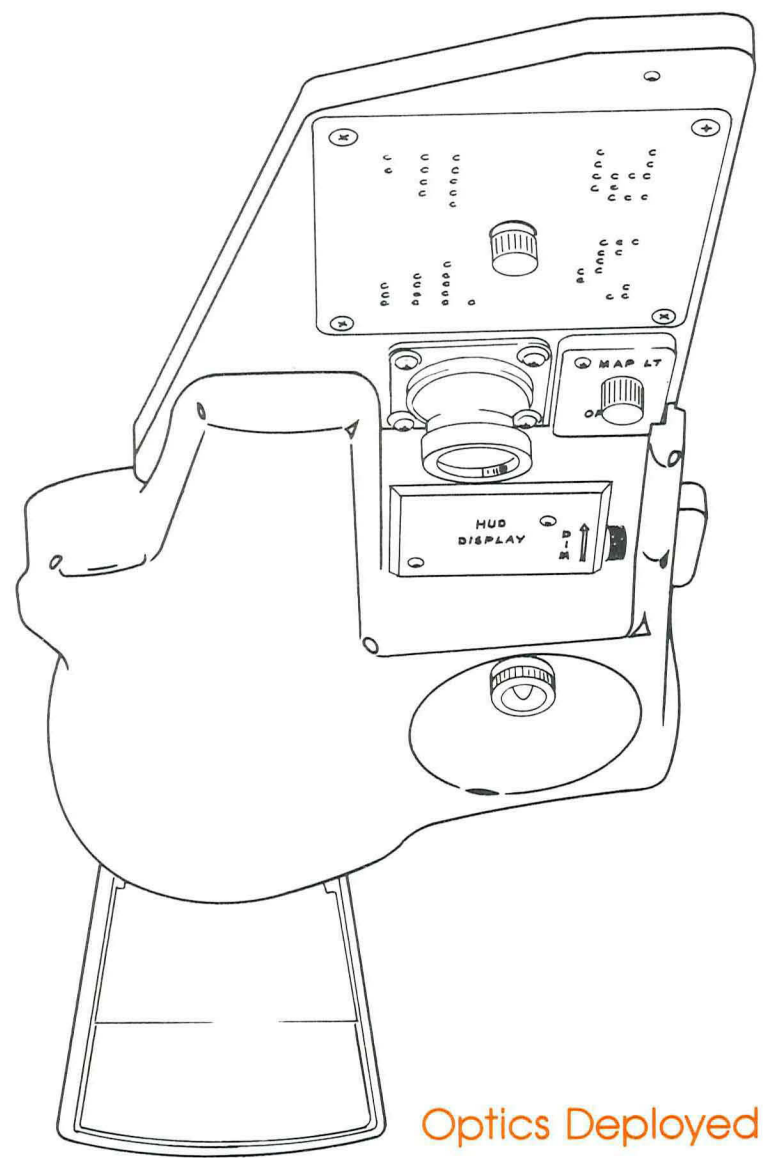# SUNDSTRAND DATA CONTROL
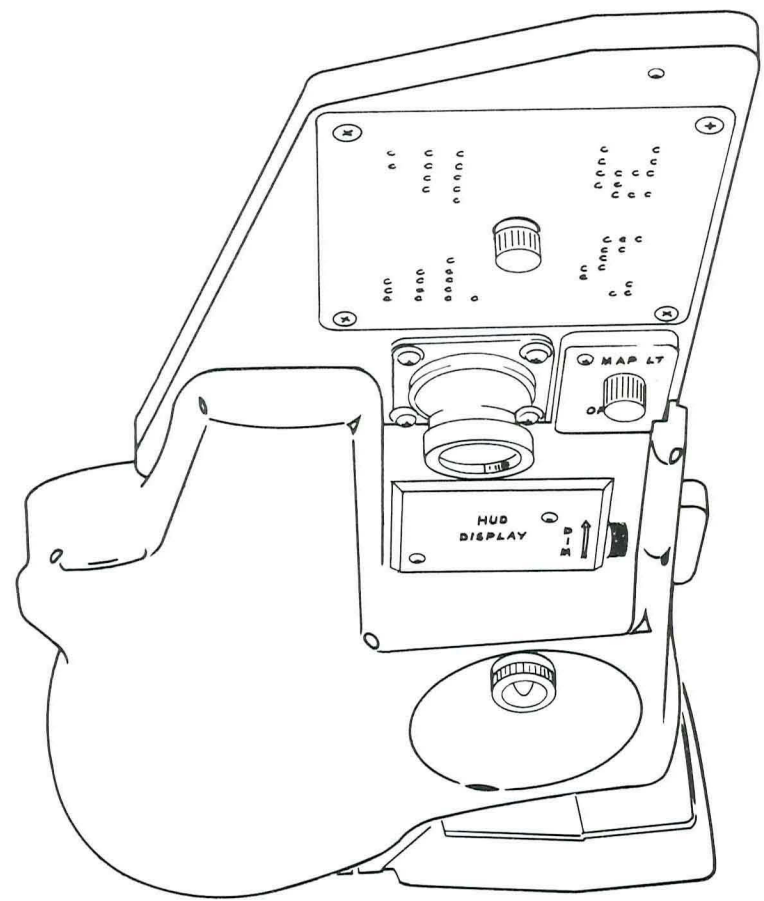
# HEAD UP DISPLAY SYSTEM

for DC-9 Super 80

Optics Deployed

Optics Stowed

Sundstrand Data Control Advanced Technology Head Up Display

- Sundstrand/Douglas Aircraft Joint Development Program Began in Early 1977.

- First U.S. Sponsored Production CRT HUD Program for Transport Category Aircraft.

- HUD System Comprises Sundstrand Developed Hardware and Software; Douglas Developed Control Laws and Symbology.

- Designed for VFR and IFR Operation and Targeted for Certification to CAT IIIa Limits.
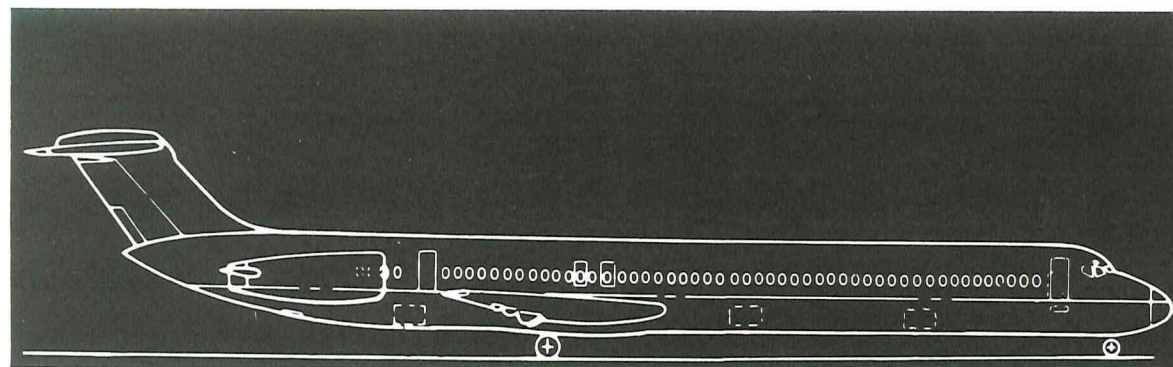
INTRODUCTION

PROGRAM

FUNCTIONS

DESCRIPTION

FEATURES

SYMBOLOGY

INTERFACE

EXPERIENCE & PRODUCT SUPPORT

SUMMARY

Program Milestones

Milestone	Date
HUD AWARD	MAR. 78
INTERIM SIMUL. UNIT	NOV. 78
CONTROL LAW & SYMBOL DEVEL.	MAR. 79
DEVEL. LAB UNITS	JUN./AUG. 79
PRE-PROD. UNITS	OCT./NOV. 79
CERTIFICATION PROGRAM	OCT. 79/JUN 80
PRODUCTION UNITS	BEGIN JAN. 80

78   79   80

DC-9-80
HUD Functions
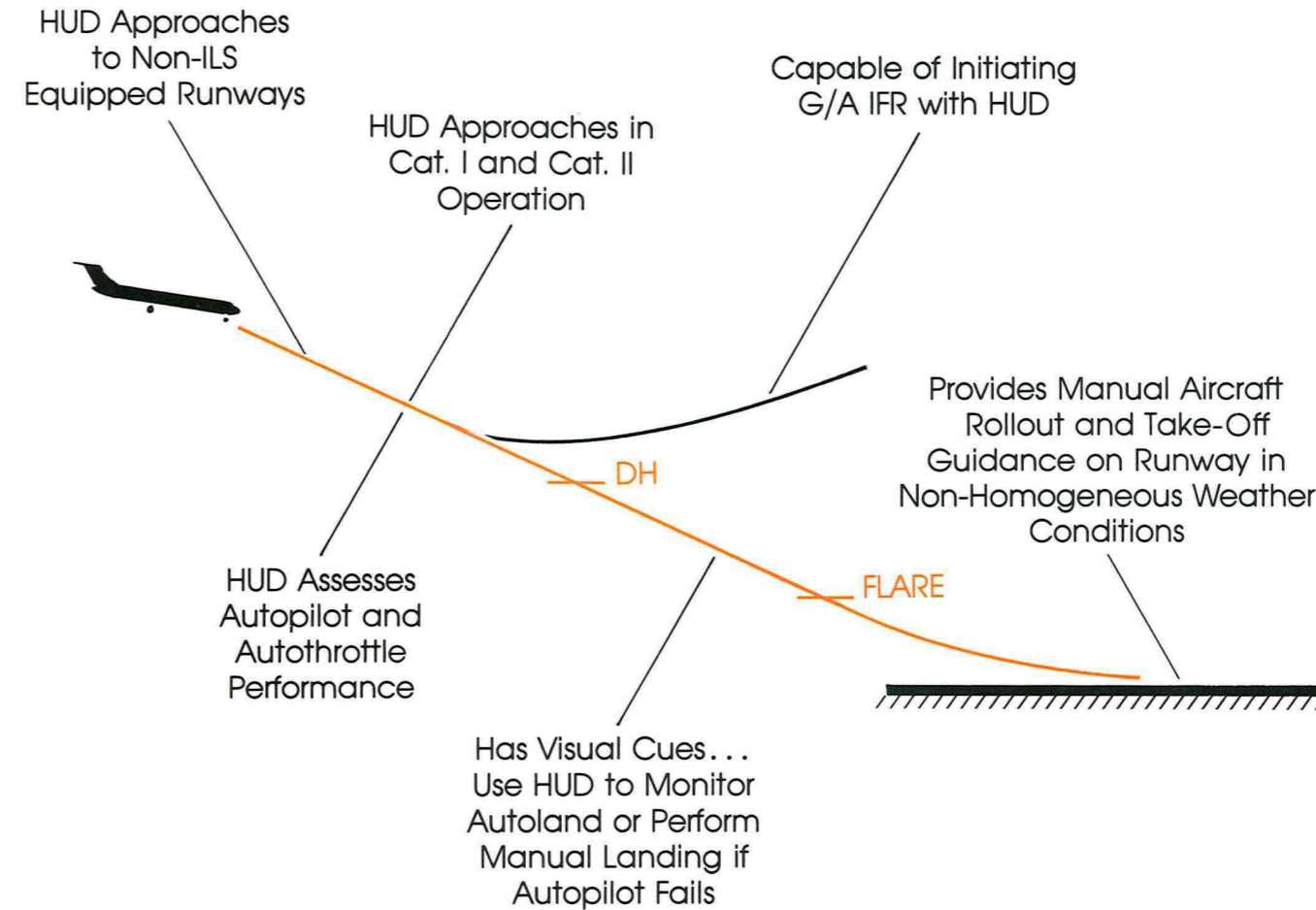
Functions

- Manual Approach to Non-ILS Runway—Visual Control to Touchdown

- Monitor of Cat. I, II, IIIA Auto Coupled Approach, with reversion to HUD, with Visual Cues to Touchdown

- Manual Approach to ILS Runways, Cat. I or II Limits, Continuing to Touchdown with Visual Cues Below DH

- Landing Rollout

- Take-Off Roll & Take-Off

- Missed Approach (Go-Around)

HUD Approaches to Non-ILS Equipped Runways

HUD Approaches in Cat. I and Cat. II Operation

Capable of Initiating G/A IFR with HUD

Provides Manual Aircraft Rollout and Take-Off Guidance on Runway in Non-Homogeneous Weather Conditions

DH

FLARE

HUD Assesses Autopilot and Autothrottle Performance

Has Visual Cues... Use HUD to Monitor Autoland or Perform Manual Landing if Autopilot Fails

Operational Modes

Take-off/Go-around

- Take-Off Roll — Provides Lateral Guidance Through Localizer Deviation and Course Error, Plus Airspeed

- Rotation — Provides Lateral Guidance Through Magnetic Heading and Vertical Guidance Through Pitch Attitude, Plus Airspeed

- Climb Out — Provides Attitude Information in Pitch, Roll and Heading, Plus Altitude, Airspeed and TO/GA Command

- Go-Around — Provides Attitude Information in Pitch, Roll and Heading, Plus Altitude, Airspeed and TO/GA Command

Approach/Landing

- Above DH — Lateral Guidance Through Localizer Deviation and Course Error, Flight Path Guidance Through Glideslope Deviation, and Pitch, Roll and Yaw Attitude Plus Airspeed and Altitude.

- DH to FH — As Above Plus DH Message and Flare Indication

- FH to TD — As Above Plus Safe Roll Limits

- Rollout — Lateral Guidance Through Localizer Deviation and Course Error

Pilot Display Unit (PDU) side view
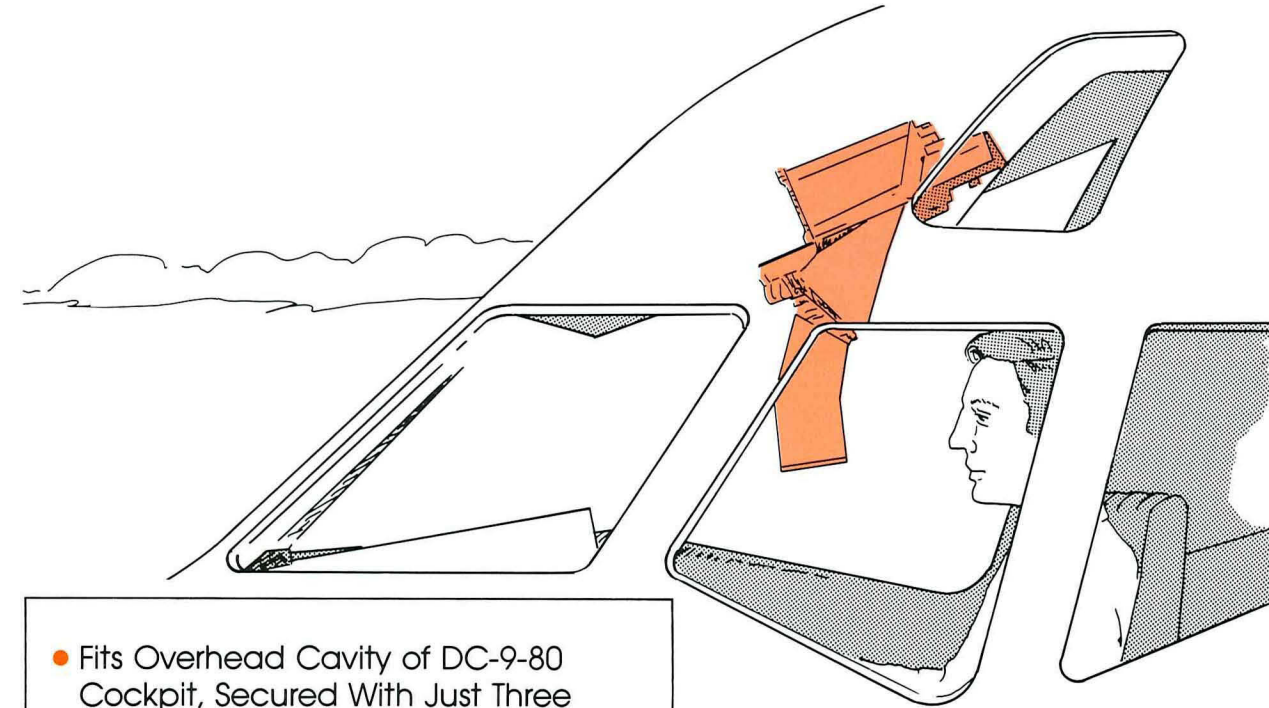
- Fits Overhead Cavity of DC-9-80 Cockpit, Secured With Just Three Fasteners

- Minimal Aircraft Modification for HUD Installation

- Remove and Replace in Ten Minutes

- Automatic Boresight Calibration

- Optics Stow Out of View When Not in Use

Pilot Display Unit (PDU)
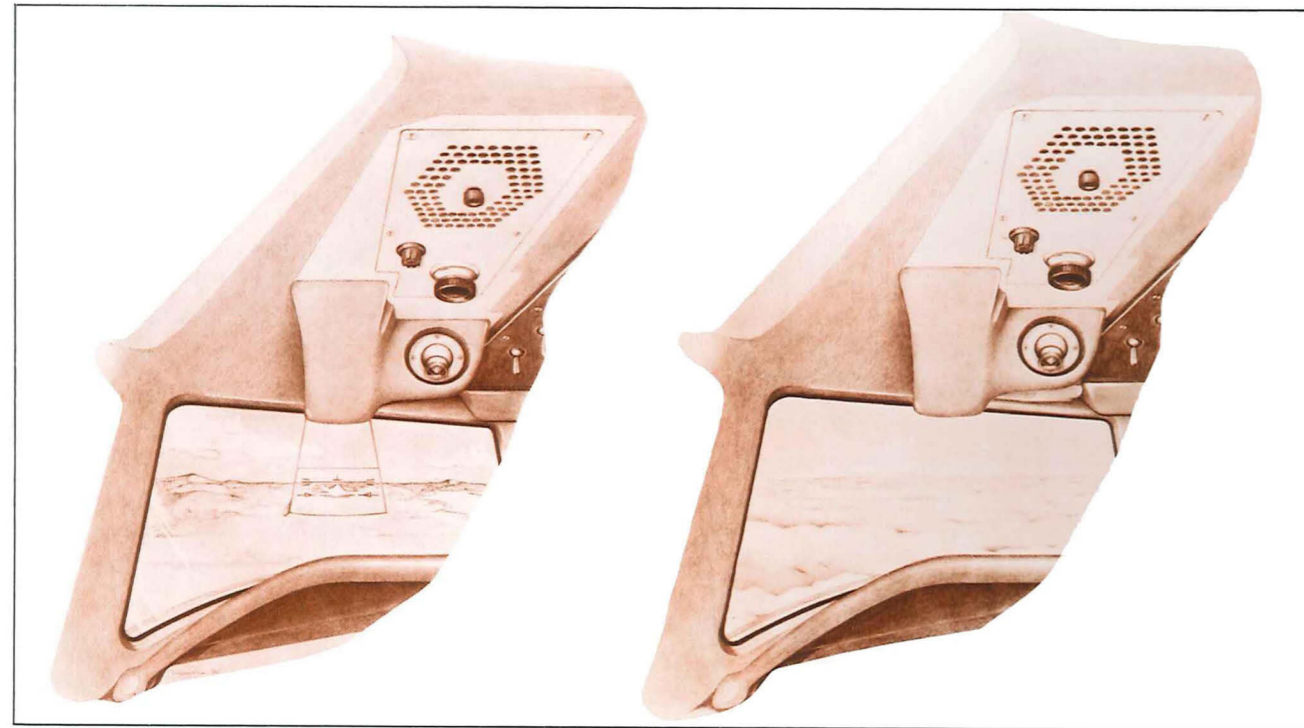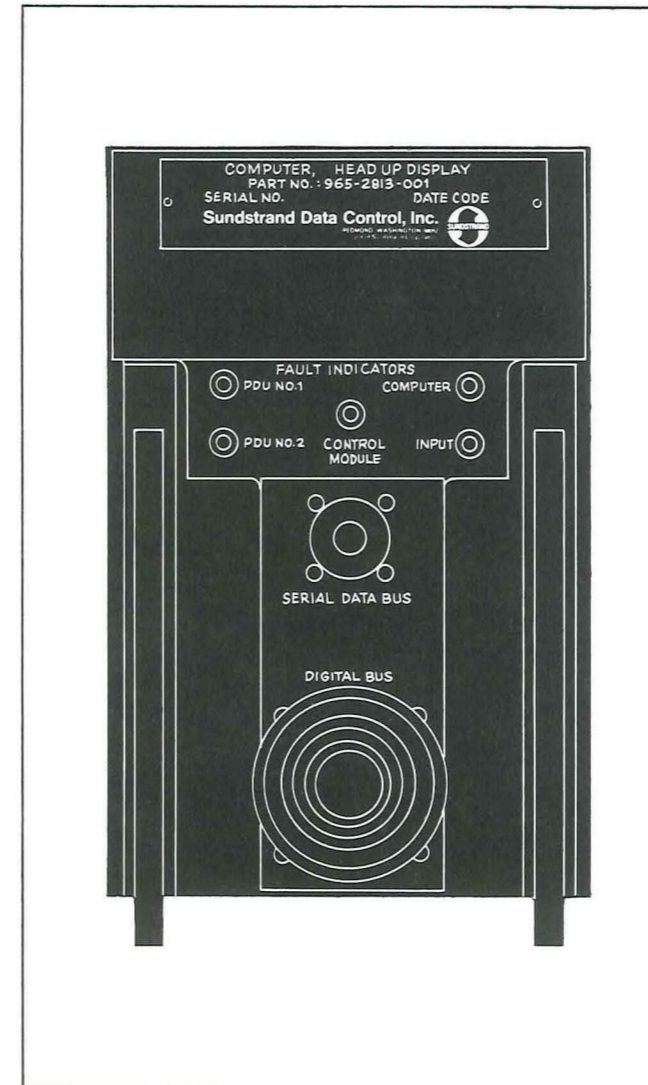

Optics Deployed

Optics Stowed

- Integrated Package Includes Optics, CRT, CRT Drive Electronics, Brightness Control, Speaker, Map Light and Air Outlet

- Design Assures Both Pilots Unobstructed Field of View, When Stowed or Deployed

Display Digital Computer Unit (DDCU)

- Contained in 1/2 ATR Enclosure

- Located in the Avionics Equipment Rack

- Interfaces with Aircraft Sensors and Other Avionics Equipment

- Provides All Control Law and Symbol Generation Computation as well as Comprehensive Auto Self-Monitoring Capability

COMPUTER, HEAD UP DISPLAY
PART NO.: 965-2813-001
SERIAL NO.   DATE CODE
Sundstrand Data Control, Inc.

FAULT INDICATORS
PDU NO.1   COMPUTER
PDU NO.2   CONTROL   INPUT
            MODULE

SERIAL DATA BUS

DIGITAL BUS

Pilot Control Module (PCM)

- Located in Center Pedestal

- Provides Pilot Selection of Desired Flight Path Angle and Readout

- Provides System Self-Test and Approach Mode Reset

System General Block Diagram

PDU-DEFL. VOLT & VERTICALITY FEEDBACK

POWER VOLTAGE FEEDBACK

PILOT CONTROL MODULE

POWER SUPPLY → POWER DISTRIBUTION

AIRCRAFT INPUT

D.C. ANALOG

SYNCHRO

SIGNAL CONDITION

SIGNAL CONDITION

ANALOG MUX

A-D CONVERT

CENTRAL PROCESSOR UNIT

PROGRAM MEMORY

RANDOM ACCESS MEMORY

SERIAL DATA BUS

COMPUTER BUS

CONTROL BUS STRUCTURE

DIGITAL

BUFFER-COMPARATOR

BINARY MUX

FAIL-SAFE VALIDITY

DISCRETE

SIGNAL CONDITION

SYMBOL GENERATOR
- SEQUENCE CONTROL
- SYMBOL MEMORY
- D-A CONVERSION

X, Y

Z

STOWING MECHANISM

A_L

OPTIC & TEST RETICLE

Display Digital Computer Unit

Pilot Display Unit

Pilot Display Unit

- Stowable, Integrated, Compact, Modular, Overhead Installation Design

- Auto Calibration and Stabilization

- Innovative Optical Design with Safety Breakaway Feature

- Auto Contrast Control

- Comprehensive Manual Self-Test by Push Button

- Quick Removal & Replacement
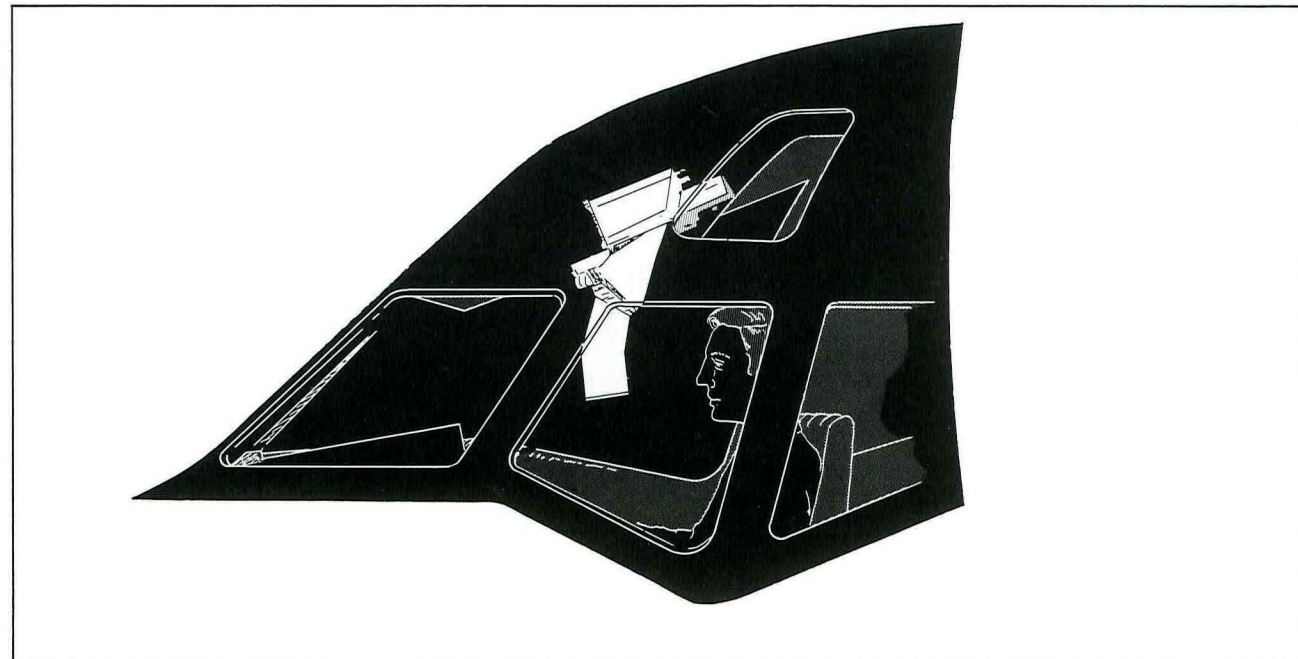
Display Digital Computer Unit

- High Speed 16-Bit Bi-Polar, Bit-Slice, 4 mHz Clock
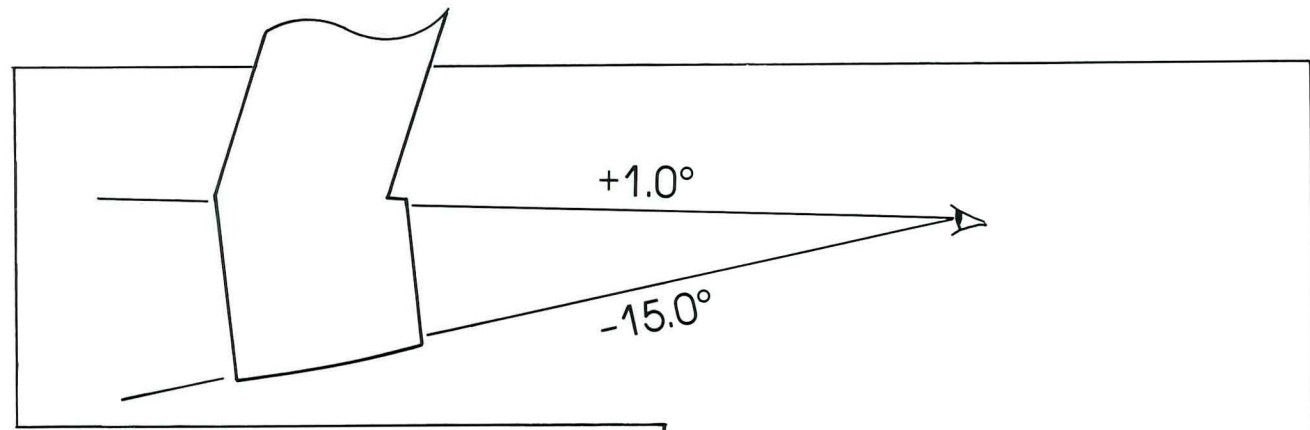
- Memory 60 ns Bi-Polar ROM & RAM

- Addressing Capability of 65K

- 140 Instructions, Microprogrammed

- Qualified to RTCA DO-160

- Automatic Built-in Test Verifies Proper System Operation Every 60 m Sec.

- Manual Self-Test Allows Pilot to Check Symbology and Optics on Ground or In flight
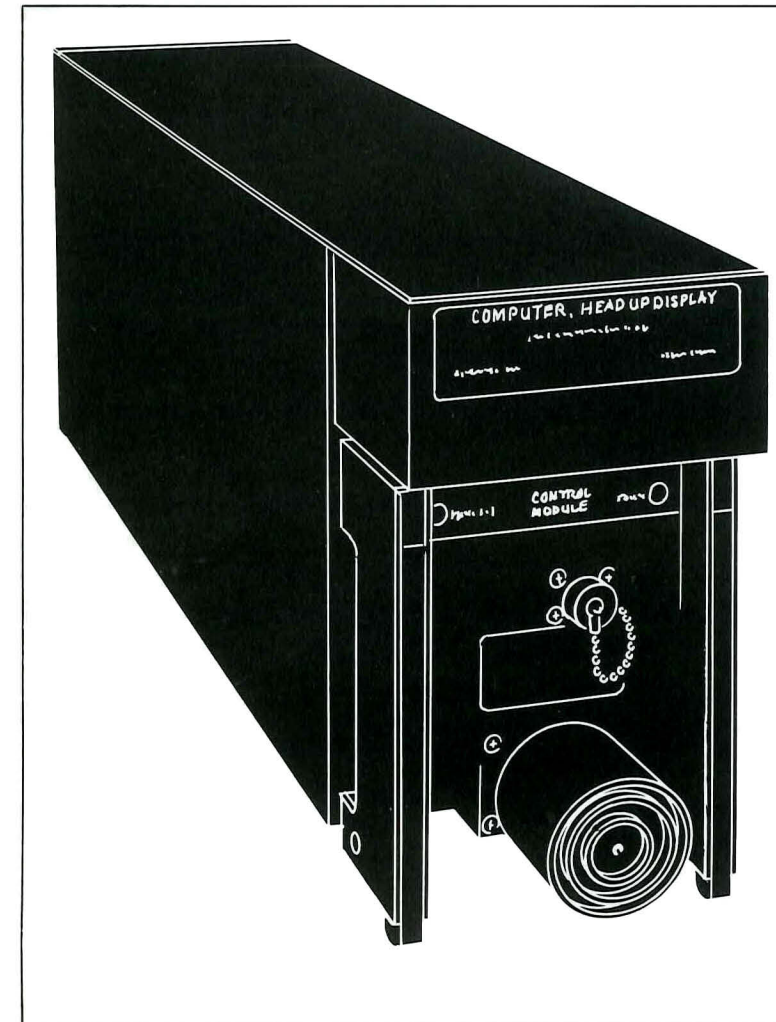
FEATURES

SYMBOLOGY

INTERFACE

EXPERIENCE & PRODUCT SUPPORT

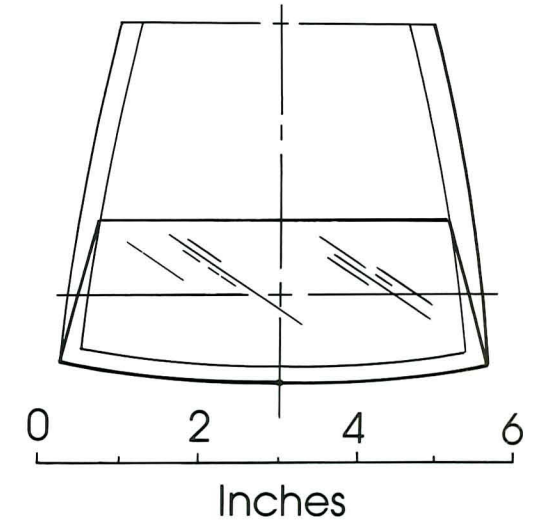**SUMMARY**

Optics
Field of View

Vertical
16 Degrees Instantaneous[1]
26 Degrees Total with Head Movement[1]

Lateral
13.4 Degrees Instantaneous Binocular[1]
30.0 Degrees Instantaneous Total[2]

[1]Limited by Optics
[2]Limited by CRT Display

Symbology

Symbols presented to the pilot are electronically generated by a programmable digital implementation. All symbols used are continuously computed, position updated and electronically projected to the face of the cathode ray tube, then in turn, through use of an immersed optics system, they are presented to the pilot. This information is superimposed in the pilot's forward field of view. Although all symbols are continuously written, only those symbols applicable to the current mode of operation are visible, all others are blanked.
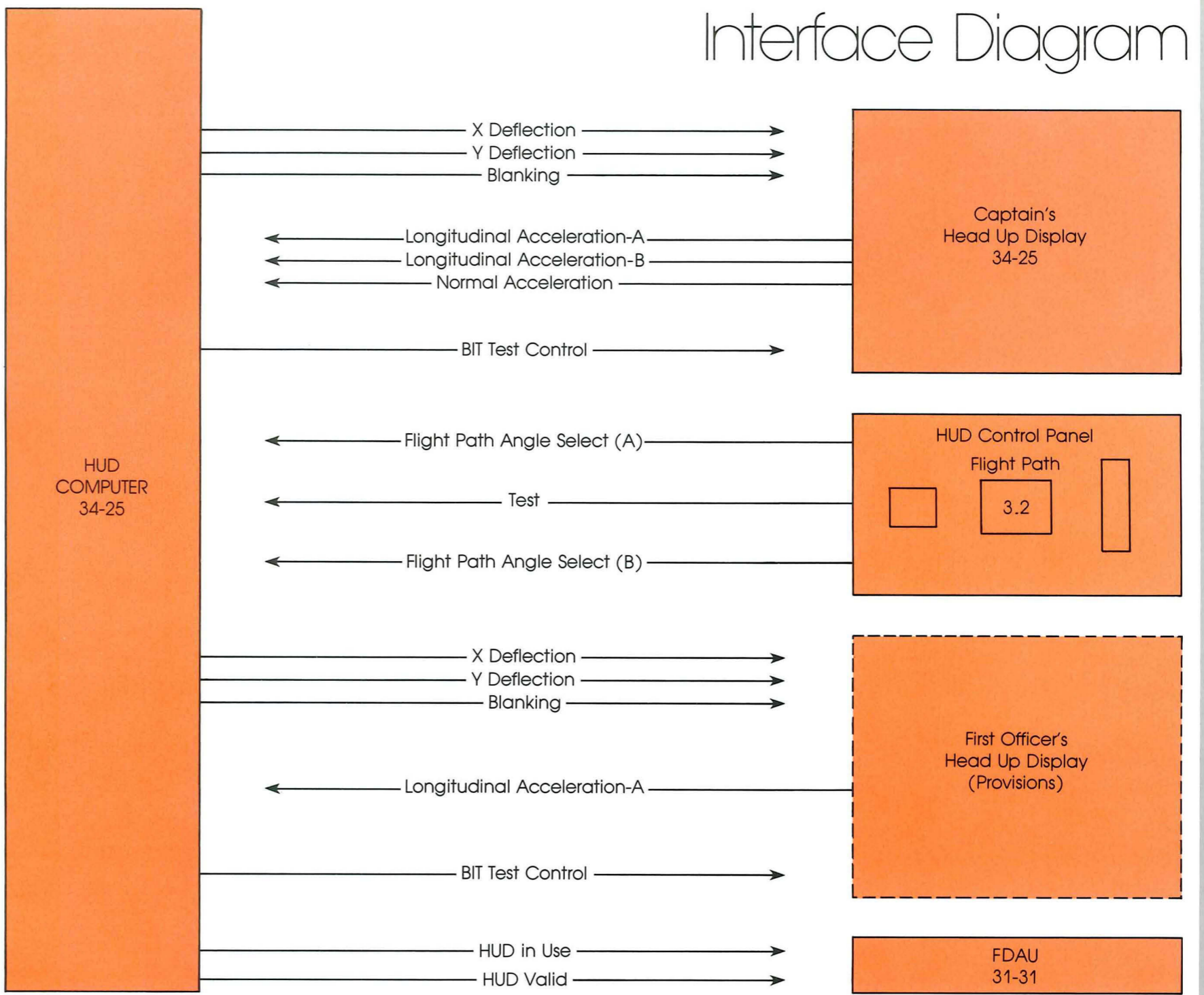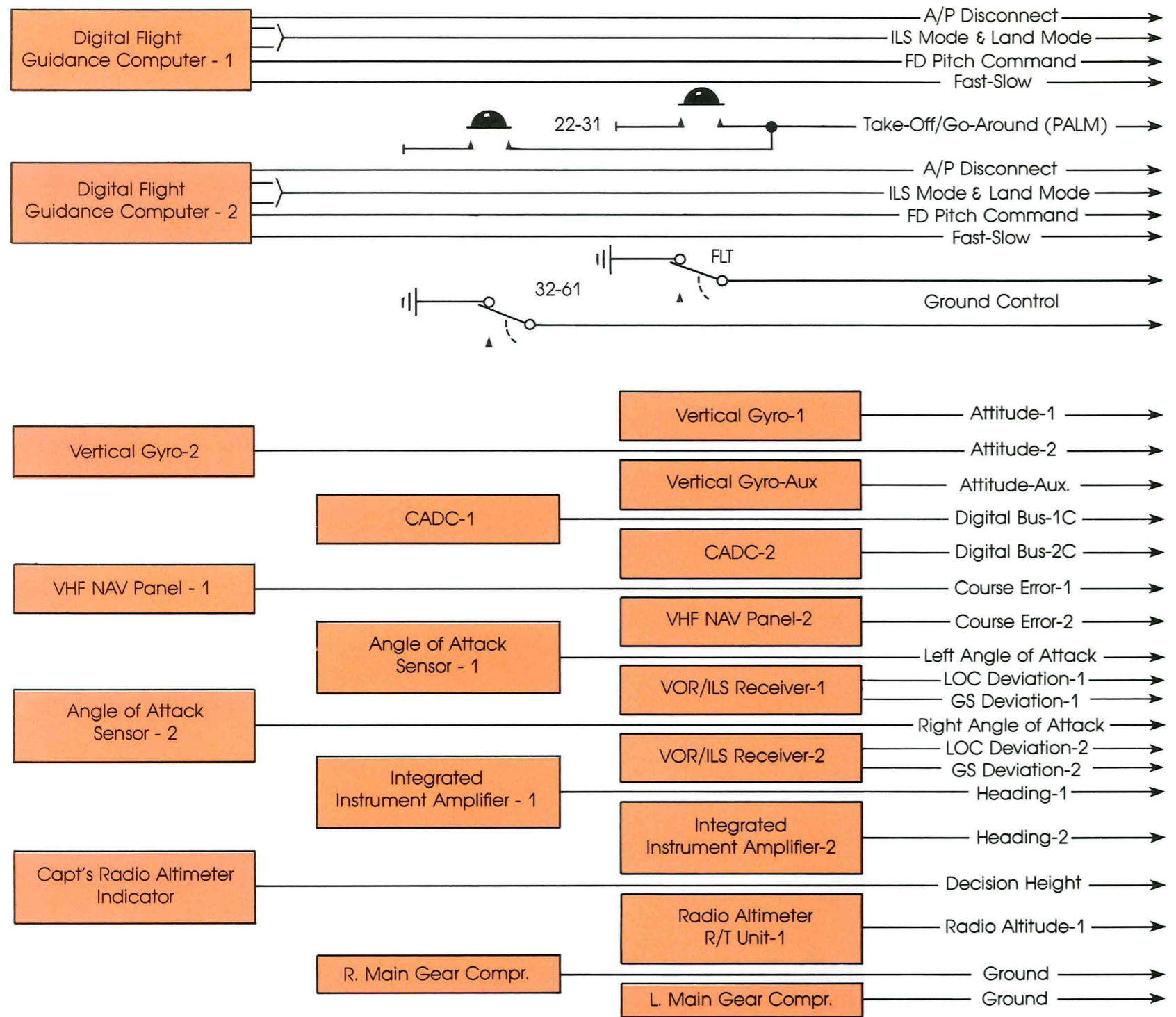
● Horizon Line	Artificial horizon coincident with earth horizon
● Pitch Reference	Fixed reference represents airplane fuselage reference line
● Course Error Marker	Shows airplane deviation from selected course
● Airplane Symbol	Indicates airplane position or flight path relative to "real world"
● Lubber Line	Represents airplane heading attitude (part of horizon line)
● Aim Dot	Indicates position or direction of desired flight path
● Fast/Slow Bar	Indicates airspeed deviation from reference speed
● Safe Roll Limits	Shows envelope of safe roll attitude for touchdown
● Pitch Ladder	Provides a quantitative pitch attitude scale
● Airspeed	Presents computed airspeed in numeric digital readout
● Altitude	Presents radio altitude in numeric digital readout
● CAT II Window	Represents allowable limits on glideslope & localizer deviation (raw data)
● Runway Edge Lines	Overlay edges of "real world" runway 150 feet wide, 11,000 feet long
● Runway Inner Lines	Represents allowable excursions of airplane on runway
● DH Message	Indicates that decision height has been reached
● Takeover Message	Indicates autopilot has disconnected—manual control required
● TO/GA Message	Indicates Take-Off/Go-Around mode

Interface Diagram

Digital Flight Guidance Computer - 1
- A/P Disconnect →
- ILS Mode & Land Mode →
- FD Pitch Command →
- Fast-Slow →

22-31 → Take-Off/Go-Around (PALM) →

Digital Flight Guidance Computer - 2
- A/P Disconnect →
- ILS Mode & Land Mode →
- FD Pitch Command →
- Fast-Slow →

FLT
32-61 → Ground Control →

Vertical Gyro-1 → Attitude-1 →
Vertical Gyro-2 → Attitude-2 →
Vertical Gyro-Aux → Attitude-Aux. →
CADC-1 → Digital Bus-1C →
CADC-2 → Digital Bus-2C →
VHF NAV Panel - 1 → Course Error-1 →
VHF NAV Panel-2 → Course Error-2 →
Angle of Attack Sensor - 1 → Left Angle of Attack →
VOR/ILS Receiver-1 → LOC Deviation-1 →
GS Deviation-1 →
Angle of Attack Sensor - 2 → Right Angle of Attack →
VOR/ILS Receiver-2 → LOC Deviation-2 →
GS Deviation-2 →
Integrated Instrument Amplifier - 1 → Heading-1 →
Integrated Instrument Amplifier-2 → Heading-2 →
Capt's Radio Altimeter Indicator → Decision Height →
Radio Altimeter R/T Unit-1 → Radio Altitude-1 →
R. Main Gear Compr. → Ground →
L. Main Gear Compr. → Ground →

HUD COMPUTER 34-25

- X Deflection →
- Y Deflection →
- Blanking →
- Longitudinal Acceleration-A ←
- Longitudinal Acceleration-B ←
- Normal Acceleration ←
- BIT Test Control →

Captain's Head Up Display 34-25

- Flight Path Angle Select (A) ←
- Test ←
- Flight Path Angle Select (B) ←

HUD Control Panel
Flight Path
3.2

- X Deflection →
- Y Deflection →
- Blanking →
- Longitudinal Acceleration-A ←
- BIT Test Control →

First Officer's Head Up Display (Provisions)

- HUD in Use →
- HUD Valid →

FDAU 31-31

HUD Programs Accomplished
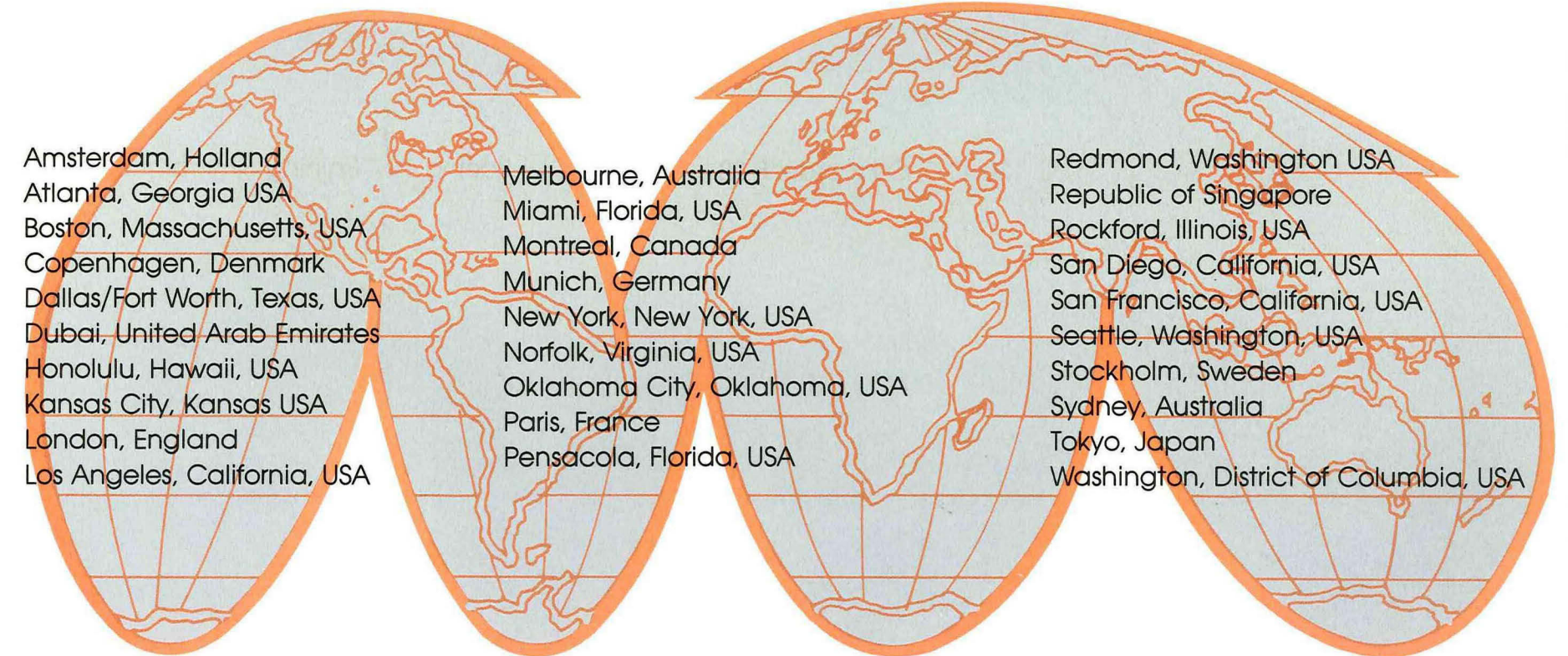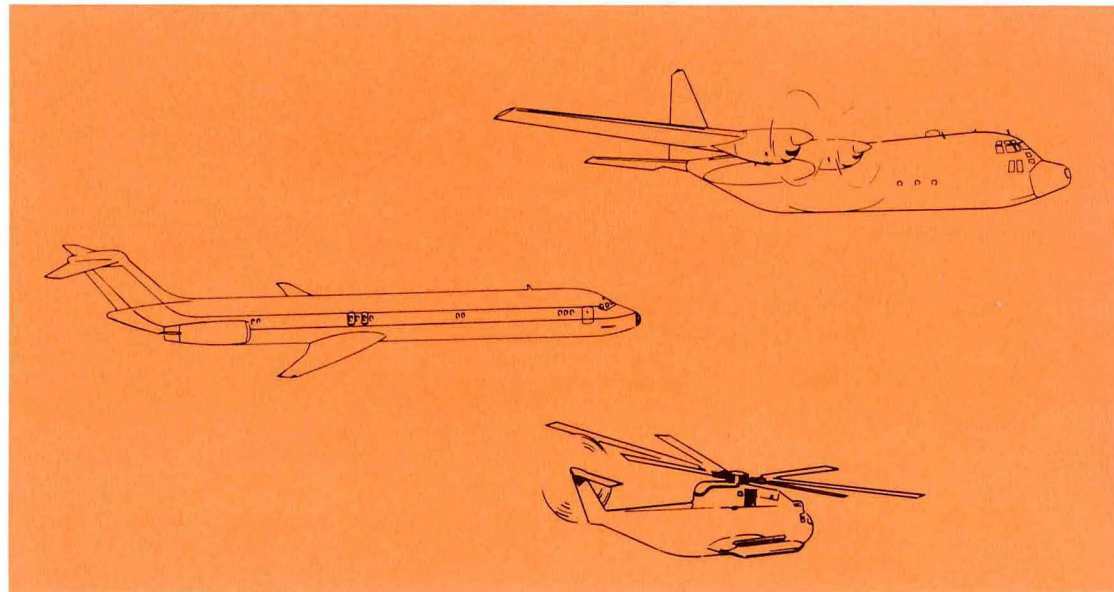
Electromechanical

- Installations and Evaluation:
  - 747, 737, 727, DC-8
  - C-130, C-5, Concorde, F-28
  - Trident, YC-15, YC-14, T-38

- Production Applications:
  - PWA 737, 727, L-382
  - HS Trident (PRC)
  - USAF C-130, CH-3
  - British Airways 737

Electronic (CRT)

- Installations and Evaluation:
  - Boeing ACS/C-14 Simulator
  - Boeing 727 Training Simulator and Test A/C (Program in Progress)

- Production Applications:
  - McDonnell Douglas DC-9-80 (Program in Progress)

Worldwide Product Support

Amsterdam, Holland
Atlanta, Georgia USA
Boston, Massachusetts, USA
Copenhagen, Denmark
Dallas/Fort Worth, Texas, USA
Dubai, United Arab Emirates
Honolulu, Hawaii, USA
Kansas City, Kansas USA
London, England
Los Angeles, California, USA

Melbourne, Australia
Miami, Florida, USA
Montreal, Canada
Munich, Germany
New York, New York, USA
Norfolk, Virginia, USA
Oklahoma City, Oklahoma, USA
Paris, France
Pensacola, Florida, USA

Redmond, Washington USA
Republic of Singapore
Rockford, Illinois, USA
San Diego, California, USA
San Francisco, California, USA
Seattle, Washington, USA
Stockholm, Sweden
Sydney, Australia
Tokyo, Japan
Washington, District of Columbia, USA

Summary

The DC-9-80 HUD constitutes an advancement in the state of the art of HUD Technology

● Designed for the Future
- New, Unique, Optical Approach
- Fast, Powerful, Flexible, Advanced Digital Computer
- Flexible CRT Image Display

● Designed for Safety
- Fail Safe System With Innovative Self-Check
- Advanced Control Law and Symbol Development
- Mechanical Breakaway Feature

● Designed from Experience
- 30 Years of Avionics Design and Production
- 10 Years of HUD Application to Commercial & Military Transport Aircraft

● Designed for Maintainability
- Integrated, Non-Obstructive Installation. Easy Remove & Replace
- Simple Modular LRU Design for Maintenance & Repair

● Designed for Reliability
- Estimated System MTBF-1750 Operating Hours
- Redundancy in Hardware, Software and Symbology

Applications of the Sundstrand Head Up Display System on the C-130, B-737, B-727, CH-3 and the DC-9-80

HEAD UP
DISPLAY
SYSTEM

Sundstrand Data Control, Inc. SUNDSTRAND
unit of Sundstrand Corporation