Aerospace Industries Association

*Rotor Manufacturing Project (RoMan)*

TOGAA
Summary

February 19, 2002
Outline

• Background
• FAA Perspective
• Team Membership
• Charter & Vision
• Impact
• AIA RoMan Report Overview
• Technology Shortfall Whitepaper Status
• Going-Forward Plan
• Summary
Background

- Modern engines have excellent reliability and safety records … but uncontained disk failures do occasionally occur

- Industry and FAA have been working to reduce these failure rates …with some measure of success
  - Over the past 5 years, 66% drop in rate of events that hazard the aircraft
  - But effects being offset by growth in commercial fleet

- Recent experience…
  - Primary causal factors for uncontained failures are material, manufacturing, and maintenance/usage induced anomalies
  - “Classical” failures (LCF, creep, etc) are trending down

- Engine Manufacturers recognize the need to address manufacturing induced anomalies… and are working to establish minimum standards and recommended practices.
Background - The Pensacola Event

**ACCIDENT**

**DL 1288, July 6, 1996 - Pensacola, Florida**

- MD-88 engine failure on take-off roll
- Pilot aborted take-off
- Stage 1 Fan Disk separated; impacted cabin
- Cause: machining induced anomaly in a bolthole
- 2 fatalities
- NTSB Report recommended ...
  - Changes in inspection methods, shop practices
  - Fracture mechanics based damage tolerance

- Represented second major premature failure of a Stage 1 fan disk in recent years due to unanticipated and undetected damage
  - Focused RISC activities on Surface Damage Tolerance methodology development
  - Spawned FAA Enhanced In-Service Inspection and Rotor Manufacturing Initiatives
Background - Post Pensacola

- Industry moves to address manufacturing induced anomalies
- Initial focus: holes
- Further work based on results of OEM manufacturing data review
FAA Perspective

Without Intervention, Projected Traffic Growth Will Result in an Unacceptable Number of Accidents

A reduction in manufacturing induced anomalies is required to compliment the damage tolerance philosophy for commercial engines
Team Membership

- Fiat
- GEAE
- Hamilton-Sundstrand
- Honeywell
- MTU
- P&W
- P&W - Canada
- RR-Corp
- RR
- SNECMA
- Volvo

**Company representation:**
Manufacturing focal person with Engineering, Quality and NDE support

**Excellent synergy with AIA RISC through personnel from P&W, RR and MTU**
**Charter:** Establish industry guidelines that improve manufacturing, engineering and quality practices towards eliminating manufacturing induced anomalies in critical rotating parts.

**Vision:** Minimize manufacturing induced anomalies in critical rotating parts.

- **Minimum Standards**
- **Recommended Practices**
  (Do’s & Don’ts)

- **Dictate tooling or process**
- **Prevent innovation**
- **Reduce competitive edge**

Guidelines documented in industry report
RoMan Guidelines Will Impact Rotor Manufacturing

- FAA will expect ALL suppliers of high energy rotating components to comply with the intent of the Advisory Circular
- OEM administration of process qualification and control minimally impacted
- In-process detection of anomalous process events, if required, may affect plant & equipment costs
Overall Recommendations

- Convey the part criticality to all parties involved in the part manufacture
- How to perform mfg process validation including skill set requirements
- Rollup mfg steps and methods into a Manufacturing Control Plan
- Educate and train personnel
- Holemaking is a sensitive mfg process
  - Use process monitoring for “high risk” holes (e.g., holes selected per RISC method)
  - Use appropriate NDE method with attention to high L/D holes
- Perform research in:
  - Process control
  - Process monitoring
  - NDE

RoMan Report

Recommendations
Mfg into Part Integ
Quality Assurance
Process Monitor
Human Fact/Train
NDE
Lessons Learned
Appendices
Integrating Mfg into Overall Part Integrity

- Use part and/or feature designation(s) to convey the need for special manufacturing controls.

- Achieve process validation via part specific or generic manufacturing approaches established by the Process Validation Function (PVF) team.

- Guidelines provided on the types of data needed for process validation …focused on the fatigue capability

- How to identify substantial mfg process changes…and how to perform process change validation.
Quality Assurance

- Use written work procedures that seek to prevent non-conforming parts from entering service.
- Perform periodic audits to ensure compliance with the manufacturing control plan.
- Identifies skill set for material review and non-conformance disposition.
Introduction on how machining induced anomalies can be created.

Guidance on how process monitors can be used to detect machining induced anomalies including setup, calibration and anomaly detection.

Process monitoring production demonstrated and recommended for “high risk” holes….other processes TBD

Recommendations
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Human Factors and Training

- Human observation is a valuable tool for maintaining mfg process capability and consistency.
- Appropriate mfg atmosphere and culture is beneficial.
- Training can help minimize machining induced anomaly creation and should include:
  - The importance of remaining within validated mfg process parameter limits per the mfg control plan
  - Change control process
  - Process monitoring equipment involved
Non-Destructive Evaluation

MTU “guidebook” full of practical experiences is available

- Discusses available NDE techniques and how to:
  - Choose an appropriate NDE method
  - Determine NDE reliability
  - Improve anomaly detection capability

- Provides NDE capability matrix for detecting anomalies in low L/D and high L/D holes (etch, visual, FPI/MPI, ECI).

RoMan Report

Recommendations
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Appendices
Lessons Learned

Discusses experiences in holemaking including process monitoring and observations from a titanium holemaking study on anomaly creation and detection.
RoMan White Papers Address Technology Shortfalls

- **Lessons Learned (Anomaly) Database** – completed; awaiting non-disclosure coverage under FAR Part 193 prior to industry data submittal

- **Visual Inspection (NDI)** – in queue for FAA funding
  - Improved (automated) optical techniques
  - Laser-Scanning - holes

- **Process Monitoring** – in queue for FAA funding
  - Acoustic Emission - potential for small diameter holes and other mfg processes
  - Vibration – potential for holes and other mfg processes

- **Improved automated probes (NDI) for anomaly detection** – in queue for FAA funding
  - Array/Flex and Absolute ECI
  - Advanced motion control
  - SQUID
  - Jentek system

- **Relationship Between Anomalies and Fatigue Life** – European led MANHIRP program underway
Lessons Learned Database

- Central location for all OEM manufacturing induced anomaly data
- Provide manufacturing process details which led to anomaly
- Provide industry with the means to avoid anomaly re-occurrence
- Data source supporting RISC manufacturing induced anomaly surface damage tolerance effort
Closure of RoMan Project is pending report submittal to AIA PC…but team will remain active under RISC

• Report content complete, Jan ’02
  ➢ Submit to AIA PC 1Q02

• Lessons Learned Database – series of telecons setup through 2002
  ➢ Oversee database population
  ➢ Review database content
  ➢ Develop recommendations from database review

• RoMan team meets under charter of RISC (Jan 2003)
  ➢ Review recommendations from database review
  ➢ Status on-going technology development programs (MANHIRP, etc)
  ➢ Disposition comments on report from AIA PC or others
Summary

• AIA Rotor Manufacturing Project (RoMan) working since 10/98 to provide guidelines on rotor manufacturing best practices

• RoMan reached team consensus on report material 1/02

• Technology shortfalls identified, prioritized & working

• Team going-forward plans and objectives identified and agreed

• Benefits of establishing rotor manufacturing guidelines include:
  – Improved flight safety by raising industry rotor mfg standards
  – Industry knowledge shared / leveraged