

Practical Application of AFGROW for Substantiating Deferred Maintenance

AFGROW Users Workshop 2015

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Background

- Small fleet
 - 32 Aircraft
- Scheduled Depot Maintenance and Modification
 - Known intervals (GAG cycles and flight hours)
- Sustainment Engineering
 - Responsible for Depot Repairs, Field Support, and Fleet Management
 - Design repairs primarily with Equivalent Strength

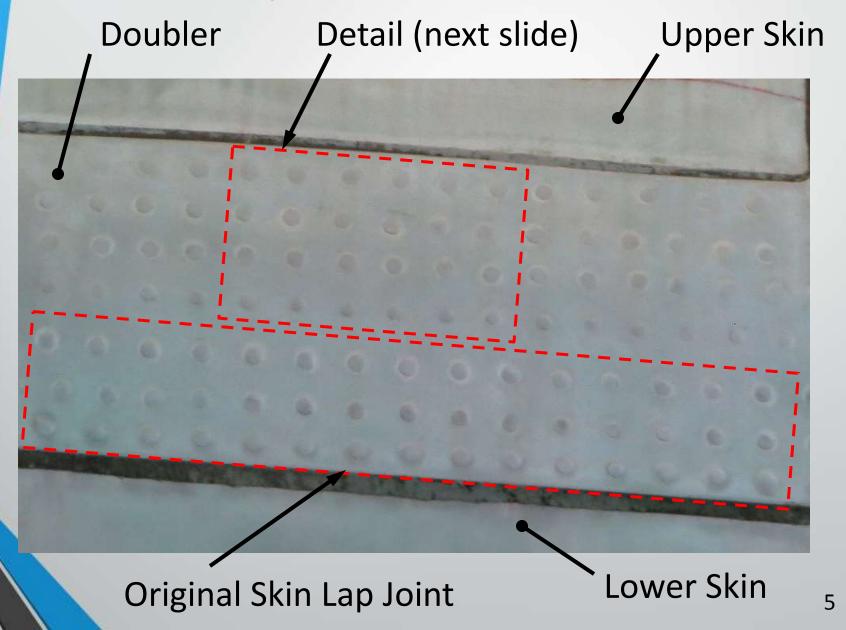
Approach

- Many unknowns
 - Spectrum, Beta factors
- Relative life vs. Analytical life
 - Impact analysis
- Lots of Conservatism + Scatter Factor
 - Still enough life to meet requirements

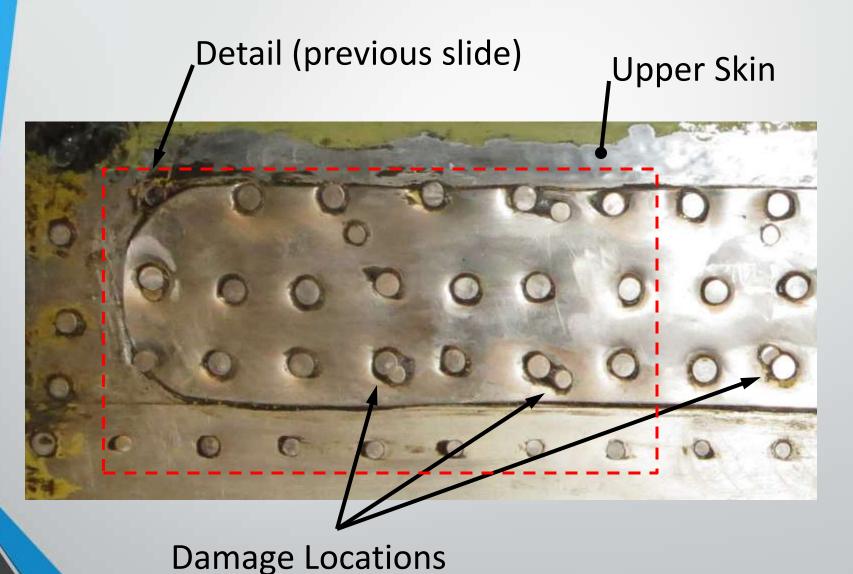
Example

- Large incoming repair
 - Doubler on fuselage skin at circumferential lap joint
- Extra holes and "snowman" holes
- Did not meet T.O. standards for pressurized skin repair
- Removing the repair would cause:
 - Skin replacement
 - Schedule impact
- Customer requested to defer replacement to next PDM

Example (External View)

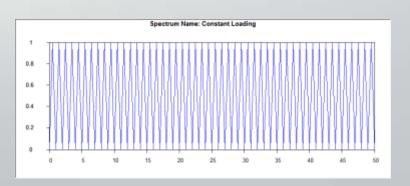


Example (Internal View)



Loading

- ASSUME: Primarily loaded from pressure
- For a thin walled pressure vessel:
 Hoop Stress = Pressure x Radius / Thickness
- AFGROW Inputs
 - Constant Amplitude Loading
 - SMF = Pressure Vessel Stress
 - R = 0



Material

- Only source of data is through AFGROW
- Increase confidence with impact analysis of available Material Models

Model	Material	Cycles
NASGRO	2024-T3 Al, [Clad; plt & sht; L-T]	114,000
NASGRO	2024-T3 Al, [Clad; plt & sht; T-L]	141,300
Harter T-Method	2024 T-3 Bare Sheet LONG CRACK DATA	158,600

Model

Aircraft Damage:



- AFGROW Classic Models
 - Does not represent aircraft
 - Fast
- FE Model
 - More accurate
 - Increased cost and time
- AFGROW Advanced Models
 - Ability to quickly vary geometry to determine "worst case"

Model

Aircraft Damage:



Modeled as

A:

 Classic Model; Strip of material around damaged hole; 2 crack fronts

B:

 Advanced Model; 3 holes; Includes 2 crack fronts

Model

Aircraft Damage:



Modeled as

C: ______

 Advanced model; 5 holes, Includes 3 crack fronts

D: _____

 Advanced model; 5 holes, Includes 4 crack fronts

Failure

- Crack growth at 1.15 Factors of Pressure
 - Outflow valve designed with +15% pressure tolerance
- Residual Strength of 3.0 Factors of Pressure
 - Value used for static strength analysis of damage
- No crack growth beyond holes

Results

Holes	Crack Fronts	Failure Mode	Cycles
1	2	Net Section Yield	10,550
3	2	Crack Transition to Hole	43,950
5	3	Crack Transition to Hole	48,200
5	4	Net Section Yield	42,100

Classic Model

- Does not represent structure (overly conservative)
- Scatter Factor of 4 still results in life >> GAG cycles until next PDM

Advanced Models

- More closely represents structure
- "Snowman" holes assumed to be one hole with cracks started on both sides
- Skin replacement deferred to next PDM!!!

Comments

- No pin load in advanced models
- Back-of-the-envelope type of calculations
 - Decision based on order of magnitude
- Haven't found damage that will fail before next PDM
 - Resilient airframe? Bad assumptions?
 - Fatigue is generally not a problem on airframe
- Quick Go-No Go analysis to minimize schedule impact from a delayed decision