

# Nondestructive Testing Contributions to the Effective Management of Aging Aircraft

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# *Aerospace Challenges*

- Strength and weight considerations result in aggressive structural performance design criteria
- Programs consistently push design limits in performance and lifetime predictions
- Space systems have little or no failure tolerance.
- Aging aircraft are flown well past their predicted design lifetimes



# *Aging System Challenges*

- Healthy systems can perform well into extended lifetimes
- Defect detection requirements range from identification of life limiting problems to predictive failures
- Economical maintenance of aging structures balances detection/repair with costs of continued usage

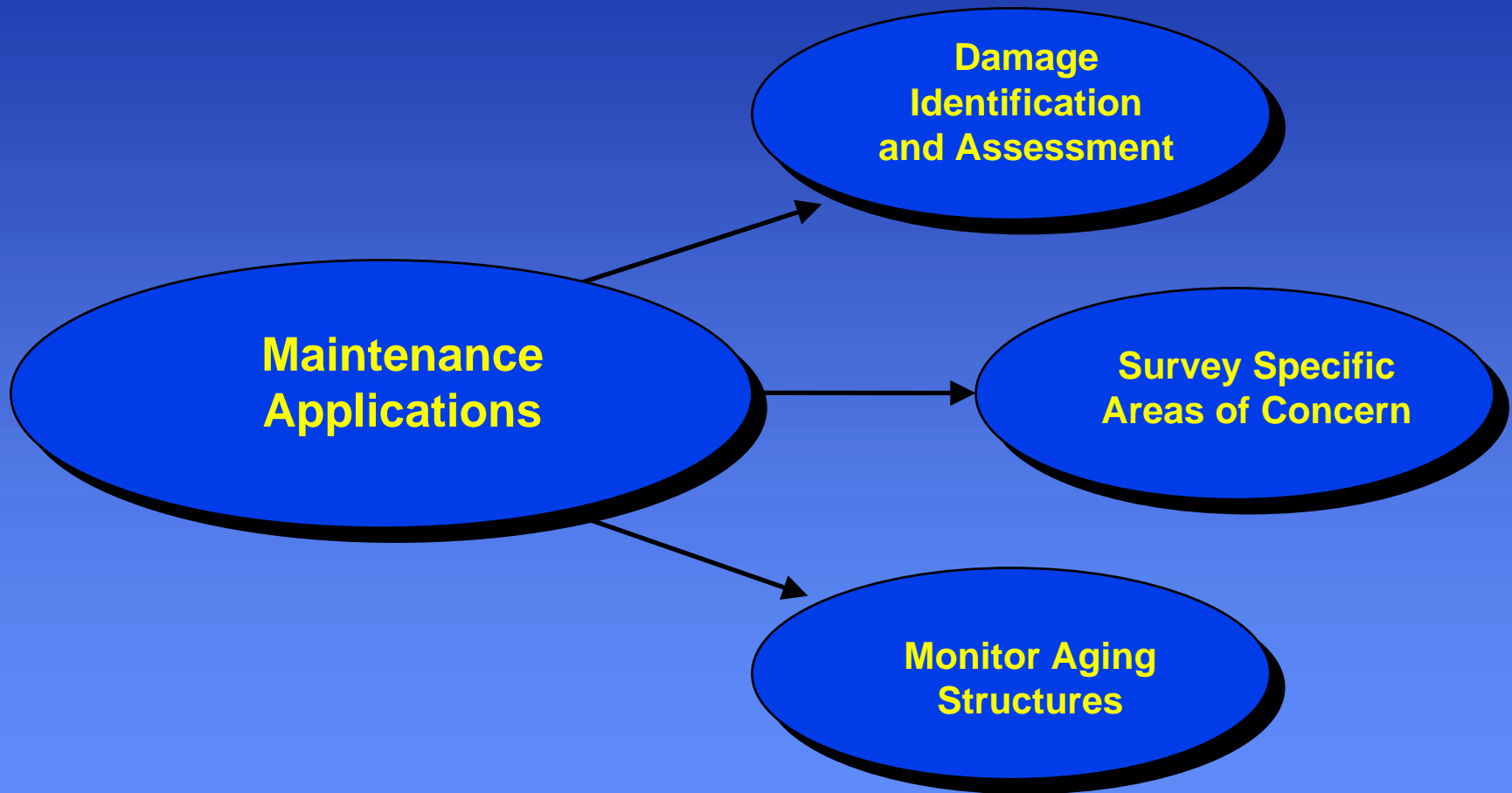


# *Nondestructive Testing*

- Nondestructive testing verifies structural quality without incurring irreversible damage to the structure
  - Identifies defects arising from unexpected loads and stresses
  - Verifies structural analysis and life predictions
  - Used throughout the life of critical structures



# *Inspection Considerations*



# *Nondestructive Testing*

- Aerospace NDT Considerations
  - There are many types of materials and structures encountered within an airframe or space system
  - Potential defects may be created during production or in-service
  - Aging defects include delaminations, cracks, and corrosion
  - Inspectors may be searching for one or several types of defects within the same structure
  - Defect is not always critical to the performance of the structure
  - Defect monitoring is often the preferred approach until the defect size is significant

# *Advantages of Area Images*

- Complex structures can be difficult to inspect manually since variations within the structure affect the signal response of the sensor
- Sensor signals contain a wealth of information if the indications can be correctly identified
- Digital interpretation provides additional information to categorize signal responses due to the physical characteristics in the structure
- Supports communication between NDI and maintenance personnel

Shim or support plate behind flange



Rib

Honeycomb core

Pulse-echo Amplitude C-scan of 757 Rudder - Upper Section of Rudder

# *Corrosion Detection*

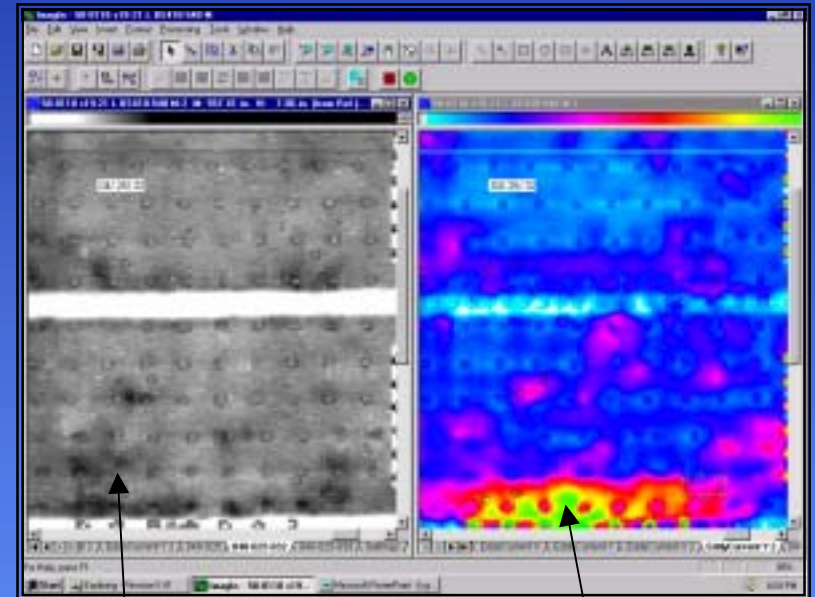
- Aging tanker fleet is over forty years old
- Life extension estimates for another thirty years
- Limited cycles result in corrosion issues rather than cracking concerns
- Maintenance programs established to identify/repair corrosion in all doubled surfaces and lap seams
- Critical elements
  - Cost of inspection
  - Production flow time
  - Logistics planning



# Corrosion Detection



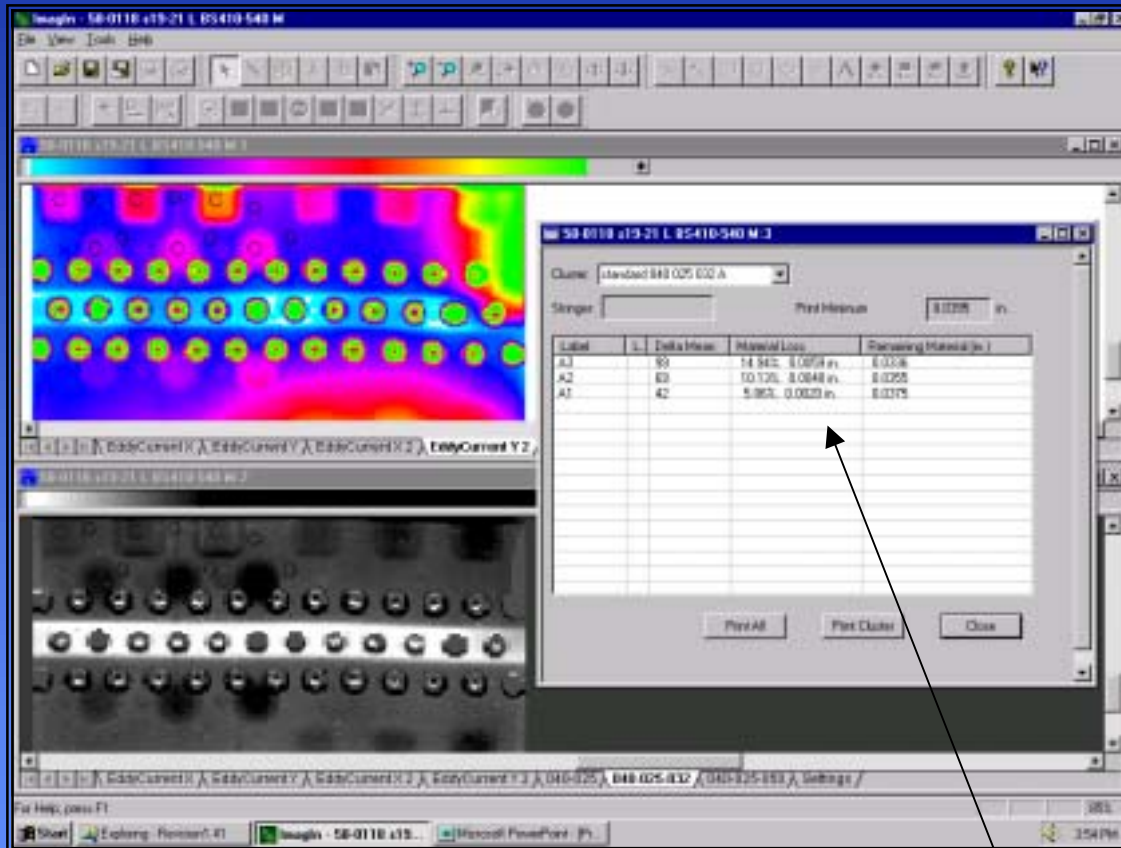
MAUS scanner on bottom of fuselage



Actual corrosion

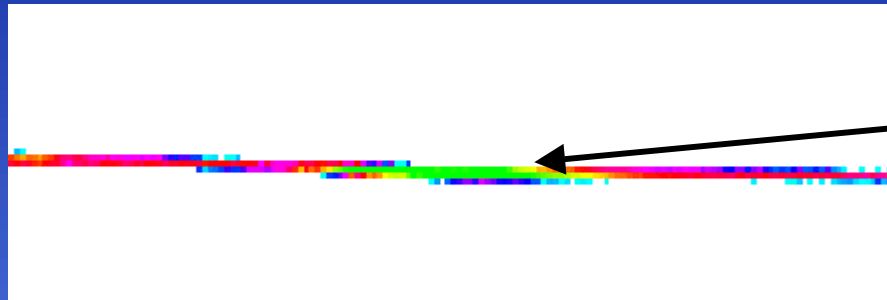
Larger initial corrosion indication

# Corrosion Detection



Summary report describes corrosion extent and remaining material

# Crack Detection

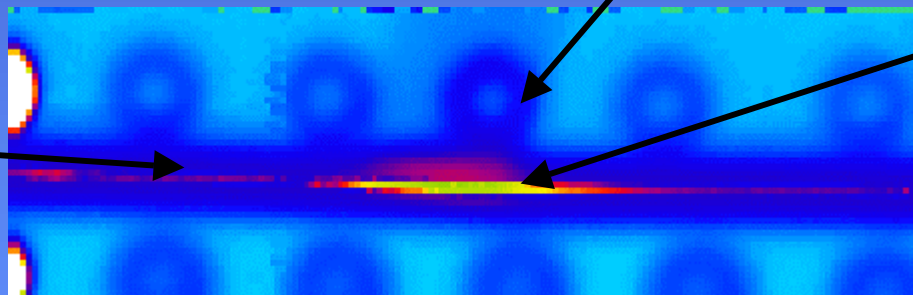


Crack indication –  
Response increases  
when probe is over  
crack

Crack indication on fastener  
inspection – no crack found when  
fastener removed

Crack indication  
overlay with  
fastener/seam  
information

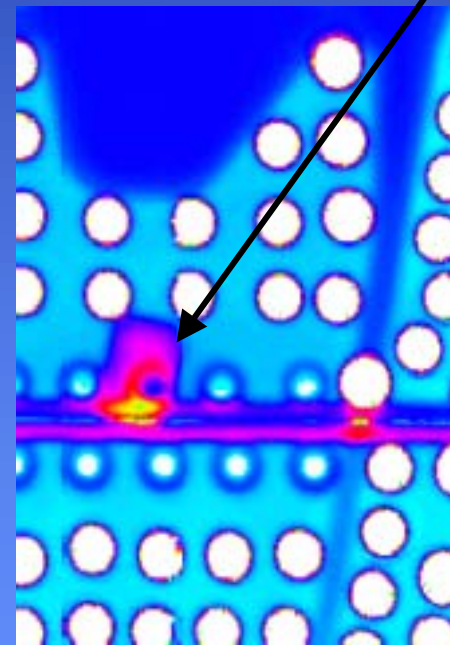
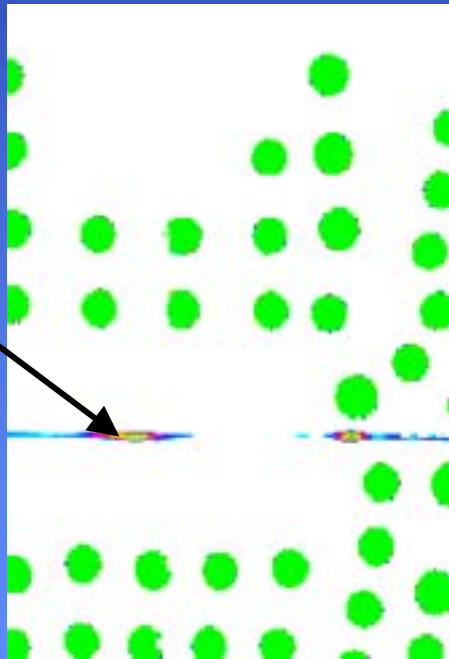
MAUS scan added  
other elements in  
probe response



# Crack Detection

Full C-scan shows  
conductive material  
between skin and  
splice plate

Line scan  
setup with  
crack  
indication



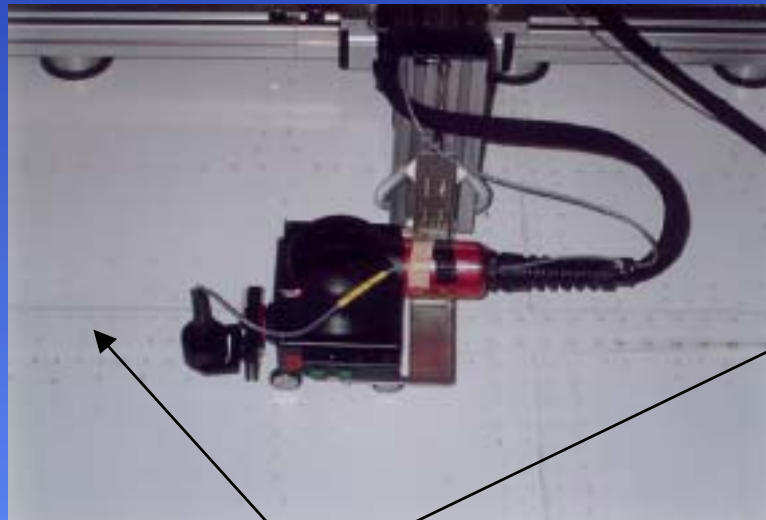
# *DC-10/MD-11 Crown Skin*



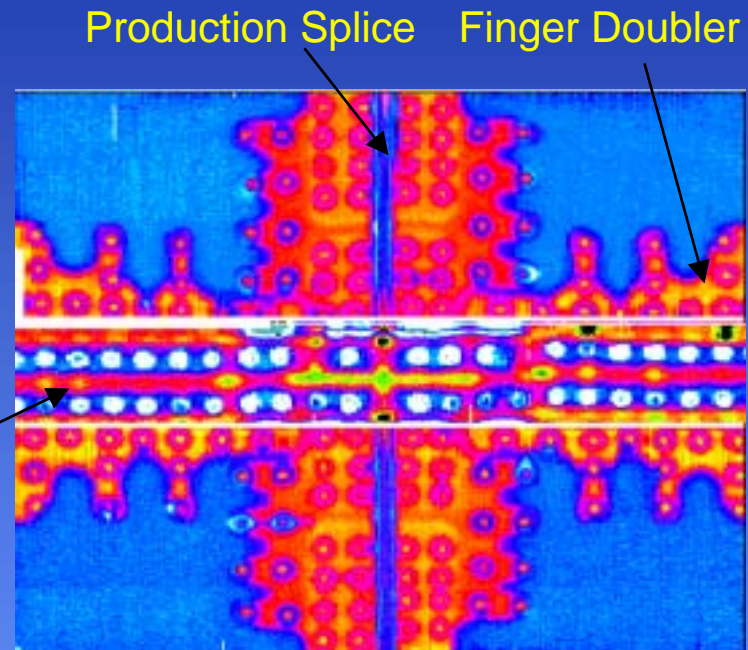
- Inspection required for structural integrity monitoring program
- Searching for fatigue cracks in up to four layers of aluminum in the skin joints
- Alternate Means of Compliance granted by FAA in June, 1996
- Inspections performed at United, Finnair and Northwest Airlines.

Inspection performed on Longeron 5R,  
Near station 1152

# DC-10/MD-11 Crown Skin



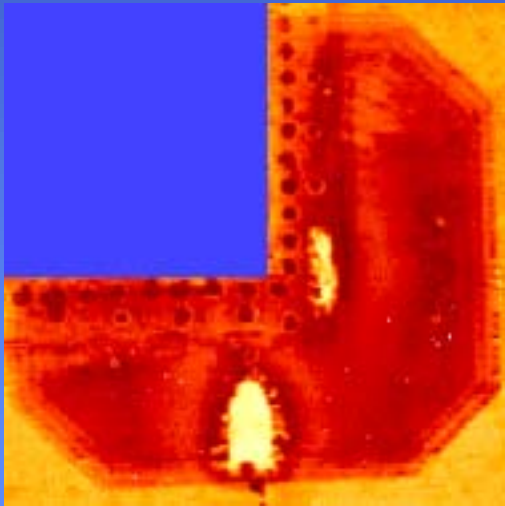
Longeron 5



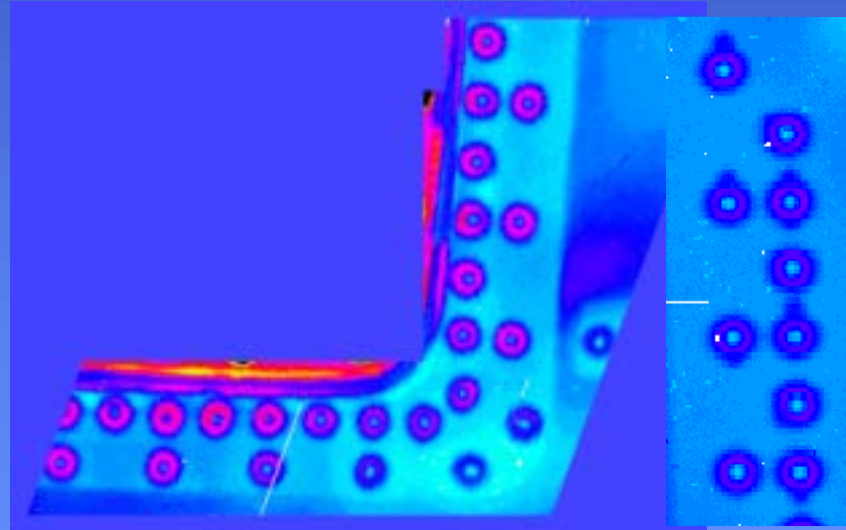
Eddy Current C-scan Image of Inspection Standard

# *Structural Repairs*

- Composite patch applied over fatigue cracks
- Provides alternate load path to relieve the crack site
- Need to monitor quality of adhesive bond
- Also need to monitor crack growth under patch



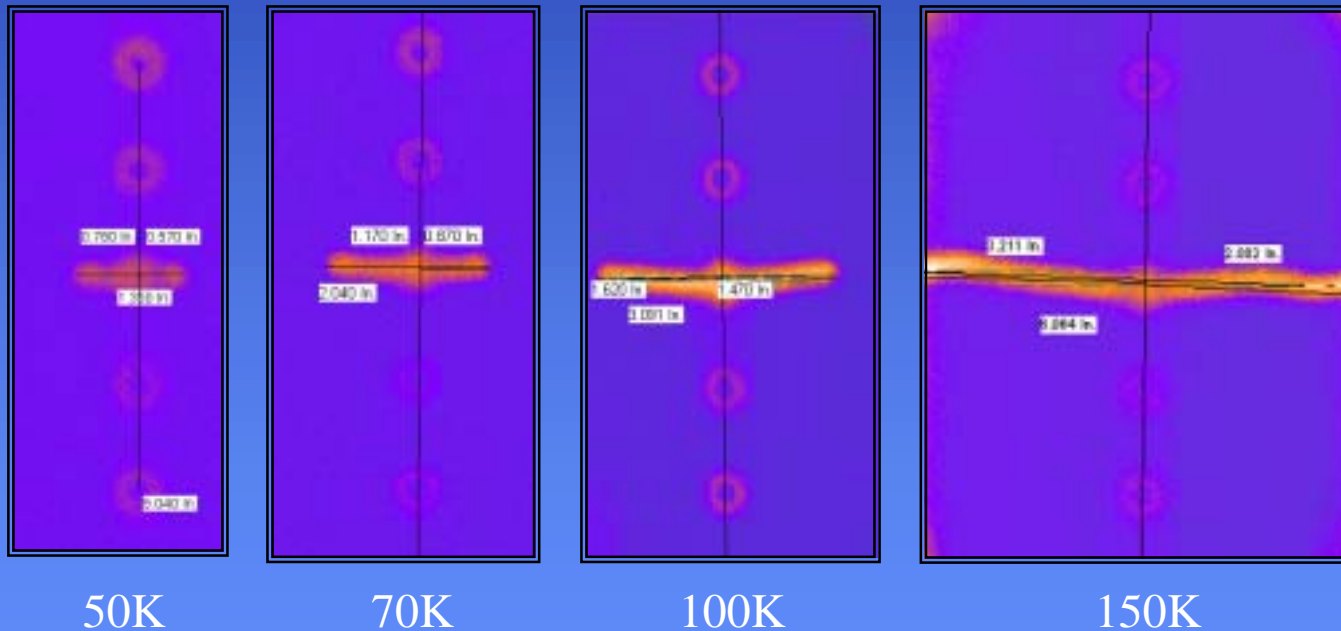
Resonance – Bond Test



Eddy current - Crack monitoring

# *Structural Repairs*

- Periodic NDI of crack growth under repair patch during fatigue cycling supports crack growth characterization



Eddy current C-scan of fatigue crack growth under repair patch

# Conclusions

Maintenance of aging structures incorporates:

- Structural integrity modeling
  - Identify areas of high stress/loads
  - Predict defect initiation and growth
- Nondestructive inspection
  - Evaluate structures after unexpected load
  - Periodic survey of likely defect sites
- Maintenance planning
  - Receives input from structures and NDI
  - Schedules remediation for critical defects
  - Logistics planning for future repair work
- Advantages
  - Saves time\reduces unnecessary work
  - Reduces aircraft downtime
  - Improves material/labor planning

