National Transportation Safety Board

Improving Maintenance Safety Through Collaboration

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Outline

- NTSB Basics
- Maintenance Improvement Steps
  - More robust initial design
  - Execution of maintenance
  - Feedback from maintenance process

NTSB 101

- Independent federal agency, investigate transportation mishaps, all modes
- Determine probable cause(s) and make recommendations to prevent recurrences
- Primary product: Safety recommendations
  - Favorable response > 80%
- *SINGLE FOCUS IS SAFETY*
- Independence
  - Political: Findings and recommendations based upon evidence rather than politics
  - Functional: No “dog in the fight”

The Challenge: Rare But Serious Maintenance-Related Mishaps

- DC-10, Chicago, IL (1979)
- MD-80, Pensacola, FL (1996)
- MD-80, California (2000)
- Beech 1900, Charlotte, NC (2003)
- Eurocopter AS-350, Las Vegas, NV (2011)
- Multiple Engine Cowl Loss In-Flight Post Engine Maintenance (Multiple aircraft types)

Current NTSB Activity

– NTSB is currently engaged in several investigations potentially involving maintenance

Crucial Steps in the Process

- More robust initial design
  - Incorporate maintenance expertise early in the design process
- Execution of maintenance
  - Human factors awareness
  - Quality of maintenance and inspections
  - Training
- Feedback from maintenance process
  - Feed maintenance experience back to OEMs for design improvements and redesign

Improved Initial Design

- Long-term maintainability is crucial for aircraft to be economically viable
- Aircraft manufacturers benefit from input from end-users, i.e., pilots, during design phase
- Likewise, input from maintenance community during design phase helps make airplanes more maintainable

Improved Maintenance Process

- Human factors awareness
- Quality of maintenance and inspections
- Training

Human Factors: The Dirty Dozen*

- Lack of communication
- Lack of teamwork
- Lack of assertiveness
- Complacency
- Fatigue
- Stress

* Source: FAA AMT Handbook 8083-30

The Dirty Dozen (con't)*

– Lack of knowledge
– Lack of resources
– Lack of awareness
– Distraction
– Pressure
– Norms

* Source: FAA AMT Handbook 8083-30

Quality of Maintenance and Inspection

- Maintenance
  - Following manufacturer's instructions?
  - Materials current?
  - Best practices, e.g., work cards?
- Inspection
  - Independent?
  - Complete?
  - Feedback?

Improved Training

- Does one size fit all?
  - Compare: Type rating for pilots
- OJT: Effectiveness if trainer
  - Does not know how to train?
  - Does not enjoy training?
  - Is not good at training?
- Simulators?
  - Not required
  - Use is increasing
  - Significant potential for improvement

Feedback from Maintenance Process

- CAST: Collaborative effort to improve aviation safety
- CAST Safety Enhancement: Continuous Monitoring of Service History by Original Equipment Manufacturers

The Challenge

- Accident rate came down for decades, but stopped declining in early 1990s
- Volume of flying projected to double in 10-15 years
- Concern that flat rate times double volume = twice as many accidents
- Needed to think out of the box

The Solution: CAST

- Commercial Aviation Safety Team
- Collaborative program that included everyone with a “dog in the fight”
- Success story: Reduced “stuck” accident rate by 83% in only 10 years
- Icing on the cake: Sustainable because safety enhancements also improved productivity
- Moral of the story: Everyone who is involved in the problem should be involved in the solution

CAST Maintenance Safety Enhancement

– Original Equipment Manufacturer (OEM) Continuous Monitoring of Service History (SE #170, underway)
  - Reduces accidents due to improper maintenance by ensuring maintenance task difficulty data is collected and reported to the OEM and proper maintenance is being performed to ensure aircraft systems continue to perform as designed

CAST Safety Enhancement (con't)

- Operators and maintenance organizations will incorporate the best practices into their reporting processes for maintenance task problems
- OEMs will incorporate reported maintenance task difficulties into their continuing airworthiness/design review processes

Recent Example: In-Flight Fire

- February 8, 2012
- American Airlines 767-323ER
- Fire in right engine, CF6-80C2, climbing thru 9,000 feet
- Fire extinguished, aircraft returned to JFK for overweight single engine landing

NTSB On-Scene Examination

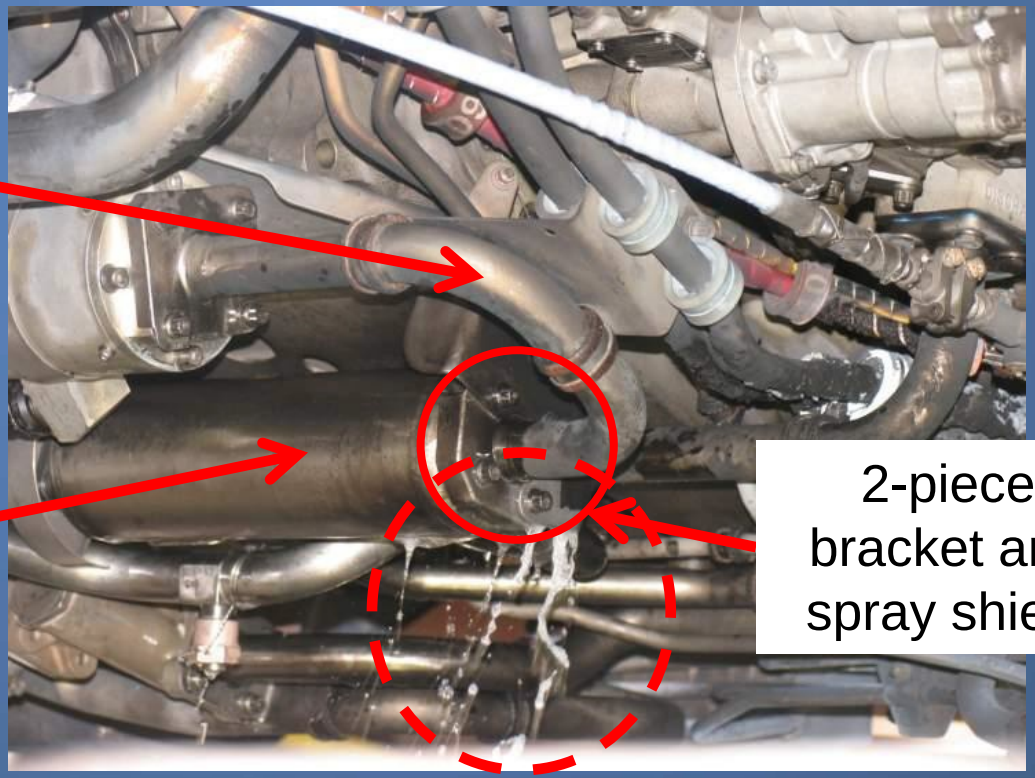
– Soot, melted insulation, and burned wires confirmed undercowl fire

Previous Maintenance

- Work in the area performed the previous evening
- Work included replacement of:
  - Fuel flow transmitter
  - Tube between transmitter and Integrated Drive Generator (IDG) fuel-oil heat exchanger
- Fire occurred after 2 flight cycles

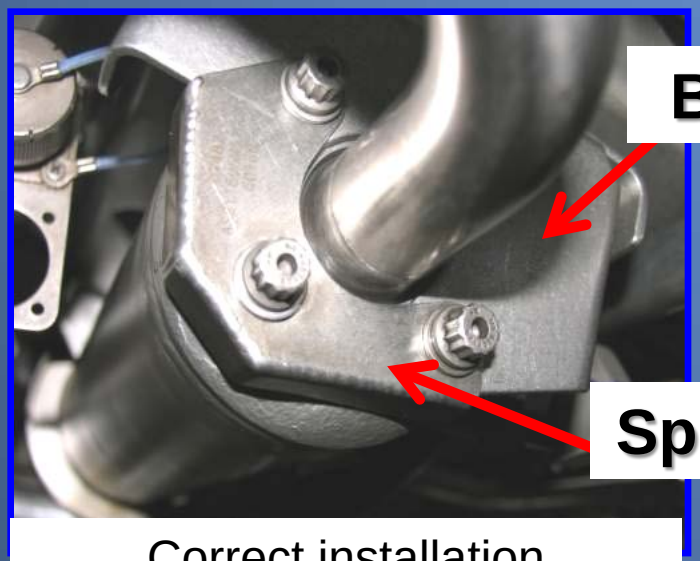
Fuel Leak

– Investigators wet-motored right engine, fuel leaked from front side of fuel-oil heat exchanger

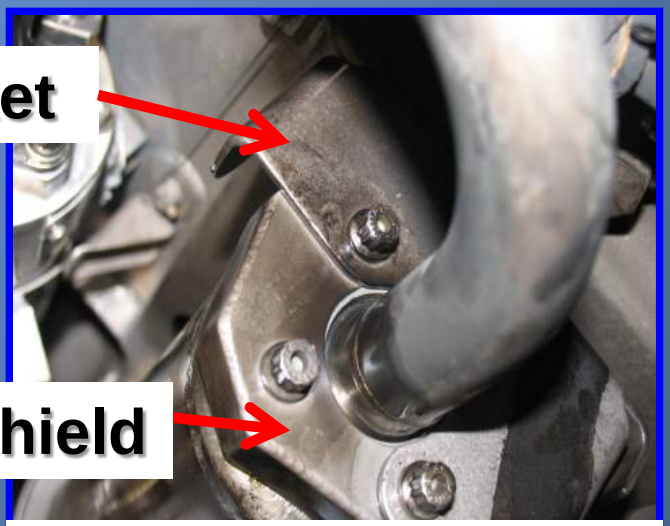


Two-Piece Bracket and Spray Shield

- Two-piece bracket and spray shield on front of heat exchanger was misassembled
- Spray shield was under rather than over the bracket



Correct installation



Incorrect installation

Cause of Fire

- Incorrect installation of bracket over spray shield
  - Resulted in insufficient clamping force on seal between heat exchanger and tube
  - Edge of seal blown out, causing fuel leak
  - Fuel leaking into engine compartment subsequently ignited on hot case, causing fire
- Contributing factors
  - Maintenance manual lacked pictorial diagram of 2-piece assembly
  - Work done outdoors, on rainy night

Previous Event

- June 6, 2006
- Delta Air Lines 767-332ER
- Fire in left engine, CF6-80C2, climbing through 3,000 feet
- Fire extinguished, aircraft returned to the airport for overweight single-engine landing

Engine Examination

- Damage to Delta engine was virtually identical to damage noted on American engine
  - Engine covered with soot
  - Melted insulation and burned wires confirming under cowl fire
- During investigators' wet motoring of engine, fuel leaked from front of IDG fuel-oil heat exchanger and two piece bracket and spray shield
- Maintenance work in this area shortly before incident

NTSB Safety Recommendation

- Service Bulletin: 73-0242 original release May 17, 1996
- SB to replace two-piece bracket and spray shield with one-piece bracket and spray shield design
- NTSB Safety Recommendation A-12-47, issued July 12, 2012, to require incorporation of service bulletin 73-0242 on CF6-80C2 engines

FAA Action

- August 13, 2012 – FAA issued NPRM
  - Require installation of one-piece bracket and spray shield
  - All CF6-80C2 engines
- December 31, 2012 – FAA re-issued NPRM (to address comments)
- April 16, 2013 – FAA issued Airworthiness Directive 2013-08-20 with an effective date of May 31, 2013
  - Compliance – If the fuel tubes are disconnected for any reason or the next engine shop visit, whichever comes first, comply with the SB

Crucial Steps in the Process

- More robust initial design
  - Could improved involvement of maintenance community during design have decreased the likelihood of this type of error?
- Execution of maintenance
  - Need for better documentation
  - Need for better training
  - Inadequacy of inspection
  - Workplace environment?
- Feedback from maintenance process
  - In-flight fire (June 1996) soon after first service bulletin (May 1996) indicated need not only to mandate change (retroactive) but also to revise design (prospective)

Next Steps?

- Improved safety culture, SMS at all levels – systematic and documented safety improvement efforts
- Implementing SMS: Sharing a common goal – improving safety – enables collaboration
- CAST has demonstrated the power of collaboration to improve the safety of flight operations
- Collaboration can also improve the quality of maintenance at all levels
  - Initial design
  - Execution of maintenance
  - Feedback from maintenance process

Conclusion

- The quality of maintenance is generally very good, but there will always be room for improvement
- The CAST collaborative process has been very successful for improving the safety of flight operations and can also help improve maintenance

Thank You!!

Questions?