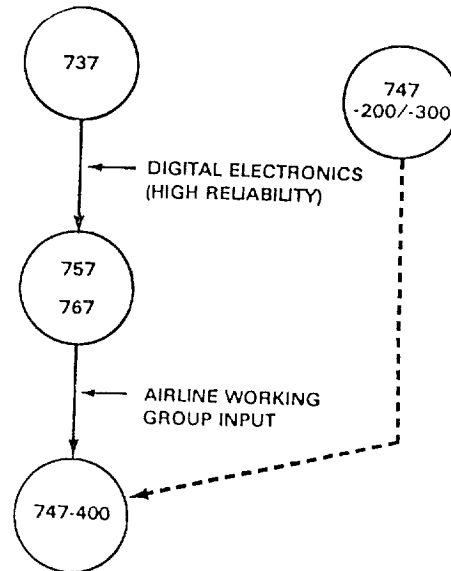


**BOEING FLIGHT DECK DESIGN
PHILOSOPHY**

**Harty Stoll
Boeing Commercial Airplane Company**

FLIGHT DECK EVOLUTION

- EXTERNAL VISION
- WORKLOAD
- FAILURE MANAGEMENT
- PILOT INCAPACITATION
- FLIGHT MANAGEMENT COMPUTER & MAP
- AUTOMATED MONITORING
- INTEGRATED CAUTION AND WARNING
- QUIET DARK CONCEPT
- SIMPLIFIED CREW ACTION
- COLOR CRT DISPLAYS
- DEDICATED CREW REST AREA
- INCREASED REDUNDANCY
- CENTRALIZED MAINTENANCE COMPUTERS
- IMPROVED FLIGHT MANAGEMENT



FLIGHT DECK DESIGN GOALS

747-400

THE DESIGN OF THE 747 FLIGHT DECK IS BASED ON THE RECENT SUCCESSFUL 757/767 PROGRAMS AS WELL AS ON THE EXPERIENCE GAINED FROM MILLIONS OF FLIGHT HOURS ON BOEING COMMERCIAL JET TRANSPORTS. SPECIAL EMPHASIS IS PLACED ON THE LATEST DIGITAL TECHNOLOGY AND CONTROL/DISPLAY INTEGRATION TO PROVIDE UNCLUTTERED INSTRUMENT PANELS, IMPROVED REACH AND SCAN CAPABILITY, AND OPTIMIZED CREW WORKLOAD. THE RESULT IS ENHANCED SAFETY AND PRODUCTIVITY THROUGH IMPROVED CREW COMFORT, PERFORMANCE, AND WORKLOAD OPTIMIZATION.

GOALS

- ENHANCED SAFETY
- IMPROVED OPERATIONAL CAPABILITIES
- PERFORMANCE/WORKLOAD OPTIMIZATION
- INCREASED RELIABILITY/MAINTAINABILITY
- REDUCED OPERATING COST
- IMPROVED CREW COMFORT

TECHNOLOGY

- DIGITAL COMPUTERS/MICROPROCESSORS
- INTEGRATED DISPLAYS
- INTEGRATED FLIGHT MANAGEMENT
- CDU's
- LASER GYRO INERTIAL REFERENCE
- ADVANCED SYSTEM MONITORING
- CENTRAL MAINTENANCE SYSTEM WITH STANDARDIZED BITE

FLIGHT DECK DESIGN CONSIDERATIONS

INDUSTRY

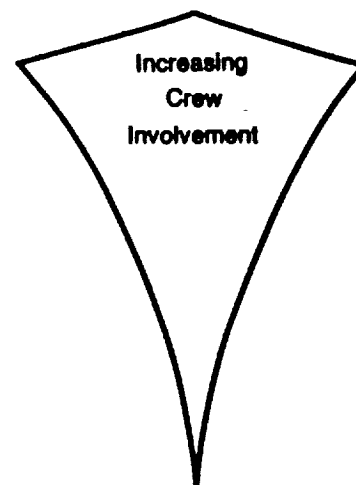
- AIRLINE INPUT
- FAA STUDIES
- NASA STUDIES
- NTSB
- SAE RECOMMENDATIONS
- ATA
- FLIGHT SAFETY FOUNDATION
- COMPETITIVE AIRFRAME MANUFACTURE
- SYMPOSIUMS
- WORKSHOPS
- AIAA
- ARINC
- RTCA
- ICAO
- ALPA, IFALPA, APA
- MISC. STUDIES (1969 UAL-ALPA)
- ASRS
- MILITARY - AIR FORCE, NAVY, ETC.
- HUMAN FACTOR ORGANIZATIONS

BOEING

- ACCIDENT/INCIDENT DATA
- BOEING FLIGHT TEST
- CREW TRAINING
- BOEING IR & D
- CUSTOMER SERVICE UNIT
- DATA ON EXISTING BOEING MODELS
- RELIABILITY AND MAINTAINABILITY
- QUESTIONNAIRES TO AIRLINES

Functions Allocated to Crew

- **Guidance**
- **Control**
- **Separation**
- **Navigation**
- **Systems Operation**

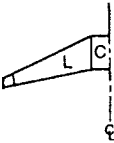
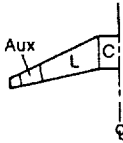
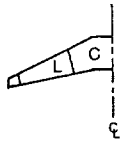


DESIGN PHILOSOPHY

- CREW OPERATION SIMPLICITY
- EQUIPMENT REDUNDANCY
- AUTOMATED FEATURES

Simplicity Through Design Refinement

Wing Fuel Tank Development – Example

	Original 3-Tank  Jan '78	5-Tank Proposal  Jun '79	Revised 3-Tank  Jan '80
Wing Structure Weight	Base	Large Decrease	Large Decrease
Fuel System Weight	Base	Moderate Increase	Small Increase
Total Weight	Base	Moderate Decrease	Large Decrease
Crew Operation	Simple	More Complex	Simple

REDUNDANCY

(EXAMPLES)

- **TRIPLEX**
 - INERTIAL REFERENCE SYSTEMS
 - ELECTRONIC FLIGHT INSTRUMENT SYMBOL GENERATION
 - AUTOMATIC FLIGHT CONTROL AND FLIGHT DIRECTOR SYSTEM
 - ILS RECEIVERS
- **DUAL**
 - FLIGHT AND ENGINE INSTRUMENTS
 - FLIGHT MANAGEMENT COMPUTER
 - NAVIGATION RADIOS
 - COMMUNICATION RADIOS
 - AIR DATA SYSTEMS
 - WARNING AND CAUTION ALERTS

AUTOMATION

(WHAT DOES IT MEAN?)

- **SUBSYSTEM AUTOMATION**
 - REDUCE CREW WORKLOAD (3 TO 2 MAN CREW)
 - REDUCE CREW ERROR
- **GLASS COCKPITS**
 - REDUCE CREW ERROR AND ACCIDENTS
 - IMPROVE PILOT SCAN
 - REDUCES COST
- **FLIGHT MANAGEMENT COMPUTERS**
 - PROVIDE MAP INFORMATION
 - REDUCE FUEL BURN
 - REDUCE CREW ERROR
- **AUTOPILOT/AUTOTHROTTLE**
 - REDUCE WORKLOAD
 - REDUCE CREW ERROR

Boeing Flight Deck Design Committee

Examples of Accident Data Reviewed

- Subsystem management accidents—worldwide air carriers 1968-1980

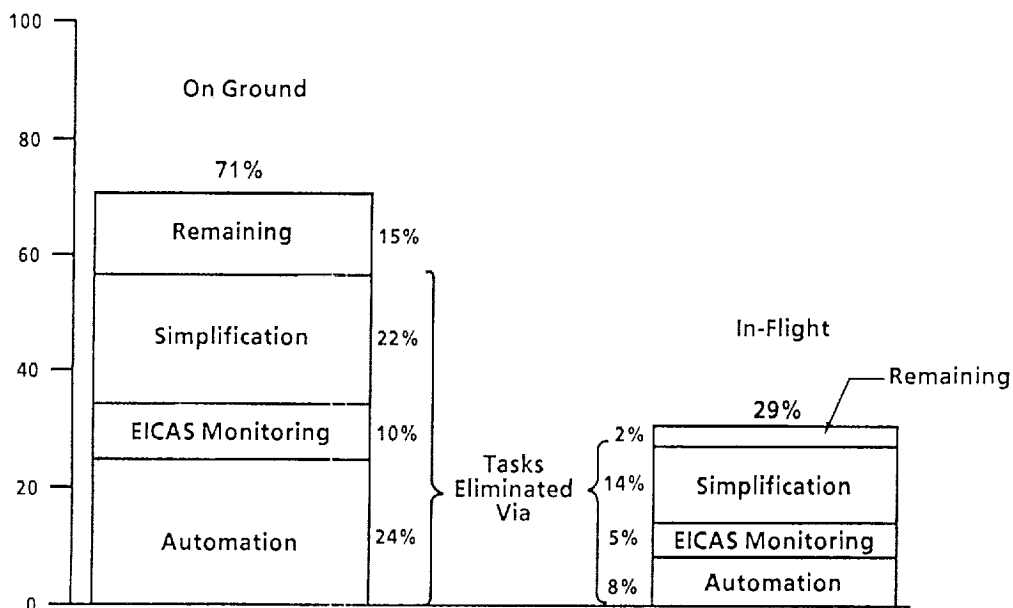
Accident Related Cause

- Crew omitted pitot heat
- Wrong position of standby power switch
- Flight engineer and captain conducted unauthorized troubleshooting
- Electrical power switching not coordinated with pilots
- Flight engineer shut off ground proximity
- Faulty fuel management
- No leading edge flaps on takeoff
- Confusion over correct spoiler switch position
- Crewman did not follow pilot's instruction
- Mismanaged cabin pressure

Design

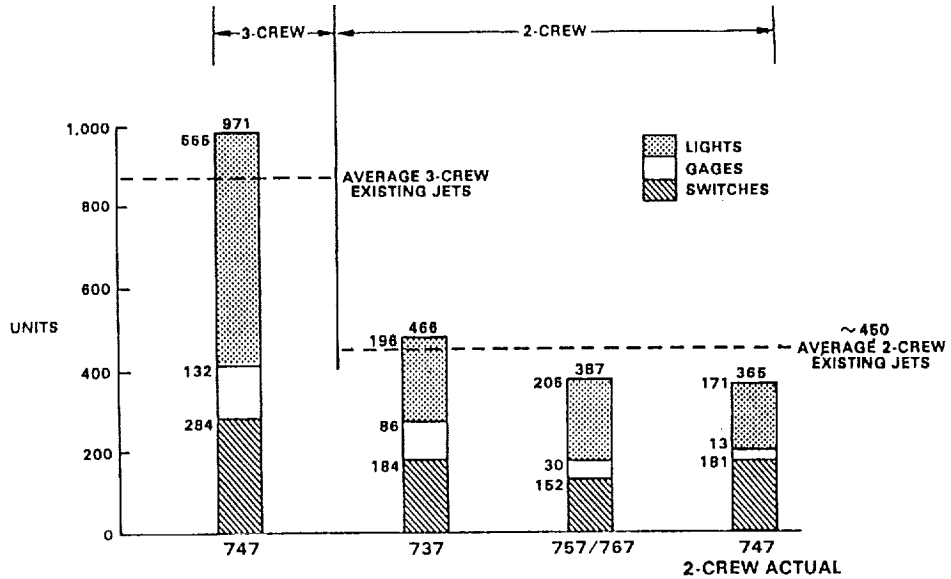
- Auto on with engine start
- Automated standby and essential power
- Simplified systems delete maintenance functions
- Auto switching and load shedding—no crew action required
- Shut off on forward panel in full view of both pilots
- Auto fuel management with alert for low fuel, wrong configuration, and imbalance
- Improved takeoff warning with digital computer
- Dual electric spoiler control
- Full-time caution and warning system
- Dual auto system with auto switchover

Allocation of 747-200 Flight Engineer's Duties to 747-400 Flight Crew



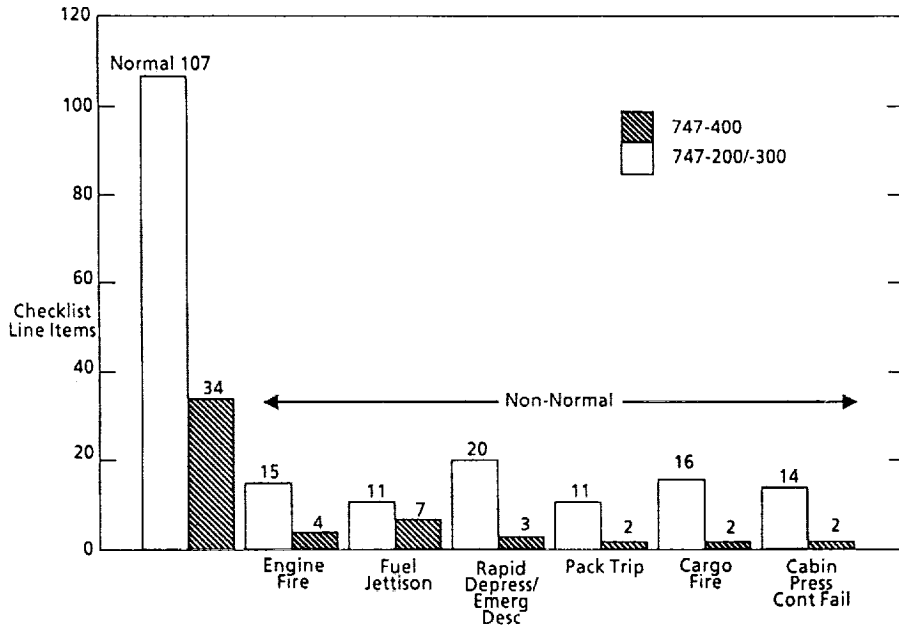
SUBSYSTEM CONTROLS & INDICATION COMPARISON

747-400

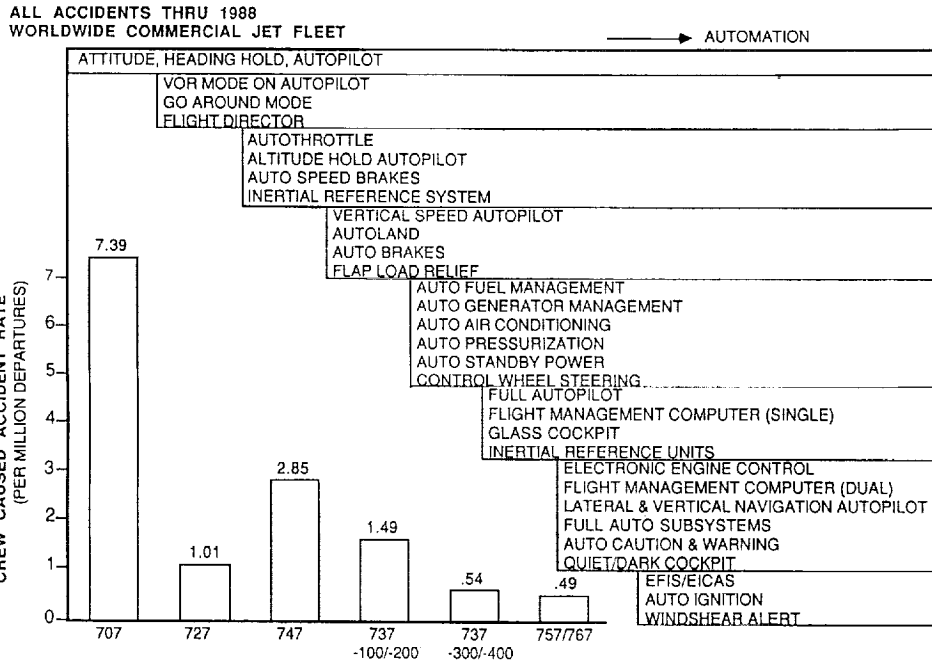


NOTE: NAV AND COMM PANELS NOT INCLUDED

747 Procedure Comparison



CREW CAUSED ACCIDENTS VS. AUTOMATION



AUTOMATION (THE GOOD AND BAD)

- THE PLUSES
 - SAFETY
 - ERROR REDUCTION
 - WORKLOAD REDUCTION
 - SIMPLIFIED CREW OPERATION
 - COST SAVINGS
- THE PROBLEMS
 - REDUCE CREW UNDERSTANDING (AUTO-MANUAL)
 - CREW OVERUSE REDUCING CREW FALL-BACK CAPABILITY
 - PILOT TRANSITION IN AND OUT OF AUTOMATIC AIRPLANES
 - BOREDOM
 - DESIGNER'S INTENT NOT TRANSMITTED TO PILOT

