The Impact of Maintenance on Passenger Airline Safety

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Outline

1. Motivation for the project.
3. Description of NTSB accident database.
4. Discussion of safety metrics.
5. Results of accident analysis.
Motivation

- A significant amount of research has been done on reducing mechanical failures and aircrew mistakes.
- The impact of maintenance on aviation safety has not attracted the same amount of attention.
- Project aims to provide insight and quantify the contribution of maintenance to aviation risk.
- Analyzed all Part 121 accidents investigated by the NTSB between 1962 and 2008.
Case Studies (1 of 3)

- Japanese Airlines Flight 123 (Boeing 747)
  - Aircraft suffered a tail strike in 1978.
  - Inadequate repairs were made to the damaged area.
  - Suffered an explosive decompression due to metal fatigue 7 years later.
  - Failure or rear bulkhead caused the vertical stabilizer to separate from the aircraft.
  - Deadliest single aircraft accident to date.
  - 505/509 lost.

Source: http://www.airdisaster.com/special/special-jal123.shtml
Case Studies (2 of 3)

- United Airlines Flight 232 (DC-10)
  - Maintenance failed to detect a fatigue crack on one of the engine’s fan disks.
  - Inspection and quality control procedures were inadequate.
  - Uncontained destruction of the engine during flight.
  - Self-destruction of engine cut all three hydraulic lines.
  - 111/296 lost.

Source: http://www.airdisaster.com/special/special-ua232.shtml
Case Studies (3 of 3)

- Alaska Airlines Flight 261 (MD-83)
  - Aircraft lost vertical pitch control and impacted the Pacific Ocean at high velocity.
  - Lack of lubrication on the threads of the jackscrew assembly which controls the trim of the horizontal stabilizer.

Source: Snapshot from: Mayday - Air Disasters. Episode: Cutting Corners
• Analyzed all Part 121 accidents investigated by the NTSB between 1962 and 2008.

• Definition of Accident:
  – “an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage” (NTSB, 2009b)

• 14 CFR Part 121:
  – “scheduled or non-scheduled passenger-carrying operations that adhere to regulations that limit operations to controlled airspace and controlled airports for which specific weather, navigational, operational, and maintenance support are available” (NTSB, 2009a)
NTSB Accident Database  

- NTSB database summarized the causes and factors of each accident.


- Database does not provide the relative importance of each cause or factor.

- Maintenance-related accidents were defined as possessing at least 1 maintenance-related cause or factor.

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>68D0</td>
<td>Improper Maintenance (Maintenance Personnel)</td>
</tr>
<tr>
<td>68D1</td>
<td>Improper Maintenance (Owner Personnel)</td>
</tr>
<tr>
<td>68D2</td>
<td>Improperly Serviced Aircraft (Ground Crew)</td>
</tr>
<tr>
<td>68D3</td>
<td>Improperly Serviced Aircraft (Owner-Pilot)</td>
</tr>
<tr>
<td>68D4</td>
<td>Inadequate Inspection of Aircraft (Maintenance Personnel)</td>
</tr>
<tr>
<td>68D5</td>
<td>Inadequate inspection of Aircraft (Owner-Pilot)</td>
</tr>
<tr>
<td>68D6</td>
<td>Inadequate Maintenance and Inspection</td>
</tr>
<tr>
<td>68D7</td>
<td>Other</td>
</tr>
<tr>
<td>68D8</td>
<td>Unknown/Not Reported</td>
</tr>
</tbody>
</table>

*Table 2. Post-1982 Maintenance Subject Codes

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>24100</td>
<td>Maintenance</td>
</tr>
<tr>
<td>24101</td>
<td>Service of Aircraft/Equipment</td>
</tr>
<tr>
<td>24102</td>
<td>Inspection</td>
</tr>
<tr>
<td>24107</td>
<td>Adjustment</td>
</tr>
<tr>
<td>24111</td>
<td>Installation</td>
</tr>
<tr>
<td>24115</td>
<td>Replacement</td>
</tr>
<tr>
<td>24119</td>
<td>Service Bulletin/Letter</td>
</tr>
</tbody>
</table>

*Table 2 only includes the most frequently reported maintenance codes.
Safety Metrics

- Metrics used:
  1. Accidents per year
  2. Fatalities per year
  3. Fatal accidents per year
  4. Average number of fatalities per accident per year
  5. Passenger mortality risk

- Issues surrounding chosen metrics:
  - Passenger mortality risk is the most sound metric but does not lend itself well to year to year comparisons.
  - Metrics 1, 2 and 3 do not convey the severity of the accidents when considered by themselves.
  - The number of fatal accidents does not accurately reflect passenger mortality risk since aviation accidents are often survivable.
  - Average passenger survival rate: 35% (for all fatal accidents between 1982-2008)

- All metrics must be considered together to obtain a holistic view of the impact maintenance has on passenger airline safety.
Accident Analysis (Number of accidents per annum)

- Maintenance has contributed towards:
  - 7% of all accidents between 1962 and 2008.
  - 5% of all accidents between 1998 and 2008.
Accident Analysis

- Maintenance has contributed towards:
  - 15% of all fatalities between 1962 and 2008.
  - 13% of all accidents between 1998 and 2008.
- Maintenance-related accidents tend to have a slightly higher fatality rate than accidents overall.
Accident Analysis  (Average number of fatalities per accidents per annum)

- Peaks in the number of fatalities are the result of a few high fatality accidents.
Accident Analysis  (Number of fatal accidents per annum)

- 13% (20%) of all fatal accidents between 1962 and 2008 (1998 and 2008) are maintenance-related.
- Peaks are due to a few severe accidents. Maintenance accidents, if fatal, tend to be severe.
- Maintenance accidents are almost twice as likely to be fatal compared to accidents overall.
  - 13% of maintenance-related accidents are fatal.
  - 7% of all accidents are fatal.

![Graph showing the number of fatal accidents from 1962 to 2008, comparing total and maintenance-related accidents. The graph highlights a change in classification scheme around 1982.](image-url)
Accident Analysis (Passenger Mortality Risk)

- Considers only passenger fatalities.
- Used data from US Bureau of Transportation Statistics
- Approximate mortality risk:
  - 1 in 10 million (total)
  - 0.3 in 10 million (maintenance-related)
- Maintenance Accounts for 30% of passenger mortality risk in commercial aviation.
- Average passenger survival rate:
  - Fatal maintenance-related accidents:
    - 1982-2008: 37%
    - 1996-2008: 20%
  - All fatal accidents:
    - 1982-2008: 35%
    - 1996-2008: 24%
Accident Analysis (Distribution of Maintenance Codes)

- 68D8 - Unknown/Not Reported
- 68D2 - Improperly Serviced Aircraft (Ground Crew)
- 68D4 - Inadequate Inspection of Aircraft (Maintenance Personnel)
- 68D6 - Inadequate Maintenance and Inspection
- 68D0 - Improper Maintenance (Maintenance Personnel)

- 2416 - Major Repair
- 2413 - Modification
- 24103 - Compliance with AD
- 24122 - Major Overhaul (engine)
- 24118 - Record Keeping
- 24112 - Lubrication
- 24106 - AAIP/Progressive Program
- 24121 - Overhaul
- 24115 - Replacement
- 24107 - Adjustment
- 24111 - Installation
- 24119 - Service Bulletin/Letter
- 24101 - Service of Aircraft/Equipment
- 24100 - Maintenance
- 24102 - Inspection

[Bar charts showing frequency by maintenance code and factor]
Summary

• Improper maintenance can have devastating consequences.
  – JAL 123, UA 232, ASA 261

• 7% (5%) of all aviation accidents, 15% (13%) of all aviation fatalities, and 13% (20%) of all fatal accidents between 1962 and 2008 (1998 and 2008) were maintenance related.

• Maintenance plays a role in up to 2 fatal accidents each year.

• Maintenance-related accidents are almost twice as likely to be fatal compared to accidents overall (13% vs. 7%).

• Maintenance accounts for 30% of the passenger mortality risk in commercial aviation.
References

