Breakout Session on:Damage Threats and Inspection Strategies

FAA/EASA/Industry Workshop on Damage Tolerance and Maintenance
June 5, 2009
Tokyo

Tasking: Directed Inspection, how to implement?

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Breakout Session Members

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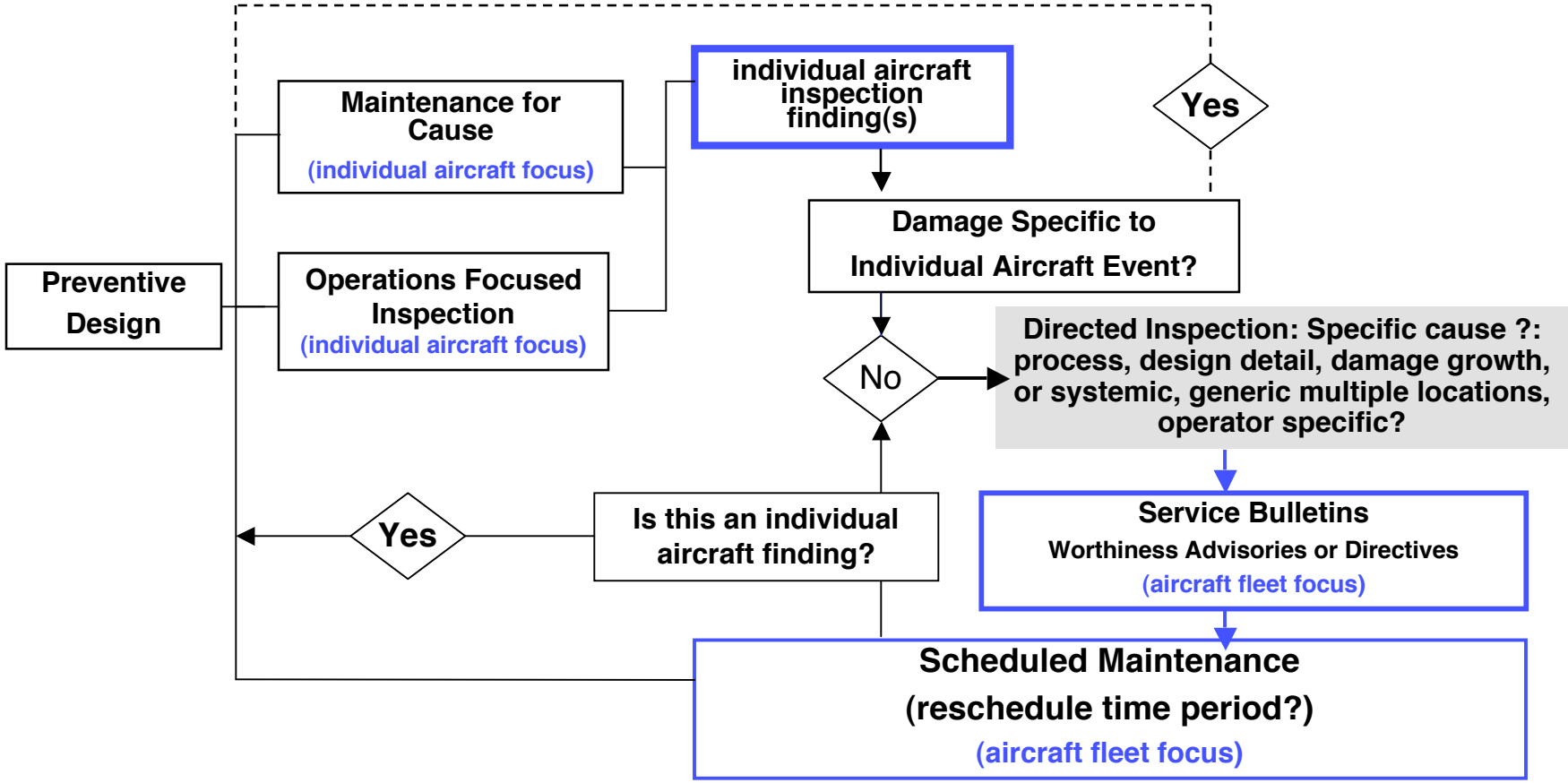
Overlapping Layers of AIR WORTHINESS MANAGEMENT

- Preventive design
- Maintenance for Cause (discrete source damage, JSSG) when possible:
  - Bird strike, FOD, Hail Ice (in-flight & on-ground), Tire rupture (on-ground, in-flight), Lightning, & --- (Threats characterized, structures zoned, cause and effect --)
  - Individual aircraft focus
    - Self evident damaging event
    - Visually self evident damage?
    - Inspections & maintenance (What, When, Where, How?) provides a focused and timely process
- Operations Focused Inspection, management of other damage classes:
  - Other Potential Failure modes:
    - Load induced delamination (maybe heavy landings, --)
    - Thermal induced delamination (GSE exhaust, --)
    - Corrosion & Other
  - Anomalous events (Blunt Impacts, ---)
  - Individual aircraft focus
  - Damage Categories
- General inspection at heavy maintenance (all aircraft)
  - Defined usage or age interval (maybe 10 years)
  - Protection from hidden damage, unknown events, ---
  - Provides data for updating individual aircraft air worthiness management.
- Balancing Risk

Layered Inspection Strategy



Damage Tolerance Awareness Criteria?

(Durability and Continuing Airworthiness)

- **Self Evident Damage?**
  - Cracking and corrosion
  - Fail-safety: Readily detectable means that a local failure or partial failure would be apparent from in- flight or post-flight visual observations, or they would be obvious during a scheduled visual inspection conducted within the predicted safe period of unrepaired usage.
- **Self Evident Damaging Events**
  - Bird strike, tire rupture, hail, --
  - Damage Threats EXTERNAL TO AIRFRAME
    - Threat Characterization?
    - B-Allowable and/or enveloping?
    - Performance based criteria (FAA Tire rupture example)
    - Typically impact threats
  - Maintenance for Cause option?
- **Ground Operations Concerns**
  - Blunt Impact with GSE & Buildings
  - Hot GSE engine exhaust impinging airframe surface
    - exceeding composite in-service T_G

Discussion on Threat Relationship to Inspection & Repair (Thresholds?)

- Some threats require immediate attention
- Potential for cumulative damage and damage growth
  - period of continued usage without immediate inspection repair action
- Some are not so severe
  - continued operation?
  - damage could be found during scheduled inspection

Lightning Damage (1 of 2)

- Direct Effects are addressed;
  - Electo-magnetic integrity
  - Fuel tank sparking
- Indirect Effects;
  - JAL & ANA operational experience
    - Operational lightning environment is severe
    - Similar to US concerns for hail ice
  - Equivalent to local thermal spike
    - Initial delamination
    - Matrix charring and then fiber vaporization
    - Small localized damage sites accumulating in service
  - Structural integrity; Damage Tolerance (potential delamination growth)
    - Damage threshold?
    - Punch through criteria?
  - Need definition of practical period of unrepaired service usage

Lightning Damage (2 of 2)

- **Inspection and maintenance for cause?**
  - **Threat Relationship to Inspection & Repair (Thresholds?) see chart 6**
  - **Monitoring magnitude of individual lightning events**
    - **Is monitoring of event possible? (measuring of line surges and recording exceedances?)**
    - **Test data for correlation of lightning magnitude to localized damage based on laminate and protection layer properties**
    - **Maintaining conductivity, see ANA briefing**
- **Potential for cumulative damage and damage growth**
  - **Period of continued usage without immediate inspection repair action? (see chart 6)**
  - **PRIME airframe lead -- Aircraft Maintenance Manual, AMM**

Damage Threats – Status Matrix of Service Induced Impact Damage

Threat	Test Protocol	Simulation Models	Threat Allowable	Self Evident Event	Impact Location(s); Zones 1 & 2
Bird Strike	Gel-pack	Yes	"B" FAR's (Wt. & Vel.)	Yes	YES
Hail	Simulated Hail Ice, SHI?	Yes Maturing	"B" Up-date MIL HDBK 310	Yes	YES
Runway Debris	Lead Ball ? Drop-tower?	?	"B" Up-date JSSG-2006 ?	Sometimes	Usually
Tire Rupture	Rubber Puck	?	AC25.963-1	Yes	YES
Panels Lost In-flight	?	?	?	Yes	Sometimes
Tool-drop	Steel or Aluminum Hemisphere Drop-tower	?	JSSG-2006 Structures	Sometimes	Yes
Incidental Contact With Ground Vehicles	TBD	TBD	TBD	Sometimes ?	Yes
Others? Lighting Strike	----	-----	-----	-----	-----

more effort needed in lightning

Damage Threats (1)

- **"Known" threats:**
  - **tool drop, bird/hail/tire strike, rotor bust, runway debris/FOD, lightning, vehicle/GSE contact – blunt impact**
  - **hard landing, overload**
  - **(more??)**
  - **extensive list in Aircraft Maintenance Manual Ch. 5**
- **Threats not previously mentioned**
- **Novel, unusual, and/or perceived threats**
  - **bullets (e.g., from Air Marshall)**

Damage Threats (2)

- **Threats that are unique to composites (i.e., that are not of concern to metal)**
  - **hot exhaust from ground vehicles or other localized heat source**
  - **UV degradation**
  - **chemical attack**

- **Other topics?**

Protection Schemes

- **Identification**
  - **motion sensors (existing sensors in a/c?)**
  - **pressure sensitive paints**
  - **vacuum patch system indicating presence of damage**
- **Mitigation**
  - **blanket pads / bumpers**
- **Deference**
  - **barricades around a/c to maintain standoff distance**
  - **hazard markings in areas of concern**
  - **proximity sensors**
  - **electro-magnetic "invisible fence" – warning alarms as well as stopping motion of vehicles/equipment**
- **Other topics?**

Performance Based Inspection Criteria

- When?
  - e.g., when does blunt impact event occur? vs. known event such as bird strike
  - can be based on Damage Thresholds?
- What?
  - Decision criteria -> Damage Categories, ADL, Critical Damage
- Where?

- How?
  - What technology needed?

Answers to the above questions are needed before putting system in place.