Applications and Service Experience

(Aircraft Operators)

•Lightning strike damage is a significant maintenance concern

• Expectations that future aircraft designs will sustain no significant damage from high energy lightning strikes common in Japanese winters. This does not assume that lightning strike damage will never occur.

• Expectations that OEM's will supply guidance based on typical damage events of critical regions to inspect (lightning strike, blunt impact).

• PDA Parts Departing form Aircraft (typically secondary structures) is a significant operator concern (ground safety, aircraft dispatch, image). Expectations are that OEM's will make improvements in part robustness to significantly reduce the occurrence of PDA's.

•Efforts to maintain "correct" conductivity between composite structures and ground planes (metal structures) has resulted in reduction of lighting strike damage on some parts.

Applications and Service Experience

(Aircraft Operators)

•Small changes in allowable damage limits (currently:15%, proposed: 20%) may result in significant reductions in the required repairs from lightning damaged metal structures.

• Lack of availability of approved data for repairs results in undesirable longer more complex repair design efforts.

•Damage detection is still generally visual supported by tap test. Under certain cases directed NDI is needed for specific service problems.
•80% of AD's requires some sort of NDI

•Damage is often times hard to distinguish from internal features and old repairs resulting in unneeded repairs or damage missed ("walk away").

•Paint cracking still a significant problem on some parts.

•Challenges faced in composite repair include: special training, extremely process dependant repairs, standardized repairs for cosmetic repairs only, large amount of materials required with limited availability.

Applications and Service Experience

•Update of rudder structural investigations previously reported in Amsterdam

- Studies revealed that the disbond can propagate due to the ground-air-ground cycle and can lead to rapid and significant reduction of the structural capability.

- Contributing design details include thin face sheets and low density core

- Possible sources for disbond initiation due to improperly performed repairs and fluid ingress heated over T=100□C.

- Disbond propagation within sandwich structure is mode I tension dominated.

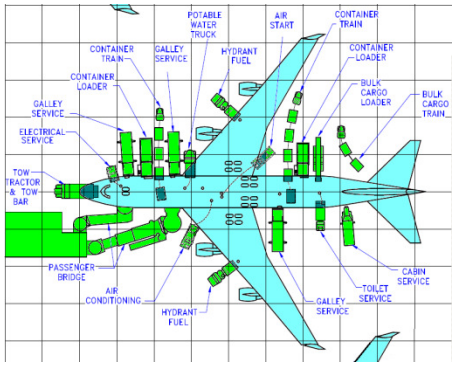
- Large scatter in core fracture properties (G1C) observed. Scatter results in high variation of residual life (low propagation rates for high G1C values)

Damage Threat & Inspection Strategies

•Primary composite threats relate to discrete source events, accidental impact, environmental damage, and inadequate repair.

•Small defect growth can occur in rare cases.

•Various impact threats pose complexities that don't simply lead to universal impact standard



Damage Threat & Inspection Strategies

- Damage Categories Reviewed

Category	Examples
Category 1: Allowable damage that may go undetected, or allowable mfg defects	**BVID, scratches, gouges, and allowable mfg. defects that retain ultimate load for life**
Category 2: Damage with sufficient residual strength to be detected by scheduled or directed inspection	**VID (ranging small to large), deep gouges, mfg. defects/mistakes, major *local* heat or environmental degradation that retain limit load until found**
Category 3: Obvious damage detected within a few flights by operations focal	**Damage obvious to operations in a "walk-around" inspection or loss of form/fit/function that retain *near* limit load strength until found by operations**
Category 4: Discrete source damage known by pilot to limit flight maneuvers	**Damage in flight from events that are obvious to pilot (rotor burst, bird-strike, lightning, severe in-flight hail)**
Category 5: Severe damage created by anomalous ground or flight events	**Damage occurring due to rare service events or to an extent beyond that considered in design, which must be reported by operations for immediate action**

Damage Threat & Inspection Strategies

•Damage Classification of Repairs by Structural Demand

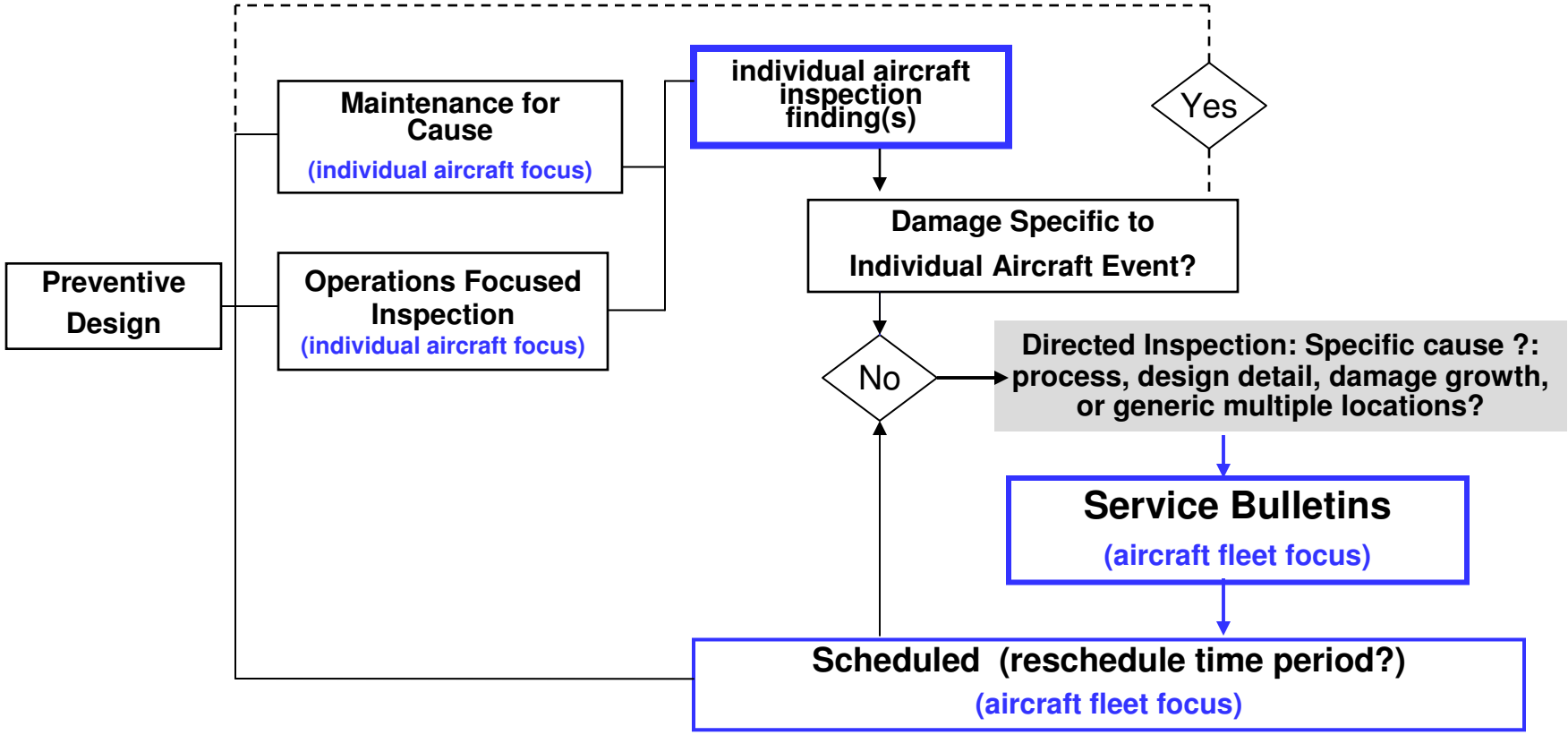
Category of Damage	Substantiation Considerations	Class of Repair	
Category 1: Damage that may go undetected by field inspection methods (detection not required)	Demonstrate reliable service life. Retain ultimate load capability. Used to define retirement.	***Class 1:*** Ultimate capability with repair failed.	**ADL**
Category 2: Damage detected by field inspection	Demonstrate reliable inspection. Retain limit load capability. Used to define maintenance	***Class 2:*** Limit capability with repair failed. Ultimate capability with repair intact.	**RDL**
Category 3: Obvious damage detected within a few flights	Demonstrate quick detection. Retain limit load capability. Used to define operations actions		
Category 4: Discrete source damage and pilot limits flight maneuvers	Define discrete-source events. Retain "Get Home" capability. Used to define operations actions.	***Class 3*** Beyond current **bonded repair** technology state-of-the-art Bolted Repair?	
Category 5: Severe damage created by anomalous ground or flight events	Repair generally beyond design validation (known to operations). May require new substantiation		

Overlapping 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

Damage Threat & Inspection Strategies

Layered Inspection Strategy



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	----	-----	-----	-----	-----

Should Damage Tolerance Threat Requirements be Defined by a "B or A Level Threat Allowable"?

Damage Tolerance and Repair Substantiation

- Composite damage tolerance and repair substantiation data/analysis are generally not publicly available
  - Highly dependent on design details
  - Semi-empirical, expensive & proprietary

- Bond strength can be significantly impacted by:
  - Substrate laminate moisture saturation can reduce bond strength (even after dry cycle).
  - Cure errors
  - Impact damage

- Remaining subjects are summarized in individual Breakout Session Summeries