POD Results: Ultrasonic Inspection of the B-1B Wing Carry Through

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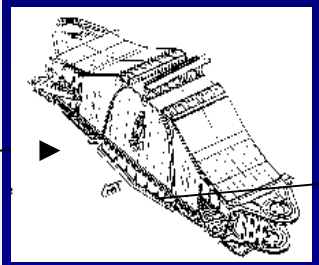
Status of WCT Inspection

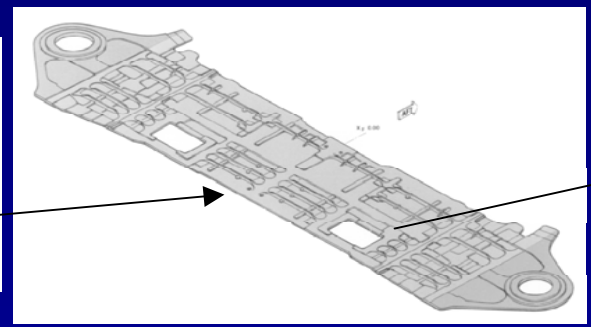
- Initially primary focus of program
  - Additional analysis shifted focus to Wing Splice during the program
- Work completed for program:
  - Inspection technique
  - Inspection procedure
  - Prototype specialized scanner
  - Probability of Detection Study

WCT Inspection Requirements

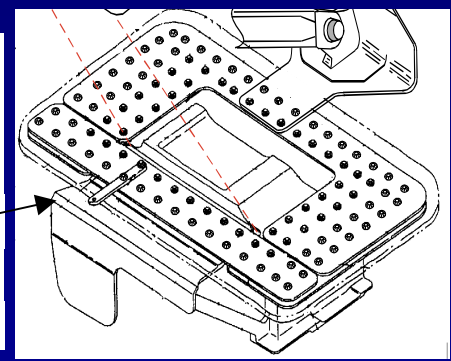
- 4 layers titanium structure, each layer 0.180" thick
- Detect cracks at faying surfaces of layer 2 (required), layer 3 (preferred), plus layer 4 (if possible)
- Critical flaw size: 0.080" corner flaw (initially through-wall)
- Cracks can emanate 360° from fastener
- Perform inspection with no aircraft disassembly

Wing Carry Through





WCT Lower Surface



Area to be inspected

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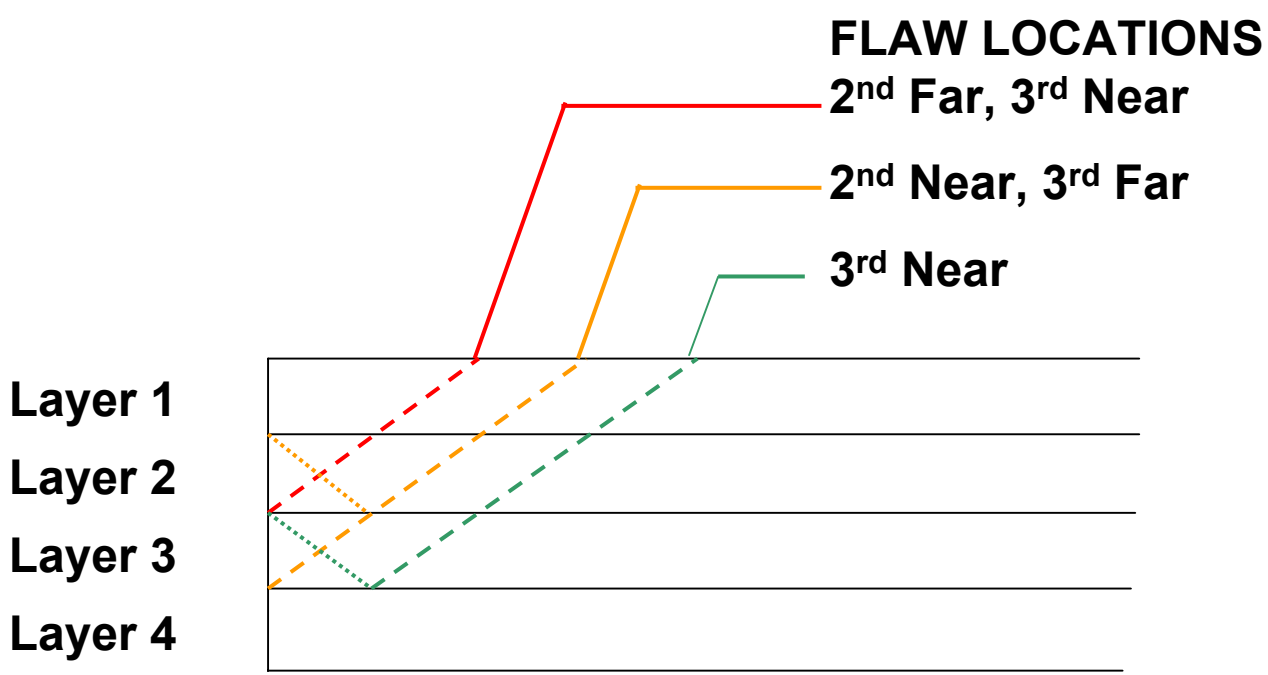
WCT Inspection Development

- Initial assessment
- Development of inspection technique
  - Sealant couples ultrasonic energy to all required layers
  - Rotary scanner to cover all cracks at 360°
  - Two transducers for detecting defects from two directions: redundant inspection
- Initial manual rotary scanner developed
- On-aircraft evaluation completed
- Prototype automated rotary scanner developed

Ultrasonic Paths to Detect Flaws



Probability of Detection Study

- Validation of inspection technique
- One of two samples did not have representative faying surface characteristics and was not used
- Flaws located at both faying surfaces for second and third layer
- Combine EDM notches and fatigue cracks at one surface: second layer far
- Flaw size distribution to meet desired objective of detecting 0.080" corner flaws

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Flaw Distribution

Flaws distributed by quadrants for each fastener to minimize total samples required: 4 inspection sites per fastener

Layer – Surface – defect type	Flaw size (inch)								Flaw quadrant			
	0.013	0.019	0.028	0.040	0.058	0.083	0.120	Tot	aft	inbd	fwd	obd
2nd – Near - notch	1	2	0	1	1	1	1	7	3	1	1	2
2nd – Far –fatigue	1	4#	1*	3	5+	0	3	17	4	5	3	5
2nd – Far - notch	1	1	0	1	2	3	2	10	2	2	3	3
3rd – Near - notch	2	1	1	1	1	2	1	9	2	2	3	2
3rd – Far - notch	2	1	1	1	2	1	1	9	2	3	2	2
Totals	7	9	3	7	11	7	8	52	13	13	12	14

#Includes 0.020"
*Measured 0.030"
+Includes 0.051", 0.054"

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PoD Data Collection

- Five inspectors collected PoD data
  - Four at OO-ALC, one at SAIC

PoD data collection at OO-ALC

Results of PoD Study

Flaw location	2nd layer – far			2nd – near & 3rd - far	3rd - near
Flaw quadrant	fwd	Inboard & outboard	aft	forward	forward
90% detection	0.030"	0.051"	0.091"	0.063"	0.108"
90/95% confidence	0.047"	0.067"	0.128"		

- Forward quadrant always more sensitive
  - Adjustments to rotary scanner holder and motors to balance load should yield data in all quadrants similar to forward quadrant
- Insufficient amount of data to determine 90/95 values for flaws located at second layer far and third layer surfaces
  - Limited by using only one sample

Fatigue Crack Detection and False Calls

- No difference in sensitivity between EDM notches and fatigue cracks: sufficient statistics to determine this is true for differences less than 0.030"
- False call rate per quadrant: 0.6%
  - 5 False calls for 4 inspectors for 795 inspection opportunities with no flaws

Implications of PoD Results for WCT Inspection

- Minor improvements to Rotary Scanner will be necessary before deployment
  - Will yield PoD results that are similar to forward quadrant for all other quadrants
- With these minor improvements, requirements for this inspection will be met
- Inspection procedure completed and available for deployment when required
- Recommend that second PoD sample be refurbished and evaluated before deployment
  - Will provide additional statistical data for layer 3 and layer 2 far
  - Will provide improved accuracy in determining sensitivity change between fatigue cracks and EDM notches

B-1B Program Summary

- Wing Carry Through inspection procedure and prototype equipment developed
- Inspection ready for transition when needed
  - Minor enhancements to Rotary Scanner recommended