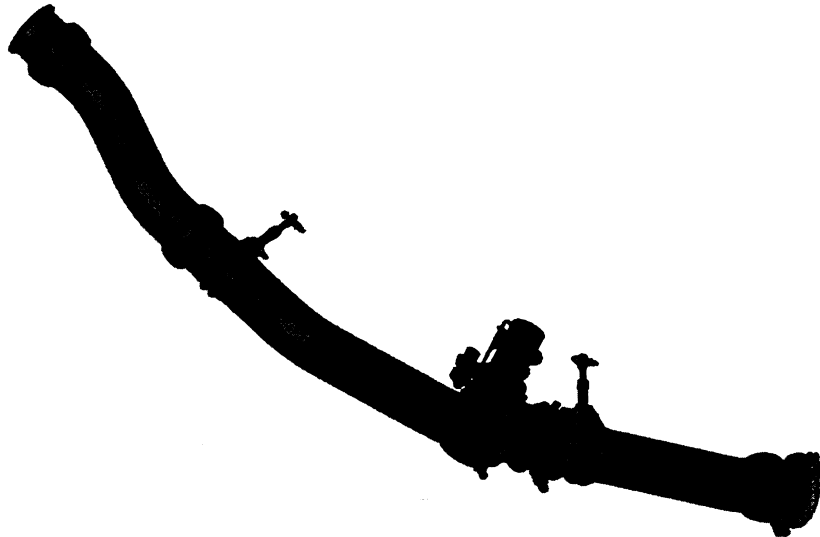


ENGINE STARTING - GENERAL DESCRIPTION

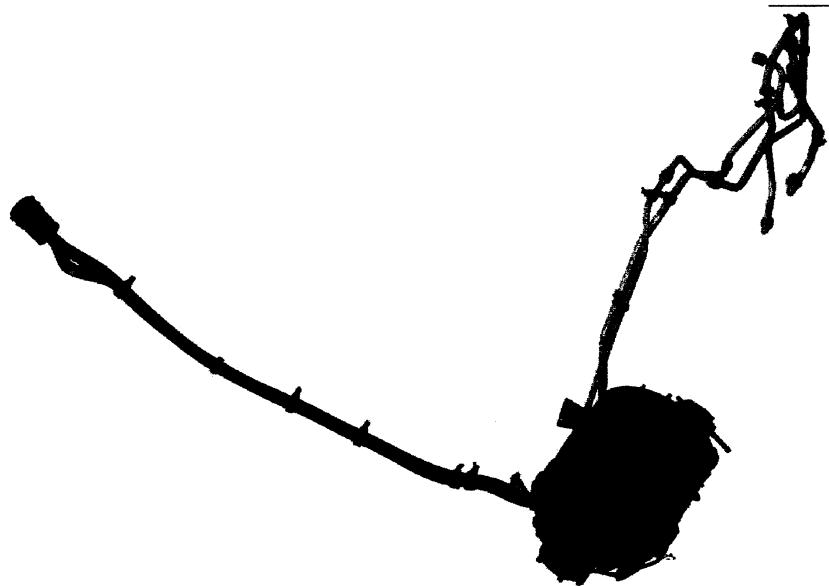
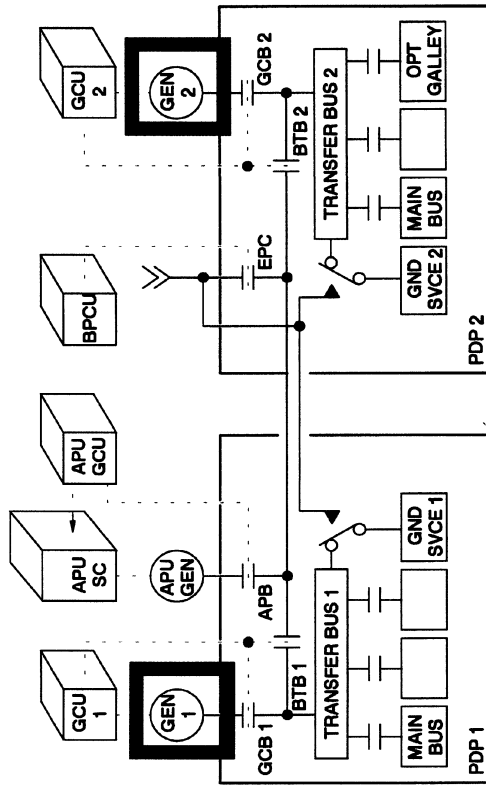
Change identifier in View - Header and Footer

STARTER

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



IDG



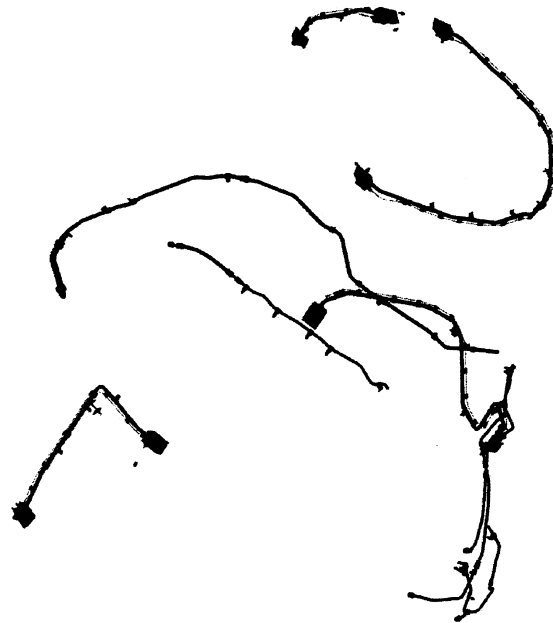
IDG

- 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

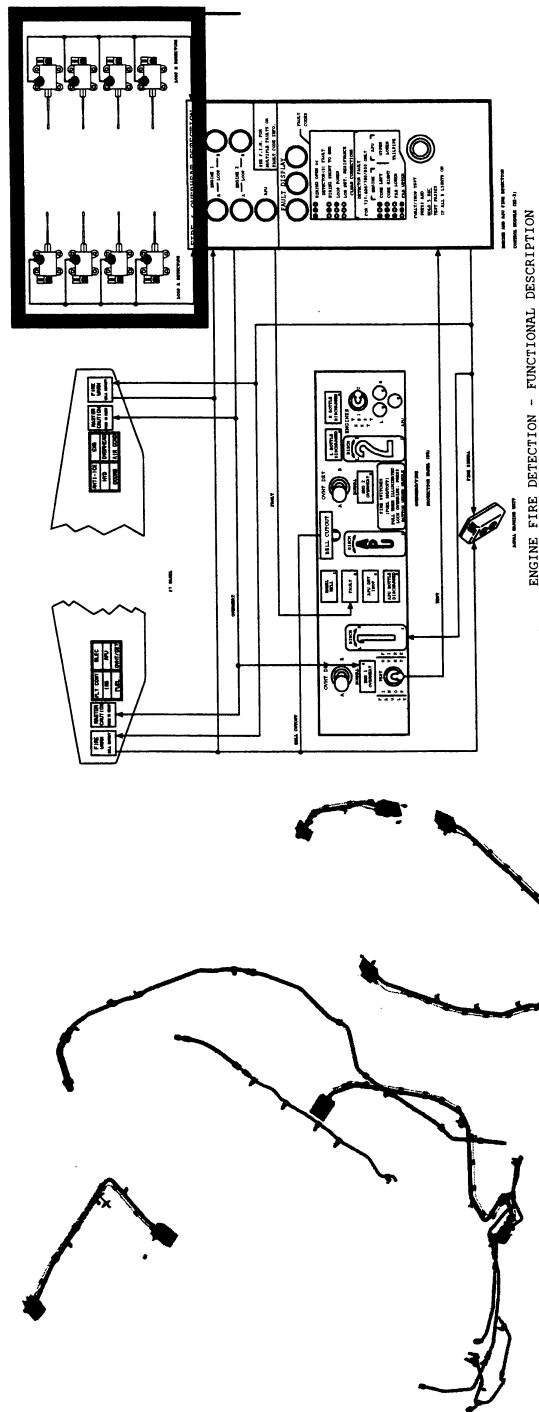


FIRE PROTECTION

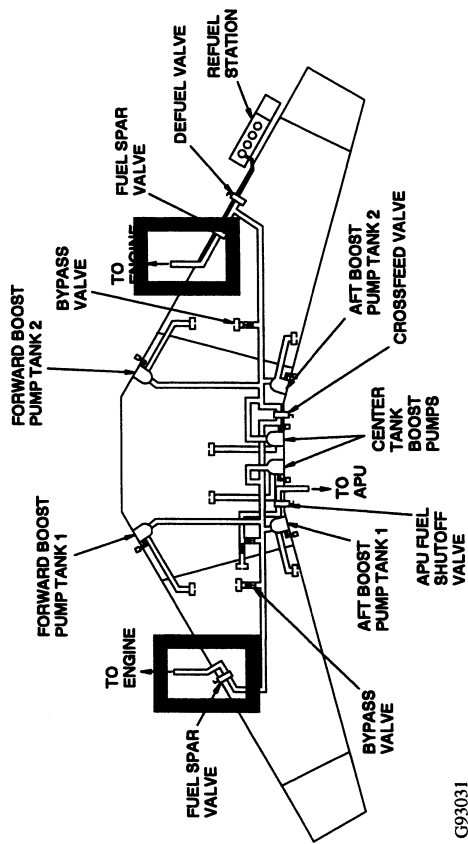
- Responsibilities
 - Fire Detectors
 - Fan Case Drains
 - Firex Tubes
- Requirements
 - Down Hill Drains
 - Overheat Detection
 - Fire Detection
 - Fire Detector Removal
 - MTBUR



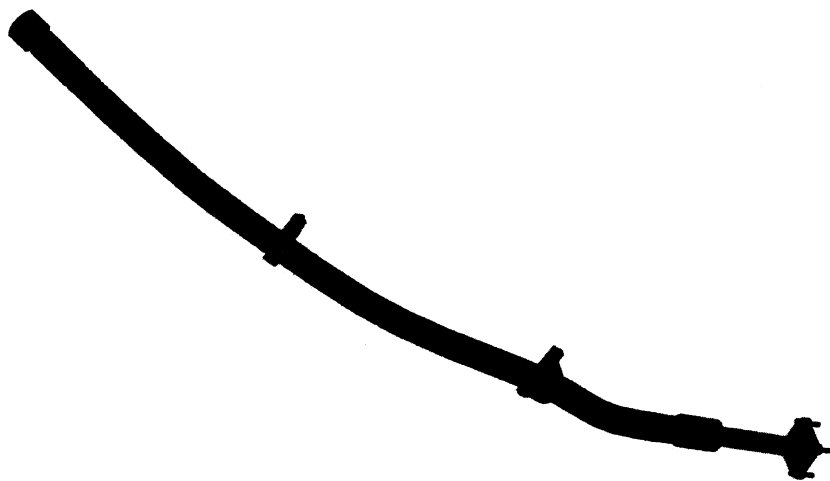
FIRE PROTECTION



FUEL

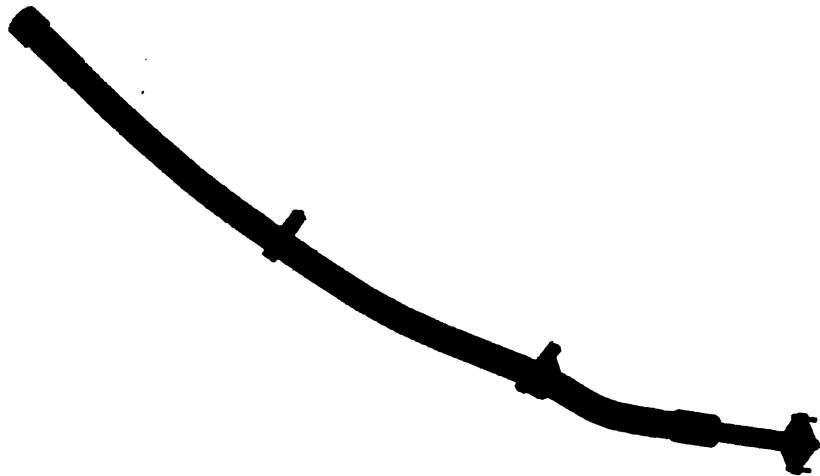


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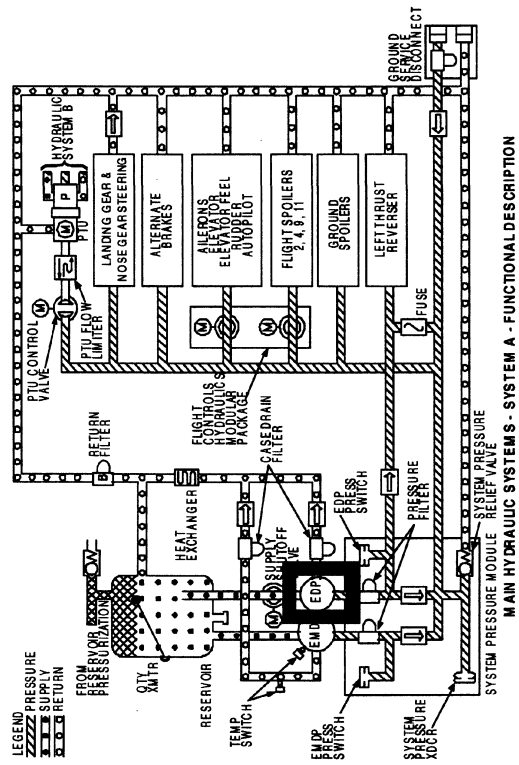
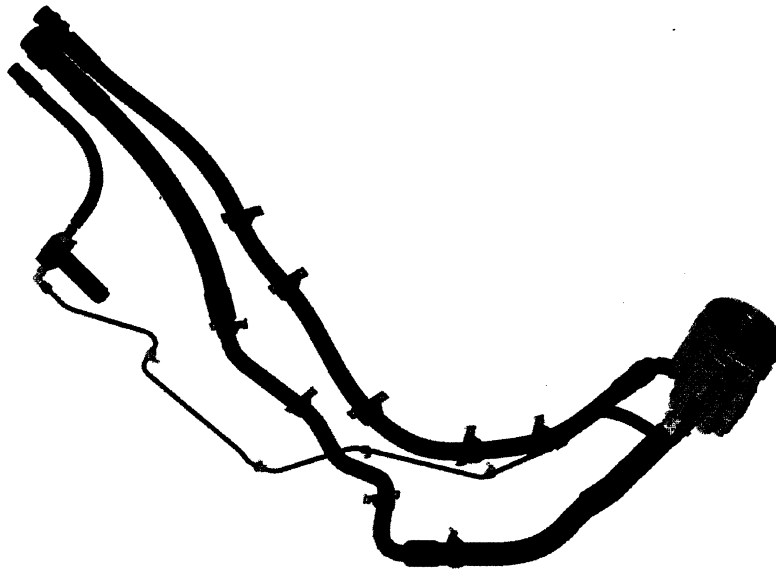


FUEL

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

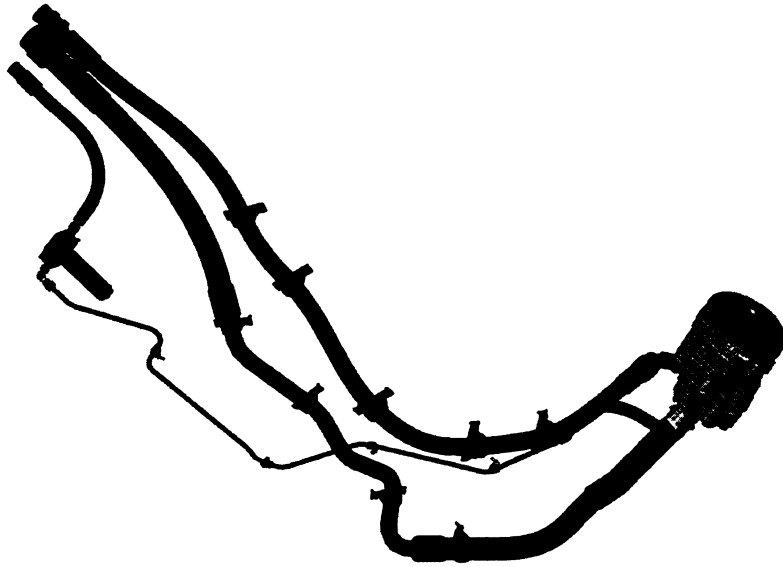


Hydraulics



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



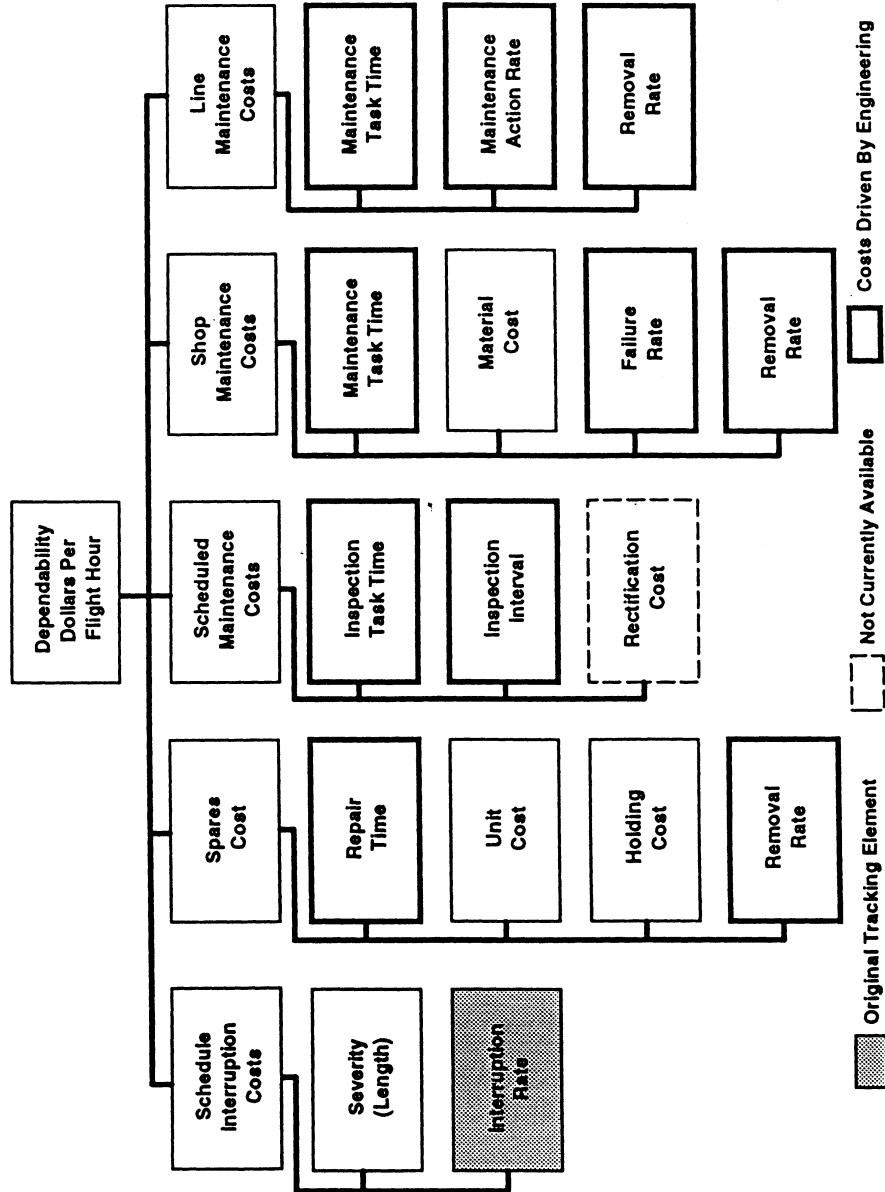
BRACKETS

- Responsibilities
 - Brackets
- Requirements
 - Retain Systems and Components



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.**