Analysis of Impact of Aircraft Age on Safety for Air Transport Jet Airplanes

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Motivation

- Concern Regarding Impact of Aircraft Age on Aviation Safety Triggered by Key Accidents
  - Structural - Aloha Airlines 243 (1988)
    - Boeing 737-297
    - In-Flight Explosive Decompression
    - 19 Years Old, 35,486 hours, 89,690 cycles
  - Systems & Electrical - TWA 800 (1996)
    - Boeing 747
    - In-Flight Break-Up, Fuel Tank Explosion, Electrical Ignition
    - 25 Years Old
Response to Aging Aircraft Concerns

- **US National Aging Aircraft Research Program**
  - 1988 Structural Focus
    - Widespread Fatigue Damage (WFD)
  - 1996 Focus Expanded to Include Systems
    - eg Electrical

- **Airworthiness Assurance Working Group (AAWG)**
  - Manufacturers, Operators, Maintenance Orgs, Regulatory Groups

- **Improved Maintenance and Monitoring Programs**

- **Limit of Validity (LOV) Approach for Structures**
  - Flight Cycles or Hours Based

- **Some States Impose Age Based Restrictions on Imports**
  - Vary from 10-25 Years (Chronological)
  - Unclear if there is a Valid Basis for Age Based Restrictions
Objective

- Evaluate if aircraft chronological age is an indicator of safety risk in the commercial air transport jet fleet
- Study supported by the Aviation Working Group* as an independent technical analysis of available safety data

* Aviation Working Group (AWG) is a not-for-profit entity comprised of major aviation manufactures, leasing companies and financial institutions that contribute to the development of polities, laws, and regulations that facilitate advanced international aviation financing and leasing
Approach

• Historical Evaluation of Correlation Between Aircraft Age and Accident Rate

• Data
  • Flightglobal Ascend Online Database (1959 - 2012)
    • Aircraft Histories
    • Region of Operation
    • Accident Narratives

• Limitations
  • Jet Transport Aircraft (MTOW > 60,000 lbs)
  • Aircraft Manufactured in CIS or Soviet Union not Included Due to Lack of Comprehensive Data
  • Aircraft Types with No Accident History not Included
  • Detailed Operational Use (Cycles or Hours) not Available for All Aircraft
Aircraft-Year Based Accident Rate Metric

- Data Was Not Detailed Enough to Use Traditional Accident Rate Metric of Accidents per Aircraft Cycle
- Aircraft-Year Based Metric Defined as the Number of Accidents Which Occurred Divided by the Number of Aircraft-Years of Operation
  - Implicitly Assumes Each Aircraft-Year has Same Risk Exposure
  - Reasonable Given High Level Scope of Analysis
- Inverse of Aircraft-Year Metric is the Average Number of Years Between Accidents.
Accident Definition

- Events Where Aircraft Sustained Substantial Damage, Became Missing or Inaccessible as well as Events where Fatal or Serious Injury Resulted from Being in the Airplane or Direct Contact with the Airplane or it’s Jet Blast

- Excluded Events
  - Sabotage
  - Hijacking
  - Terrorism
  - Military Action
  - Stowaway
  - Non-Fatal Injuries from Turbulence, Loose Objects, or Boarding
Distribution of Commercial Deliveries by Aircraft Type
Growth of In-Service Fleet and Average Fleet Age

Units

Average fleet age (year)


0 10,000 20,000

5,000 10,000 15,000 20,000

0 2 4 6 8 10 12 14
Annual Number of Accidents by Year

Number of accidents

- Nonfatal accidents
- Fatal accidents
Accidents per Aircraft-Year vs Time

Accidents per aircraft-year

 Fatal accidents per aircraft-year
Average Aircraft-Years Between Accidents by World Region

### All Accidents

- **North America**: 400 aircraft-years
- **Europe**: 300 aircraft-years
- **Asia Pacific**: 200 aircraft-years
- **Latin America**: 100 aircraft-years
- **Africa**: 50 aircraft-years
- **Middle East**: 100 aircraft-years
- **Worldwide**: 400 aircraft-years

### Fatal Accidents

- **North America**: 1,500 aircraft-years
- **Europe**: 1,000 aircraft-years
- **Asia Pacific**: 900 aircraft-years
- **Latin America**: 500 aircraft-years
- **Africa**: 300 aircraft-years
- **Middle East**: 700 aircraft-years
- **Worldwide**: 1,500 aircraft-years
Accident Trends by World Region
Accident Rate By Year-of-Build Group

Accidents per aircraft-year

Total Accidents

Fatal Accidents

Accidents by Aircraft Age at Time of Accident

Number of accidents

Age at time of accident

Nonfatal accidents
Fatal accidents
Fleet Exposure by Aircraft Age

Aircraft-years

Aircraft age during operation
Fatal Accident Rate vs Aircraft Age

Worldwide

Rate Flat Until 27 Years

Error Bars Indicate 95% Confidence Interval
Total Accident Rate vs Aircraft Age

Worldwide

Error Bars Indicate 95% Confidence Interval
Accident Rate vs Aircraft Age by World Region

- North America
- Europe
- Asia Pacific
- Latin America
- Africa
- Middle East
Accident Rate vs Aircraft Age
North America

North America

Accidents per Aircraft Year

Aircraft Age
Accident Rate vs Aircraft Age
Europe

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Accident Rate vs Aircraft Age
Asia Pacific
Accident Rate vs Aircraft Age
Latin America
Accident Rate vs Aircraft Age
Middle East

Middle East

Accidents per Aircraft Year

Accident Rate

Aircraft Age

0 5 10 15 20 25 30 35 40 45

0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08

Accidents per Aircraft Year
Occurrence Categories for Accidents of 20+ Year Old Aircraft

Fatal Accidents
N = 104

- Aircraft Related: 18.2%
  - SCF-NP: 7.7%
  - SCF-PP: 6.7%
  - F-NI: 3.8%
- Non-Aircraft Related: 73.1%

Total Accidents
N = 385

- Aircraft Related: 29.6%
  - SCF-NP: 19.3%
  - SCF-PP: 7.5%
  - F-NI: 2.6%
- Non-Aircraft Related: 67.5%

Unknown: 8.7%
Accidents of 20+ Year Old Aircraft
Distribution of Occurrence Categories by World Region

- F-NI
- SCF-NP
- SCF-PP
- UNK
- NON-AIRCRAFT
Conclusions

- **Fatal Accident Rate**
  - No Correlation with Age up to 27 Years

- **Total Accident Rate and Age Up to 18 Years**
  - No Correlation with Age up to 18 Years
  - Weak Trend of Increasing Rate with Age for AC > 20 years
  - Increase Mainly Observed in Africa
  - No Correlation in North America or Europe

- **Accidents of 20 + Year Old Aircraft**
  - Most Accidents are Not Related to Aircraft Factors
    - All Accidents 67.5%, Fatal Accidents 73.1%
  - Higher Non-Aircraft Percentages in Africa vs North America

- **Historical Analysis Does Not Support Age-Based Import Restrictions**