AIRCRAFT CARGO DOOR ANALYSIS USING ADAMS

DAVE RIESLAND
DOUGLAS AIRCRAFT COMPANY
LONG BEACH, CA

Douglas Aircraft Company in Long Beach, CA, is a division of McDonnell Douglas Corporation. The main product produced by Douglas Aircraft Company is transport aircraft, the twin-jet (MD-80/MD-90), the tri-jet (MD-11) and military transport (C-17).

Approximately six people in Structural Mechanics and Mechanical Design use ADAMS/Solver on the IBM mainframe and post-process with an in-house post-processor on Silicon Graphics workstations.

ADAMS users at Douglas Aircraft Company use ADAMS for preliminary concept development, design refinement, design verification, design reviews and test planning. ADAMS was used extensively to design and analyze the powered elevator control system on the MD-90 aircraft (Figures 1 & 2). ADAMS was also used to design and analyze a cargo door and ramp latching system (Figures 3 - 7).

Our most recent, challenging problem requiring ADAMS was the MD-11 Combi version aircraft, which has a 160" aft, upper cargo door (Figures 8 & 9). Previous designs underestimated the mechanism force requirements to close the door. ADAMS provided the link between mechanical system requirements and fuselage to door stiffness and deflections. Using ADAMS allowed us to optimize cam shapes, actuator energy, configuration, and closing sequence (Figures 9 & 10).

The main use of ADAMS at Douglas Aircraft Company is to verify system functionality. We can determine if a mechanical system will work before it is installed on the aircraft. This eliminates costly redesigns and delays in aircraft certification. Other important uses include designing the size and shapes of individual components and computing internal loads for both the mechanism and supporting structure.

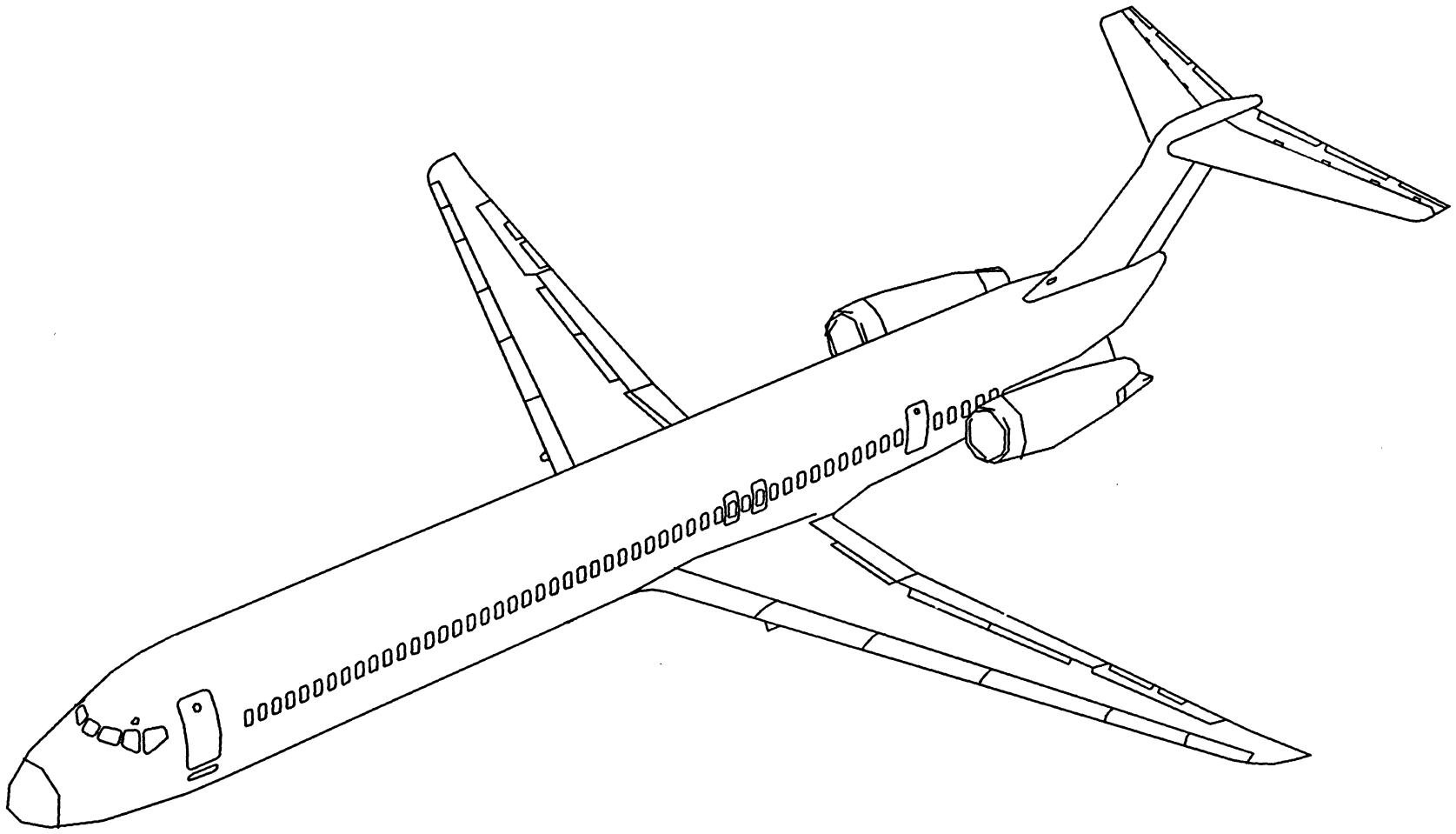
Combining all of these factors, using ADAMS in the design process saves Douglas Aircraft Company millions of dollars by providing first time quality designs. This advanced technology provides a higher quality product, which results in a greater opportunity to sell aircraft in a highly competitive marketplace.

MD-90 COMMERCIAL AIRCRAFT

POWERED ELEVATOR CONTROL SYSTEM

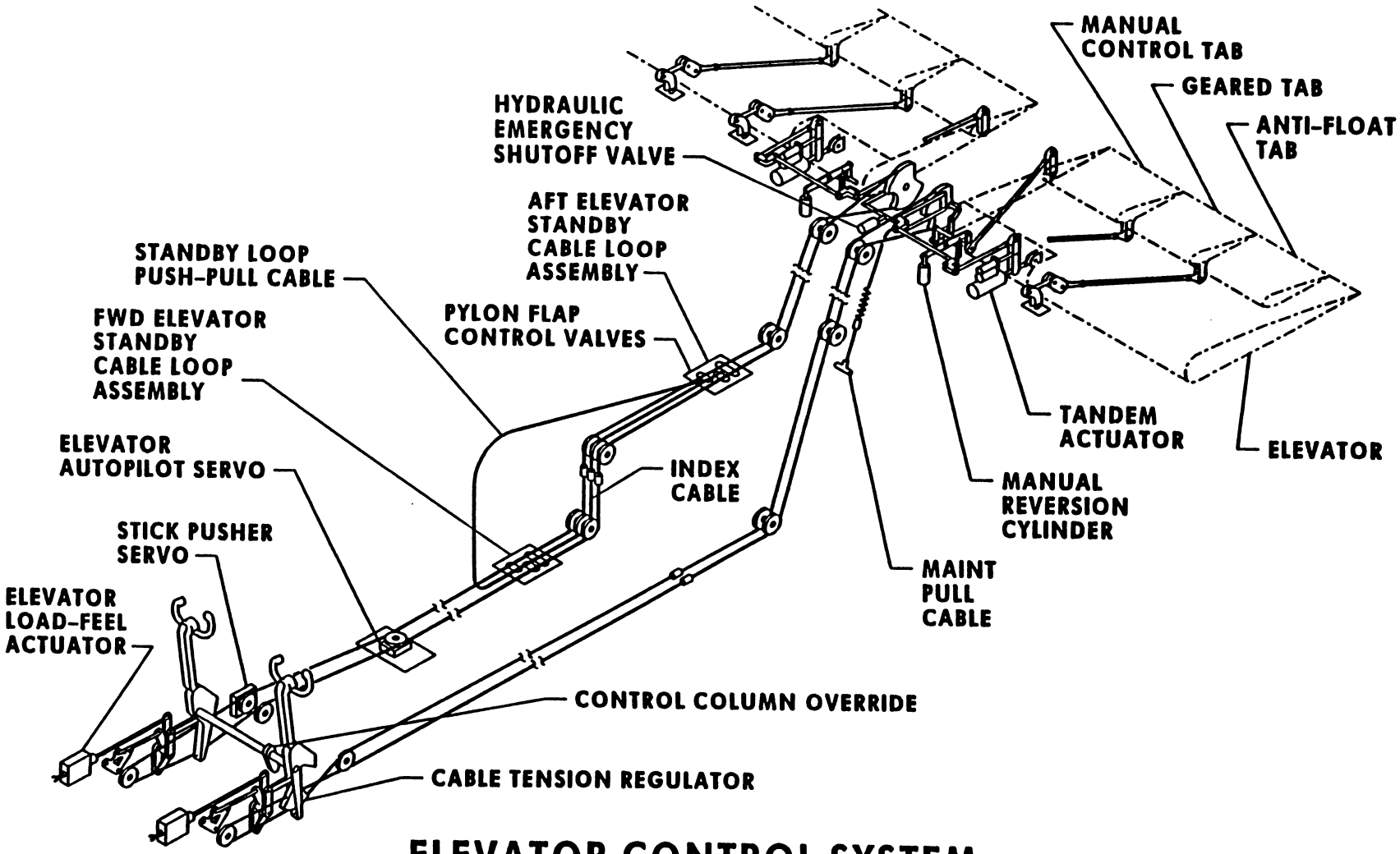
* **ELEVATOR ACTUATOR HARDOVER PROTECTION ANALYSIS**
* **POWER TO MANUAL REVERSION DESIGN AND ANALYSIS**
* **ELEVATOR LOAD FEEL DESIGN AND ANALYSIS**

+ PRELIMINARY CONCEPT DEVELOPMENT
+ DESIGN REFINEMENT
+ DESIGN VERIFICATION
+ DESIGN REVIEWS



MD-90 COMMERCIAL AIRCRAFT
FIGURE 1

MCDONNELL DOUGLAS
CORPORATION



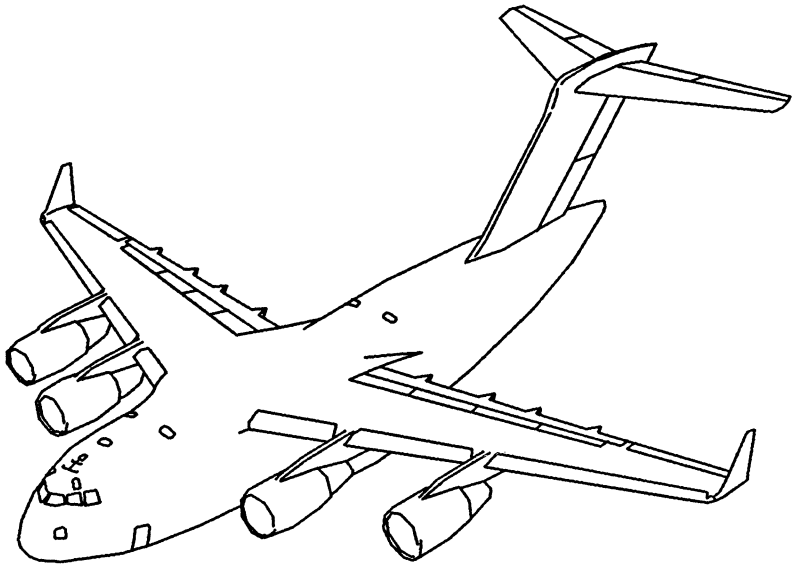
ELEVATOR CONTROL SYSTEM

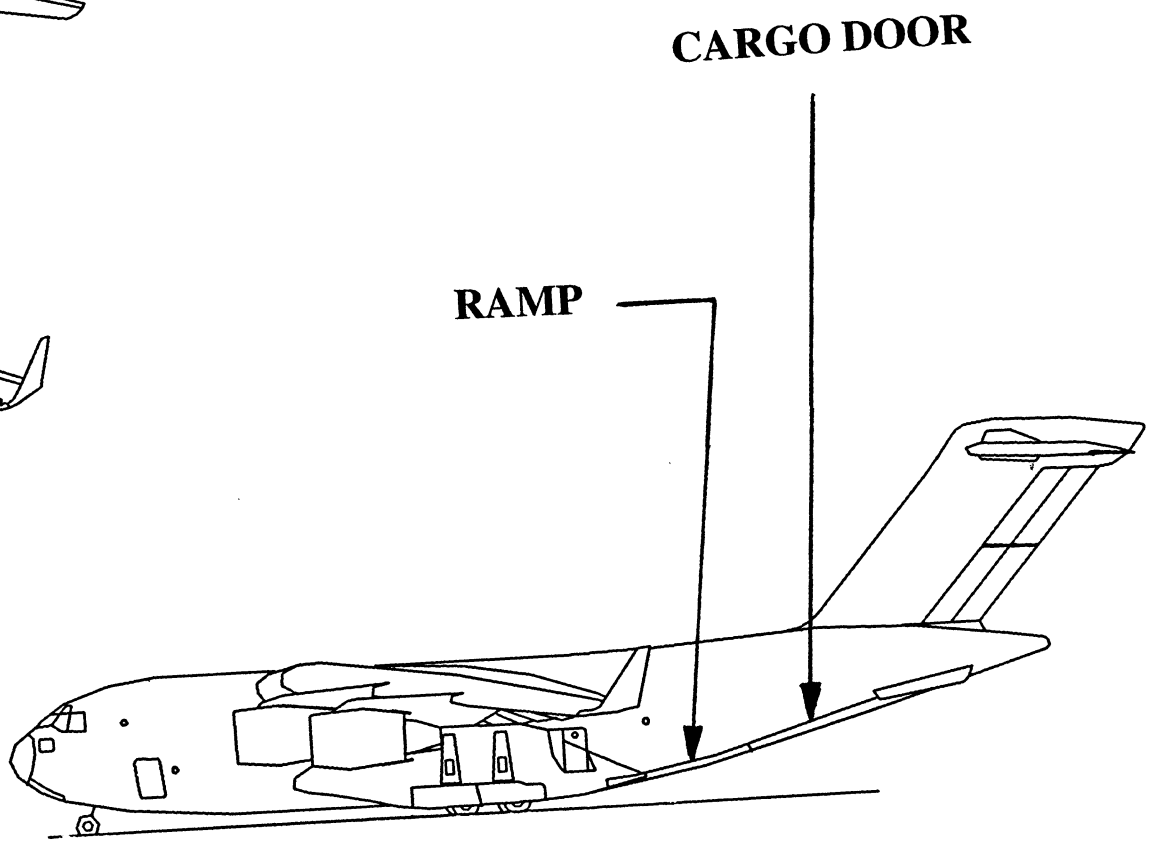
FIGURE 2

MILITARY TRANSPORT AIRCRAFT

CARGO DOOR AND RAMP

+ **PRELIMINARY CONCEPT DEVELOPMENT**
+ **DESIGN VERIFICATION**
+ **DESIGN REVIEWS**





MILITARY TRANSPORT AIRCRAFT
FIGURE 3

MCDONNELL DOUGLAS CORPORATION

CARGO DOOR INSTALLATION

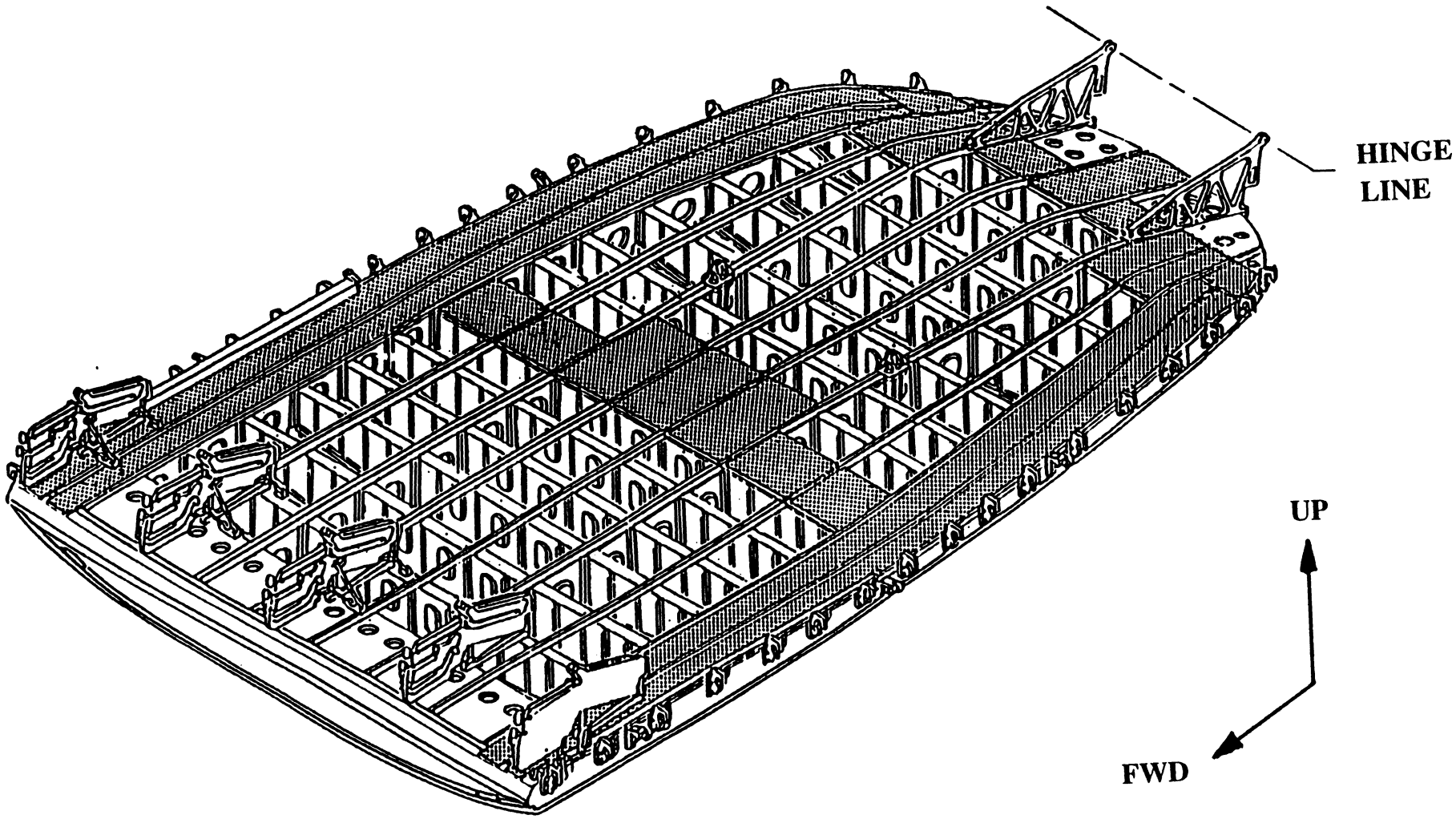


FIGURE 4

CARGO DOOR LATCH SYSTEM

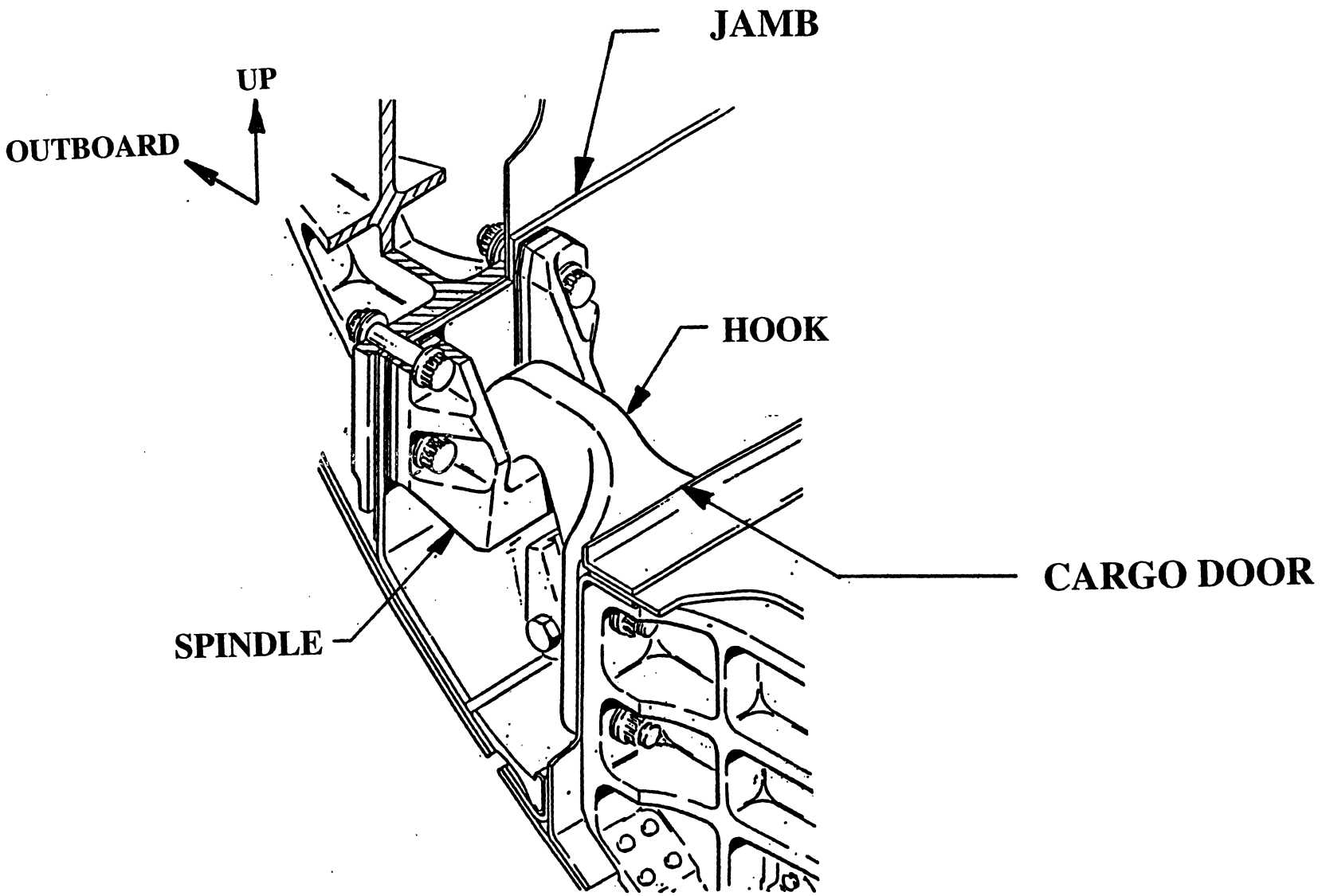


FIGURE 5

RAMP INSTALLATION

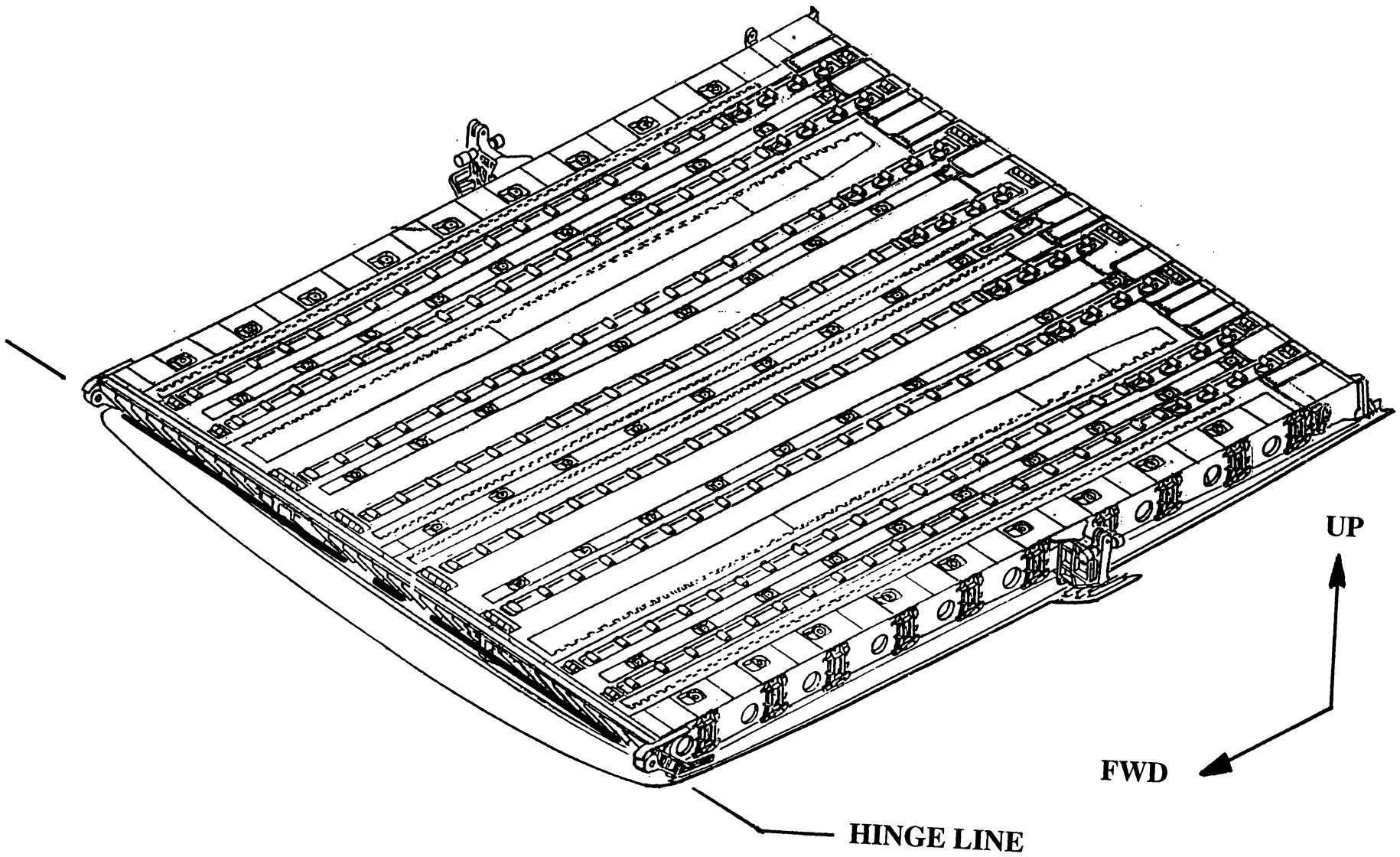


FIGURE 6

RAMP LATCH SYSTEM

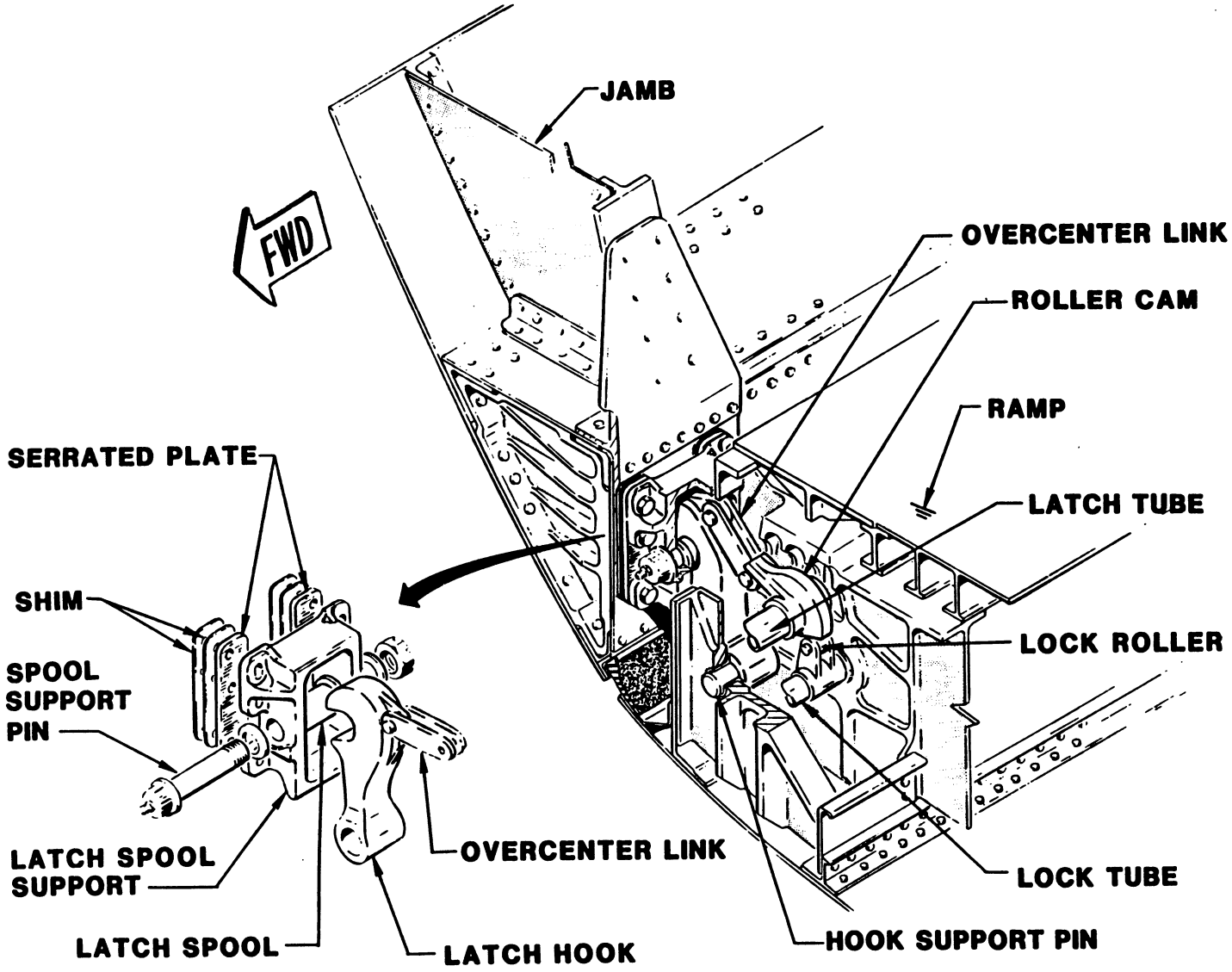
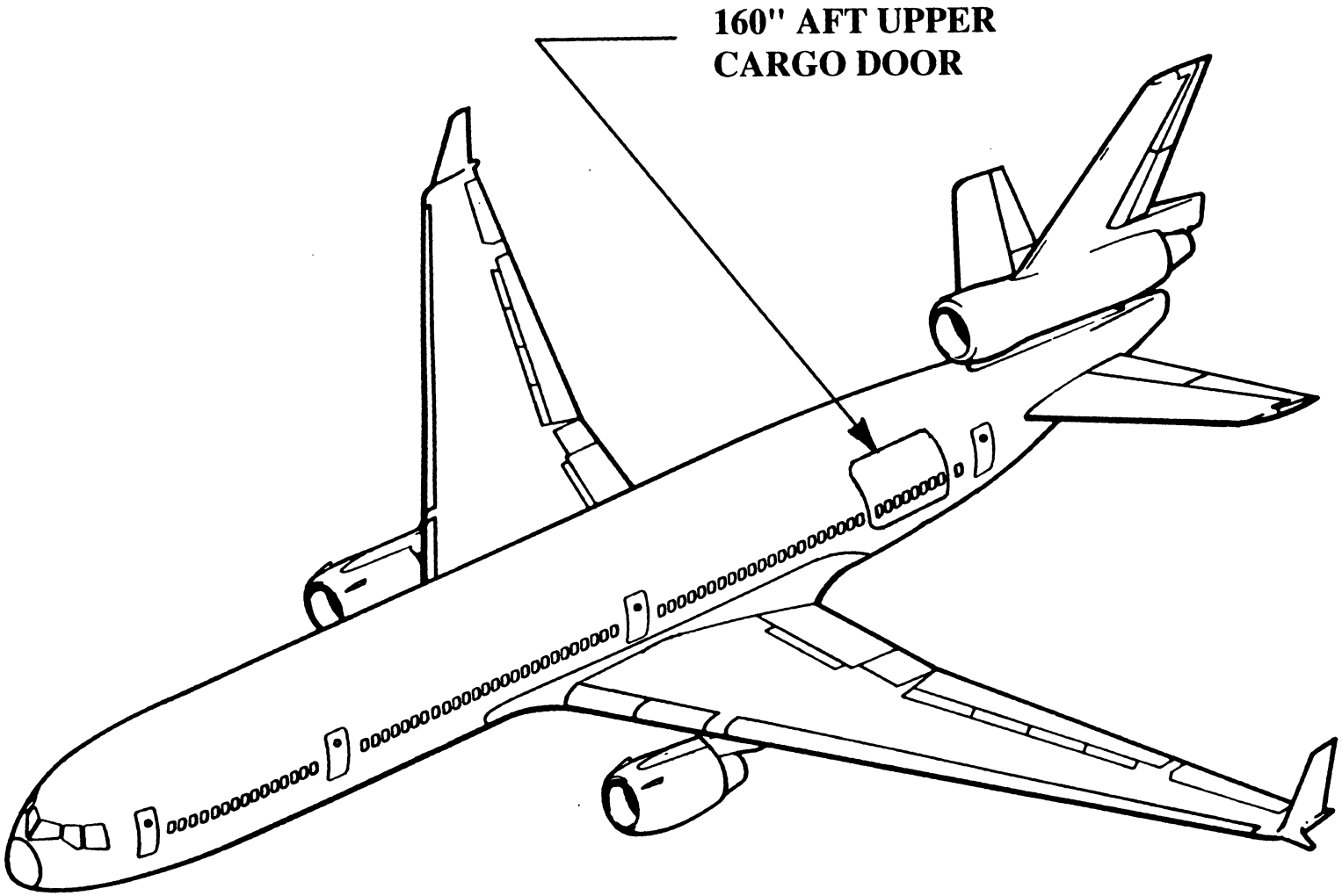


FIGURE 7

MD-11 COMBI VERSION COMMERCIAL AIRCRAFT

160 " AFT UPPER CARGO DOOR

+ PRELIMINARY CONCEPT DEVELOPMENT
+ DESIGN REFINEMENT
+ DESIGN VERIFICATION
+ DESIGN REVIEWS
+ TEST PLANNING



MD-11 COMMERCIAL AIRCRAFT

FIGURE 8

MCDONNELL DOUGLAS

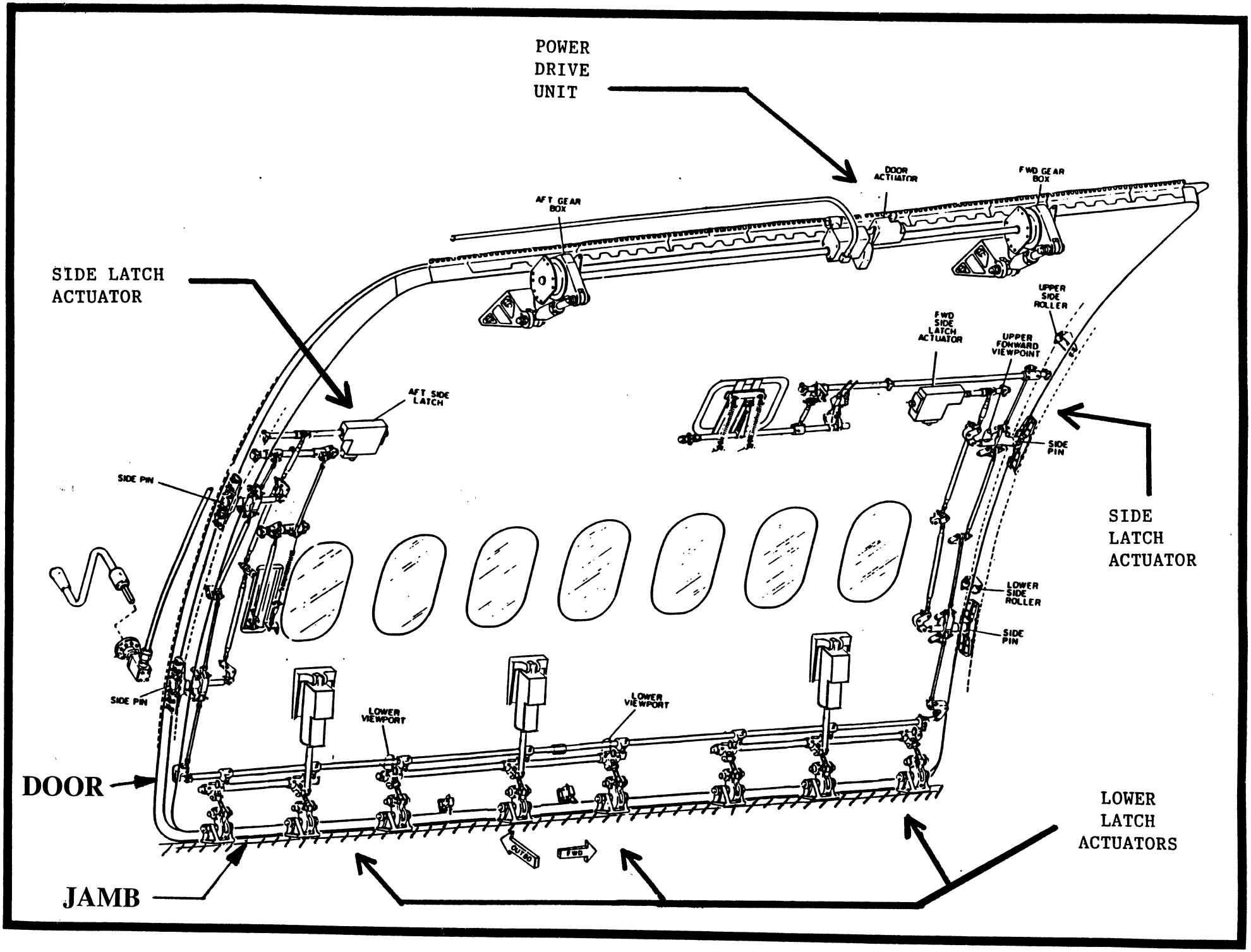

POWER
DRIVE
UNIT
SIDE LATCH
ACTUATOR
DOOR
ACTUATOR
FWD GEAR
BOX
AFT GEAR
BOX
UPPER
SIDE
ROLLER
FWD
SIDE
LATCH
ACTUATOR
UPPER
FORWARD
VIEWPOINT
AFT SIDE
LATCH
SIDE PIN
SIDE PIN
SIDE
LATCH
ACTUATOR
LOWER
SIDE
ROLLER
SIDE
PIN
SIDE PIN
LOWER
VIEWPORT
LOWER
VIEWPORT
DOOR
LOWER
LATCH
ACTUATORS
OUTBD
FWD
JAMB

FIGURE 9

MD-11
CARGO DOOR LATCH SYSTEM

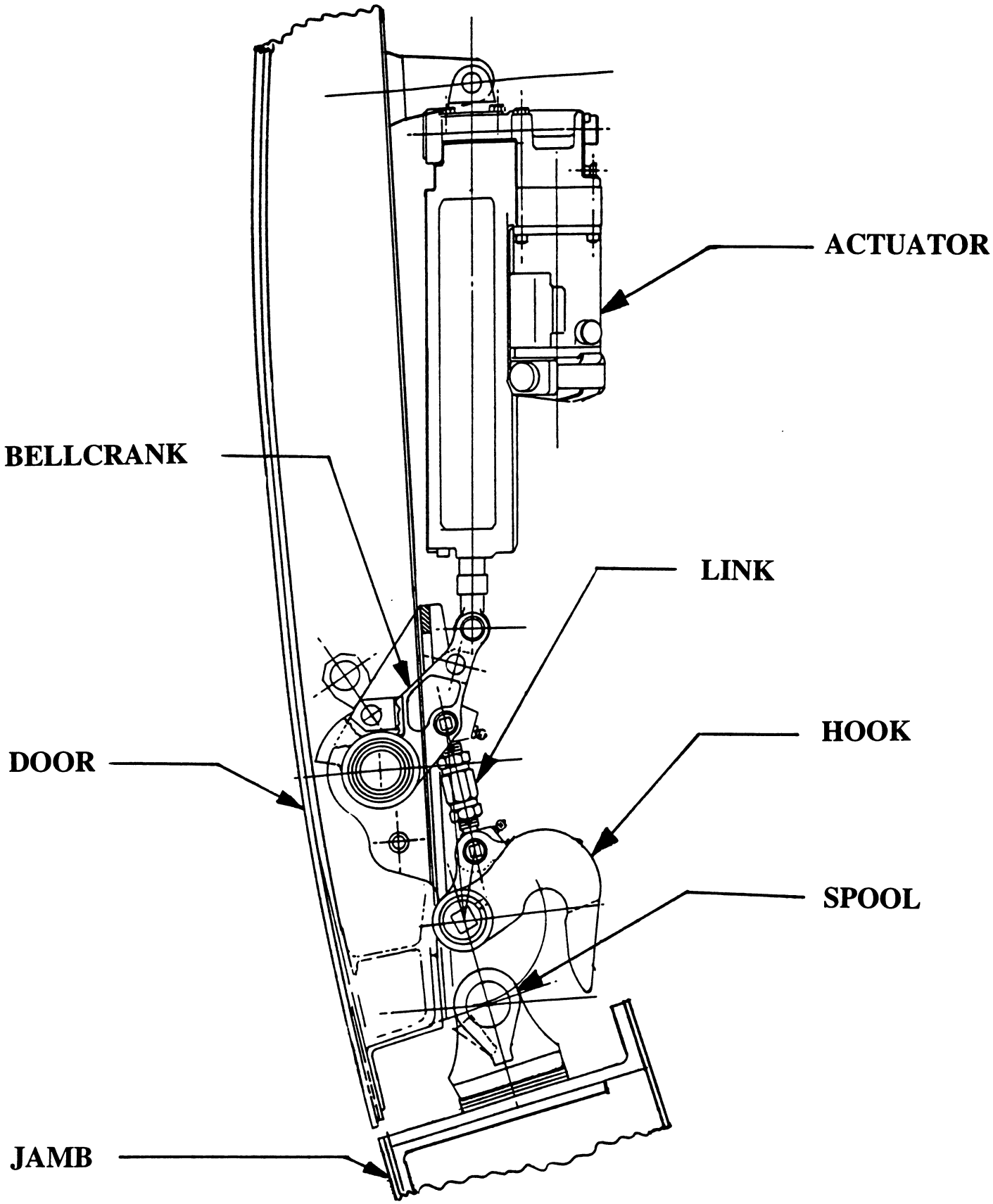


FIGURE 10

USES OF ADAMS AT DOUGLAS AIRCRAFT COMPANY

* VERIFY SYSTEM FUNCTIONALITY

* DETERMINE POWER REQUIREMENTS
  - ACTUATOR SIZING

* DESIGN SIZE AND SHAPES OF INDIVIDUAL COMPONENTS
  - LINKS
  - SPRINGS
  - BELLCRANKS
  - HOOKS

* COMPUTE INTERNAL LOADS
  - MECHANISM
  - SUPPORTING STRUCTURE

BENEFITS OF ADAMS

* COMMUNICATES DESIGN INTENT TO PEOPLE UNFAMILIAR WITH CONCEPTS AND LAYOUTS

* PRE-PRODUCTION MODELS ARE EASILY MODIFIED TO SOLVE PROBLEMS DISCOVERED DURING TESTING

* INTEGRATES PERFORMANCE ANALYSIS WITH LOADS ANALYSIS

* ELIMINATE DELAYS IN CERTIFICATION

* ELIMINATE COSTLY REDESIGNS

* PRESENT OPPORTUNITY TO SELL AIRCRAFT


MCDONNELL DOUGLAS

MD-90-30

TECHNOLOGY FOR THE 21ST CENTURY

MCDONNELL DOUGLAS

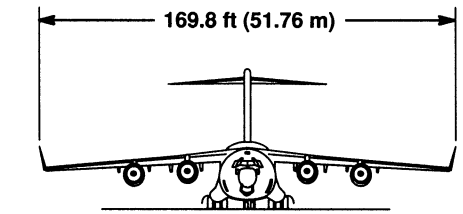
FROM REGIONAL CRISIS TO PEACEKEEPING AND HUMANITARIAN RELIEF
THE C-17, AIR MOBILITY FOR A CHANGING WORLD

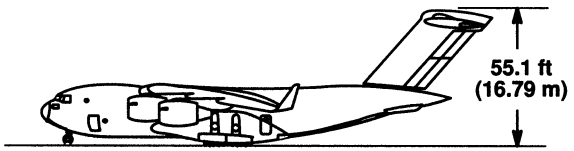
The C-17 combines the best attributes of today's airlift fleet with proven state-of-the-art technology to support our air mobility needs in a changing world. Capable of delivering outsize cargo over long distances into small austere airfields, the C-17 Globemaster III will be the cornerstone of America's global reach well into the 21st century. The C-17 will fly cargo and troops over intercontinental distances for airland or airdrop delivery. It will also provide needed humanitarian relief and aeromedical airlift, augment special operations, and move United Nations' peacekeeping forces to troubled spots throughout the globe.

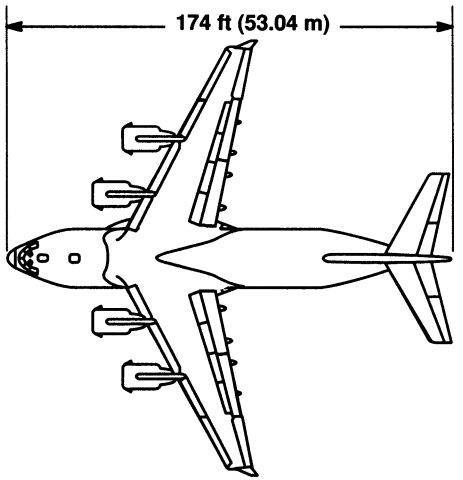
The first C-17 squadron began initial operations at Charleston Air Force Base, South Carolina, in June 1993.

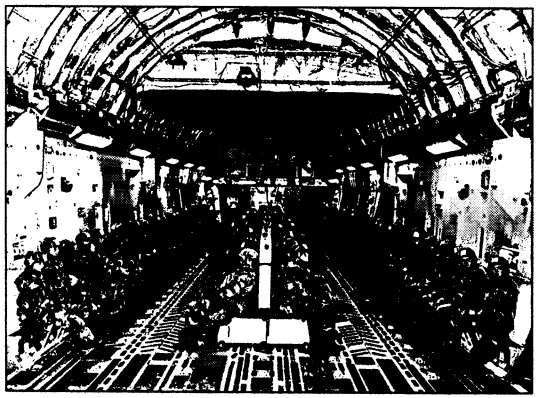
Max Takeoff Gross Weight	580,000 lb	(263,084 kg)
Max Payload	172,200 lb	(78,109 kg)
Max Fuel Capacity	182,720 lb*	(82,880 kg)
Service Ceiling	45,000 ft	(13,716 m)
Cruise Speed	0.77 Mach	
Wing Sweep	25 degrees	
Wing Area	3,800 ft^2	(353 m^2)
Engines	F117-PW-100	
Thrust Rating	40,700 lb	(181 kN)
Cargo Compartment Length	88 ft	(26.8 m)
Cargo Compartment Width	216 in	(5.48 m)
Cargo Compartment Height	148 in	(3.76 m)

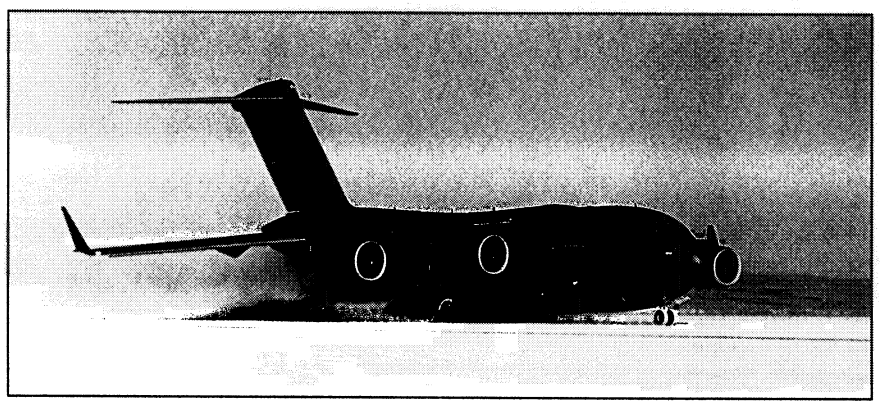
*27,110 gallons at 6.74 lb/gal (JP-8 or Jet A-1)

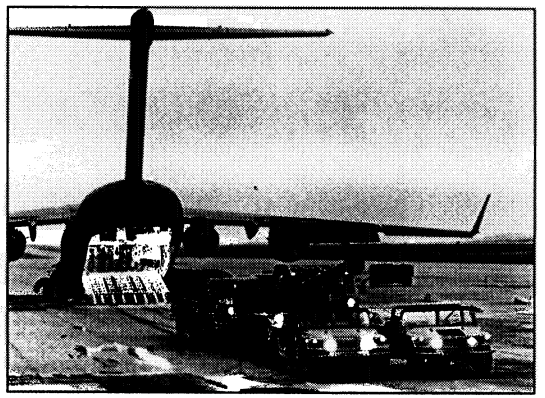












USAF / MCDONNELL DOUGLAS C-17
A NEW DIMENSION IN AIRLIFT

GC 6848-3 Printed August 1993

MD-90-30

The MD-90 series of McDonnell Douglas twin jets is a successful marriage of value-added airframe technology and the most modern power plant available from International Aero Engines. The result is a transport aircraft with the highest reliability stepping into the 21st century as the pro-environmental leader. The MD-90-30, the first of the series powered by two fuel-efficient V2500-D5 engines, continues the McDonnell Douglas product hallmarks of the highest reliability and superior durability.

The certification and in-service experience of the V2500 have demonstrated remarkable reliability, low emissions, low noise, excellent resistance to foreign object damage (FOD), bird-strikes, and water-ingestion.

The MD-90-30 interior provides two seat-rows more than the MD-80 series aircraft. The MD-90-30 continues to offer the survey-tested, passenger-preferred, 5-abreast mixed-class seating arrangement. Features include vacuum lavatories, larger and lighted overhead stowage racks, and a lighted full-grip handrail that illuminates seat-row placards.

The MD-90-30 features cost-effective cockpit technology to meet today's challenging operational requirements with the highest reliability. MD-90-30 pilots will operate:

- Electronic Flight Instrument System (EFIS)
- A Full Flight Management System (FMS)
- State-of-the-Art Inertial Reference System (IRS)
- LED Displays for Engine and System Monitoring

Avionic systems design philosophy keeps the pilot in direct control of the flight guidance systems and the aircraft.

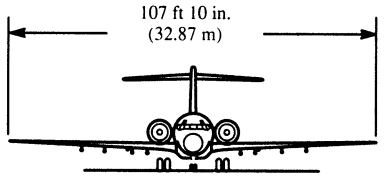
The MD-90-30 will provide unmatched high altitude performance and superior short-field and high altitude takeoff performance capability.

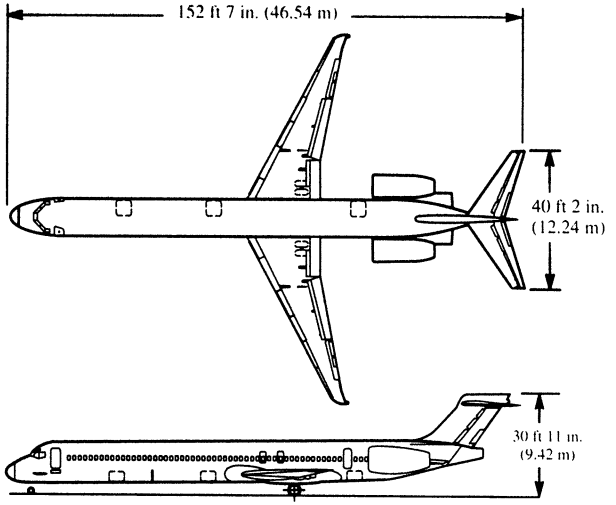
The MD-90-30 series aircraft sums the value of technology, pro-environment attributes, passenger comfort, superior performance, reliability, and maintainability to reward the operator with a more profitable bottom line.

MD-90 TECHNOLOGY FOR THE 21ST CENTURY

MD-90-30 SIZE COMPARISON

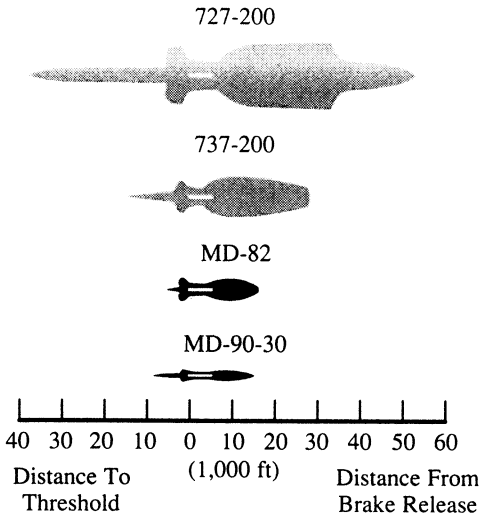
Engine	IAE V2500-D5
Thrust (lb)	25,000
MTOGW (lb)	156,000
Range (st mi)	2,610
Seats (Mixed Class)	153
(Single Class)	172



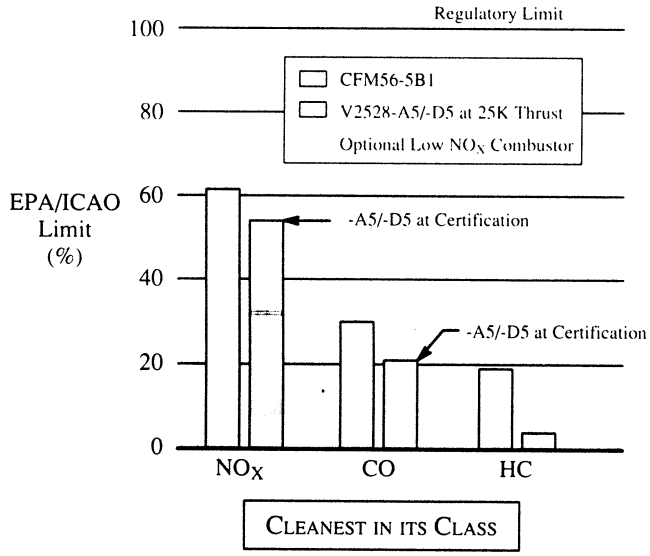


PRO-ENVIRONMENT

95 EPNdB Noise Contour Comparison
1,000-Nautical-Mile Stage Length



MD-90 Leads Industry in Reduced Emissions



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