

Center for Aircraft Structural Life Extension

Providing Structural Integrity Technology to the Aerospace Community



USAF Academy Center for Aircraft Structural Life Extension (CAStLE)

T-38 Comparison of Usages and Proposed Spectra

SOUTHWEST RESEARCH INSTITUTE®

Michael Van Shaar, Jim Feiger, Tess Moran, and David Wieland

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U.S. AIR FORCE



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Objective:

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- Perform spectrum crack growth testing based on two fatigue critical locations (FCL) “A” and “B” as well as an “old” and “new” wing configuration
- Establish SOLR values for each FCL utilizing the spectrum crack growth data
- Perform DTA and compare the results based on usages and spectra
 - Usages = Initial, Advanced, and Specialized
 - Spectra = Current and Proposed
- Provide conclusions and recommendations for usages and spectra

Steps:

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- 1. Testing**
- 2. Shutoff Overload Ratio (SOLR)
Correlation**
- 3. Damage Tolerance Analysis (DTA)**
- 4. Conclusions**
- 5. Recommendations**

Steps:

USAF Academy Center for Aircraft Structural Life Extension (CAStLE)

1. Testing
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Spectrum Crack Growth Testing

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Test Resources

- Servohydraulic test frame
- Hydraulic wedge grips
- Fracture Technology Associates hardware/software test control system
- Traveling microscopes
 - Front surface, back surface, bore crack length measurements
- Anti-buckling constraints



Spectrum Crack Growth Testing

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Fatigue Critical Locations

■ Locations

- A-Old Wing: 7075 plate
- A-New Wing: 7475 plate
- B: 7075 plate

■ Coupon Geometry

- Corner crack in an offset hole in plate (transition to through-crack)
- L-T coupon orientation

FCL	Configuration	e/D	D/t
A-Old Wing	Offset Hole in a Plate	1.95	2.389
A-New Wing	Offset Hole in a Plate	2.18	3.45
B	Offset Hole in a Plate	1.96	2.675

Spectrum Crack Growth Testing

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Test Procedures

- Precracking
 - ~0.02” by 0.02” starter EDM notch
 - Final precrack length: ~0.04” (surface)
- Spectrum Loading
 - Single column end-point file (FTA endpoint file option)
 - Target/feedback verification
 - Constant load rate
- Crack Length Data Acquisition
 - Traveling microscopes (front surface, bore length, back surface)
- Test completed upon primary ligament failure (secondary cracking monitored on opposing side of hole)



Spectrum Crack Growth Testing

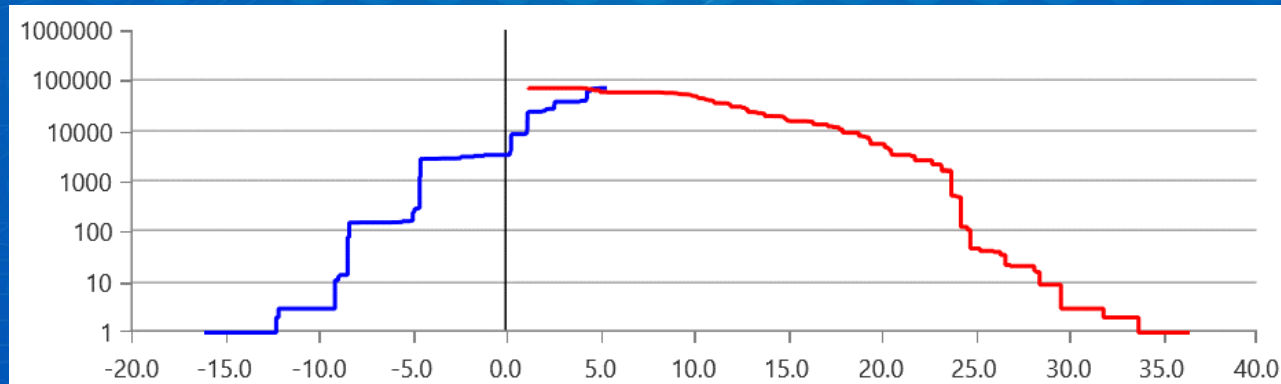
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FCL Spectrum Exceedance Curves

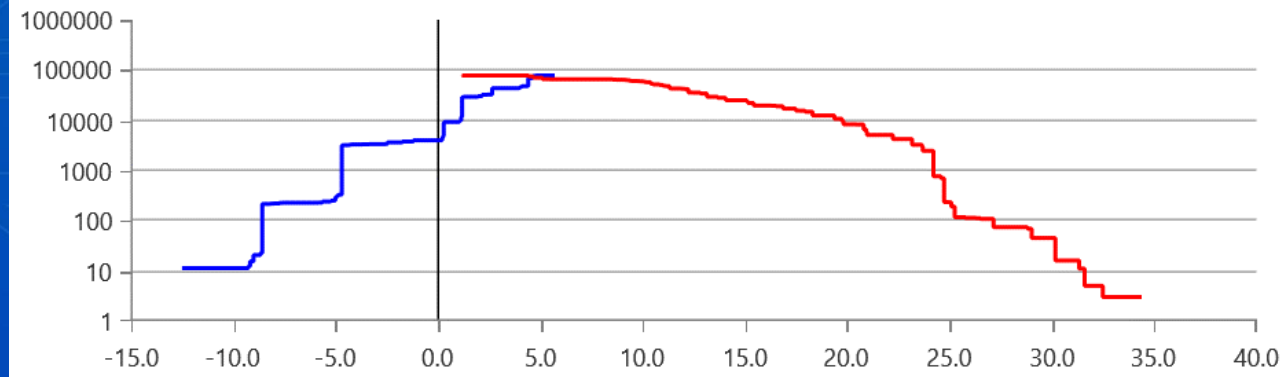
- Advanced Training Usage Spectra

Min Data
Max Data

Current



Proposed



Steps:

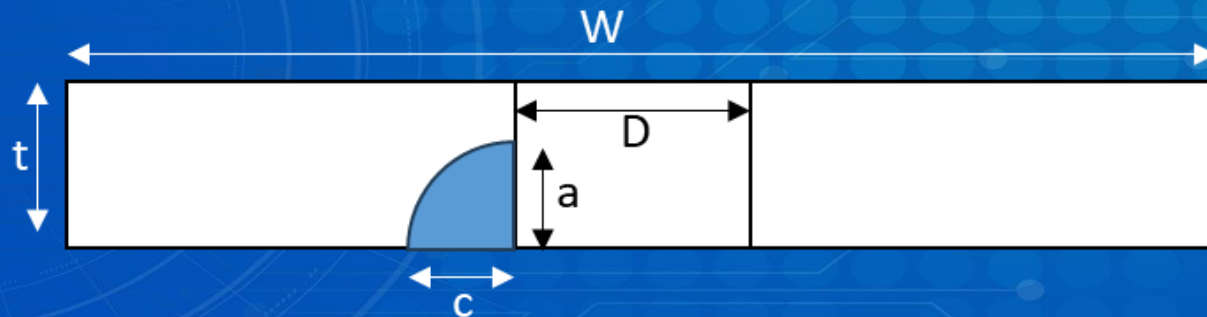
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1. Testing
2. **Shutoff Overload Ratio (SOLR)
Correlation**
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SOLR Correlation Inputs

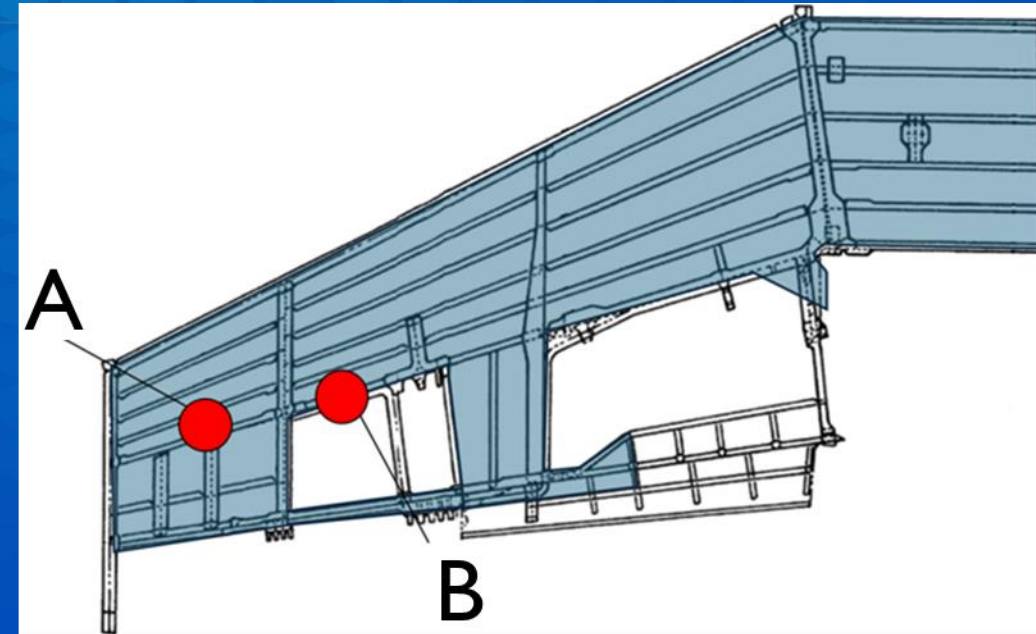
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FCL	Specimen ID	Usage	Crack Geometry	Width (W)	Thickness (T)	Hole Diameter (D)	Is the Hole Offset?	Hole Offset (B) or Fastener Spacing	Crack Length - 'C' Direction	Crack Length - 'A' Direction
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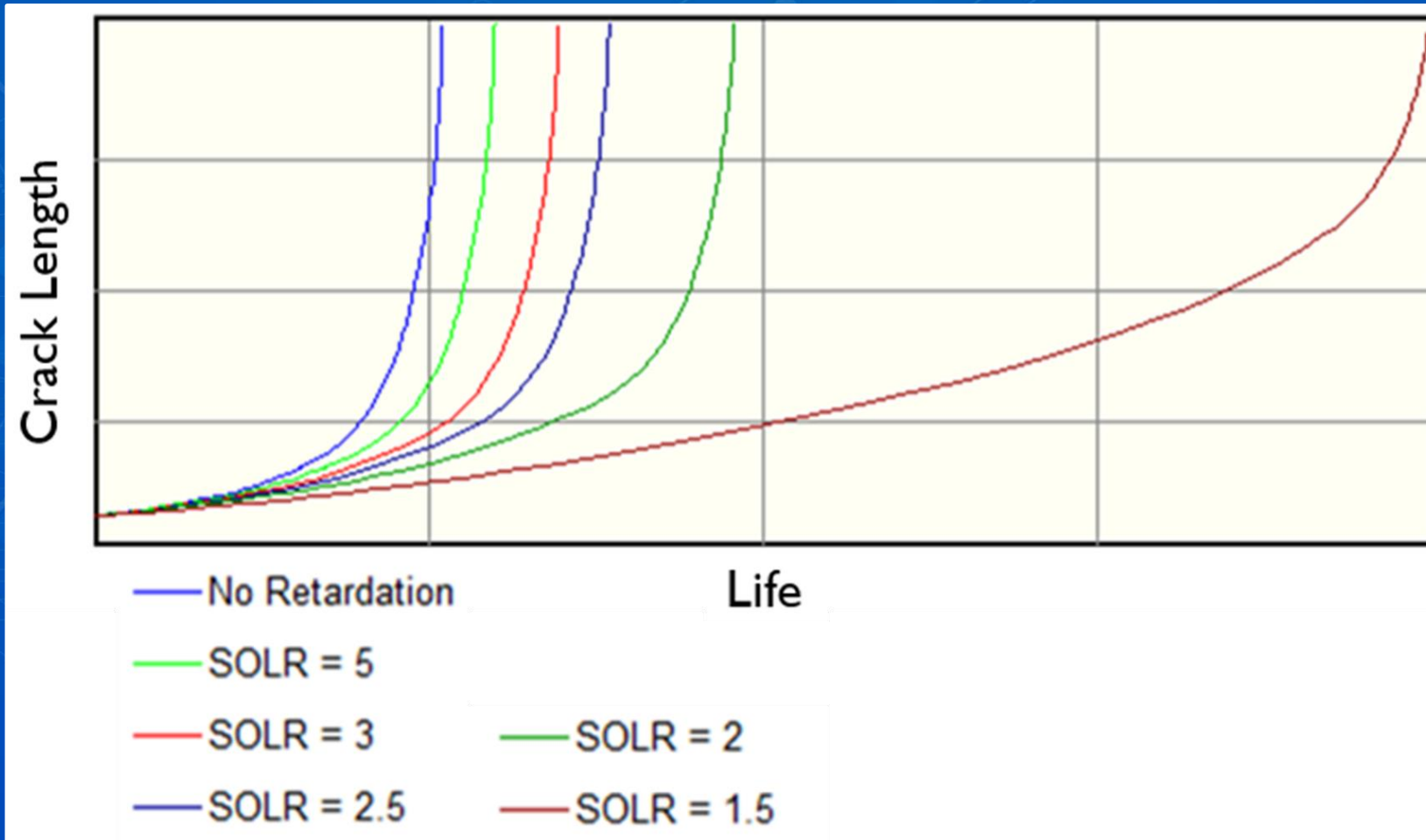
Fatigue Critical Locations (FCLs):

- A – Old Wing
- A – New Wing
- B



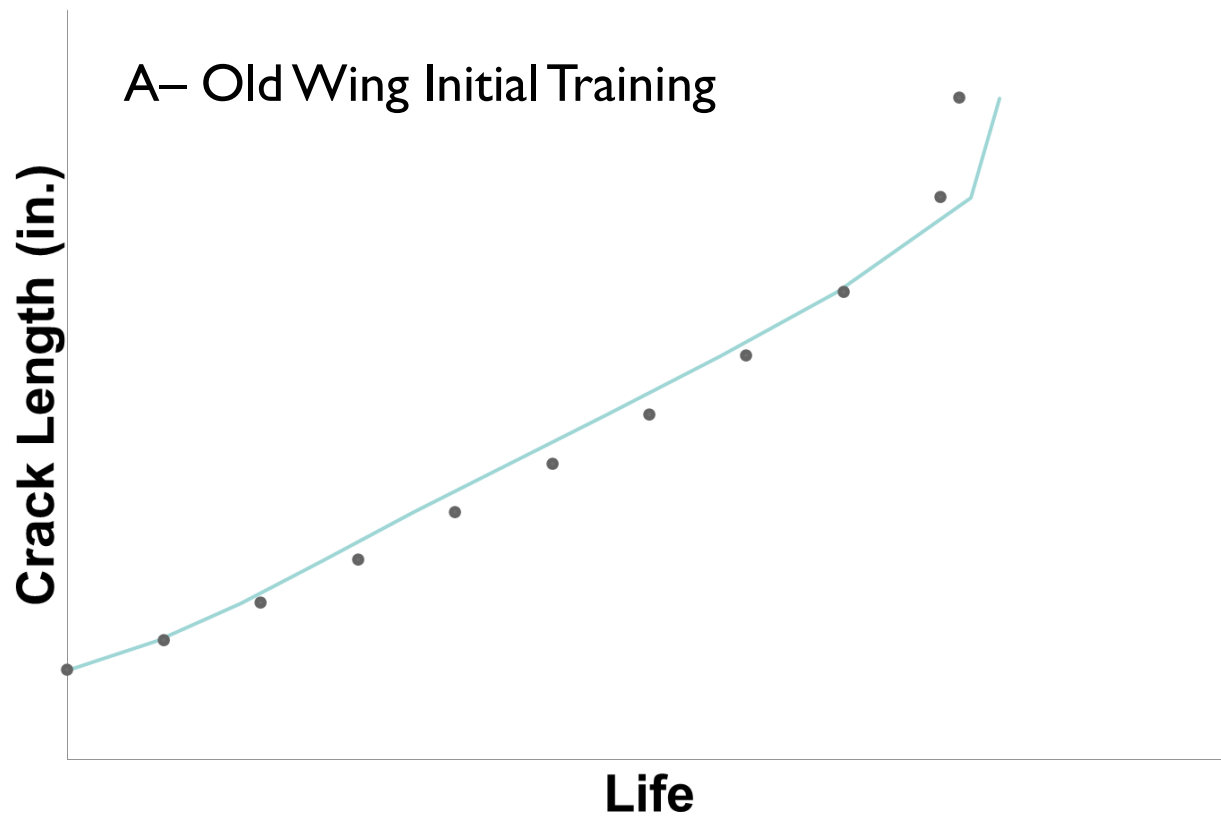
Shutoff Overload Ratio (SOLR)

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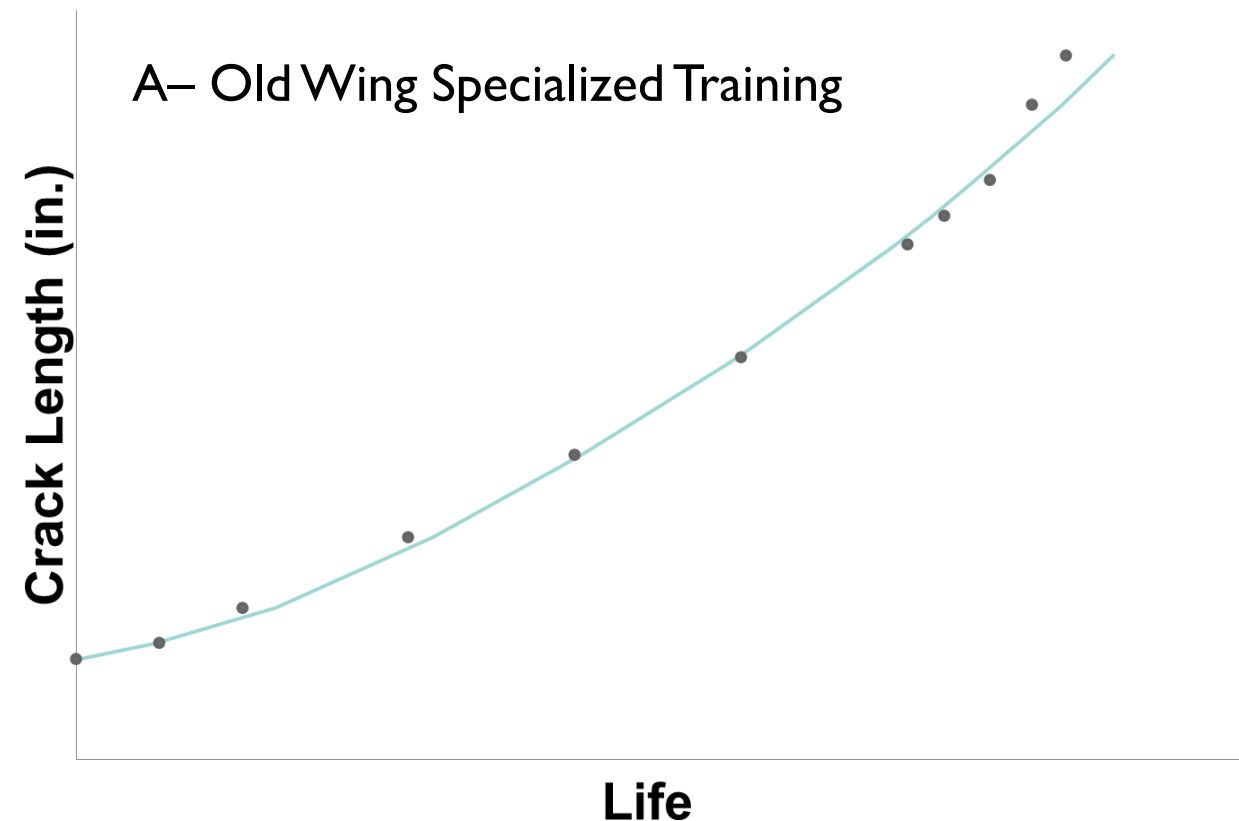


Plot Outputs: A- Old Wing

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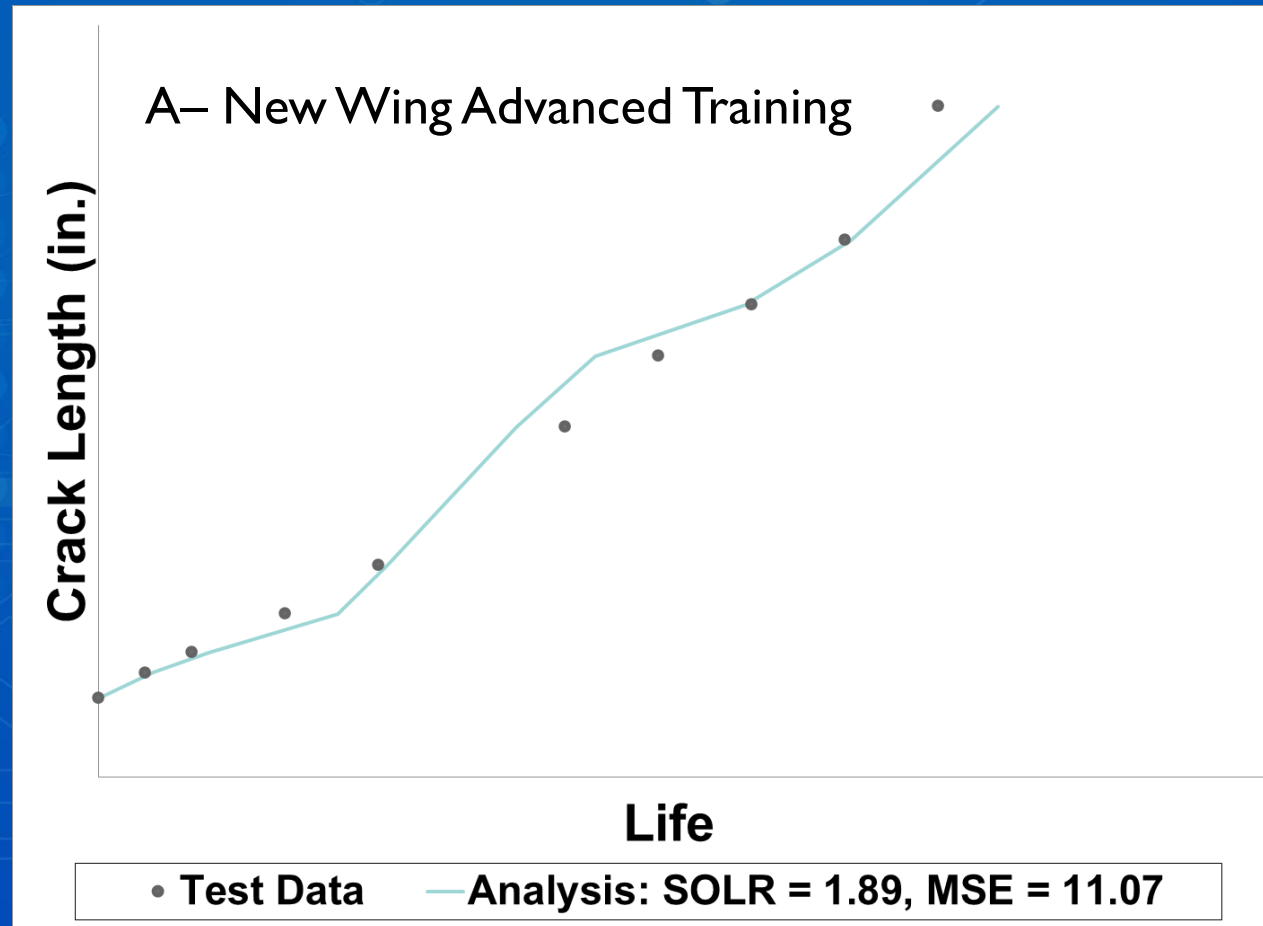
• Test Data — Analysis: SOLR = 2.93, MSE = 9.45



• Test Data — Analysis: SOLR = 4.22, MSE = 2.15

Plot Outputs: A- New Wing

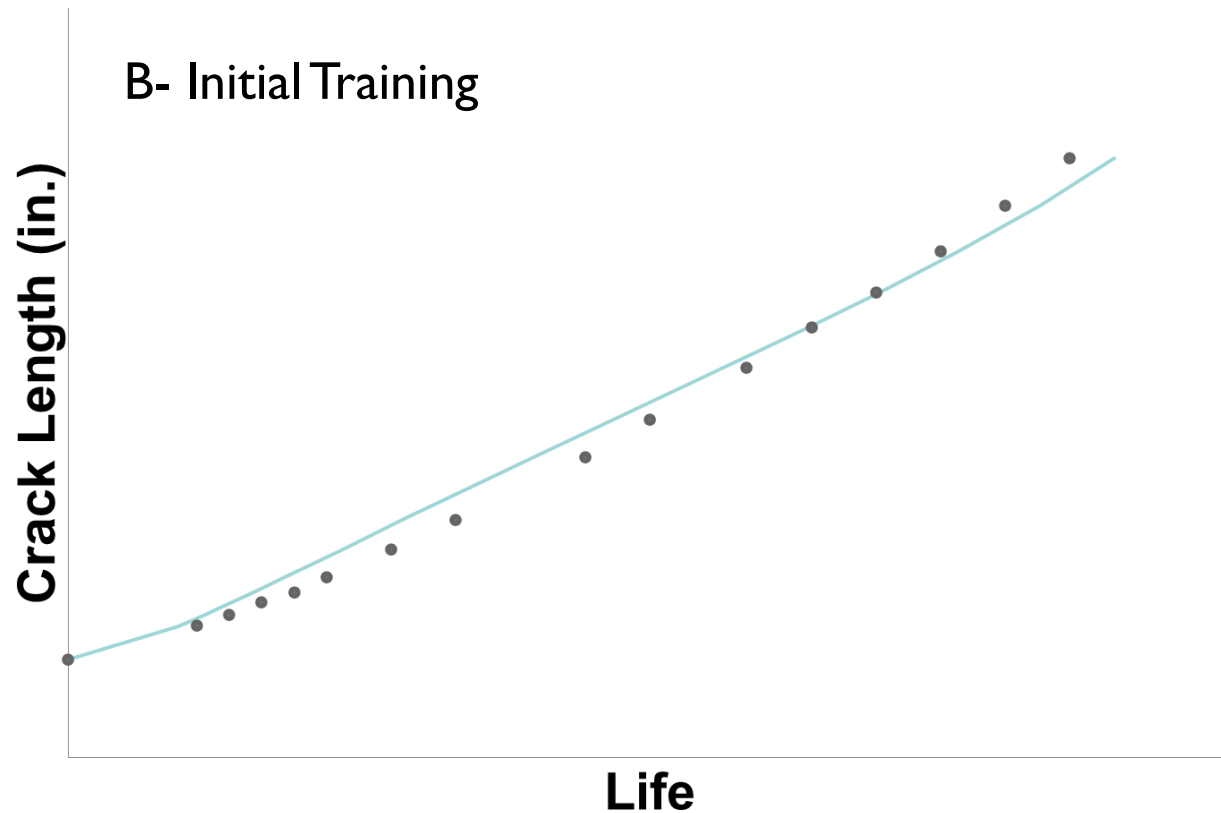
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Plot Outputs: B

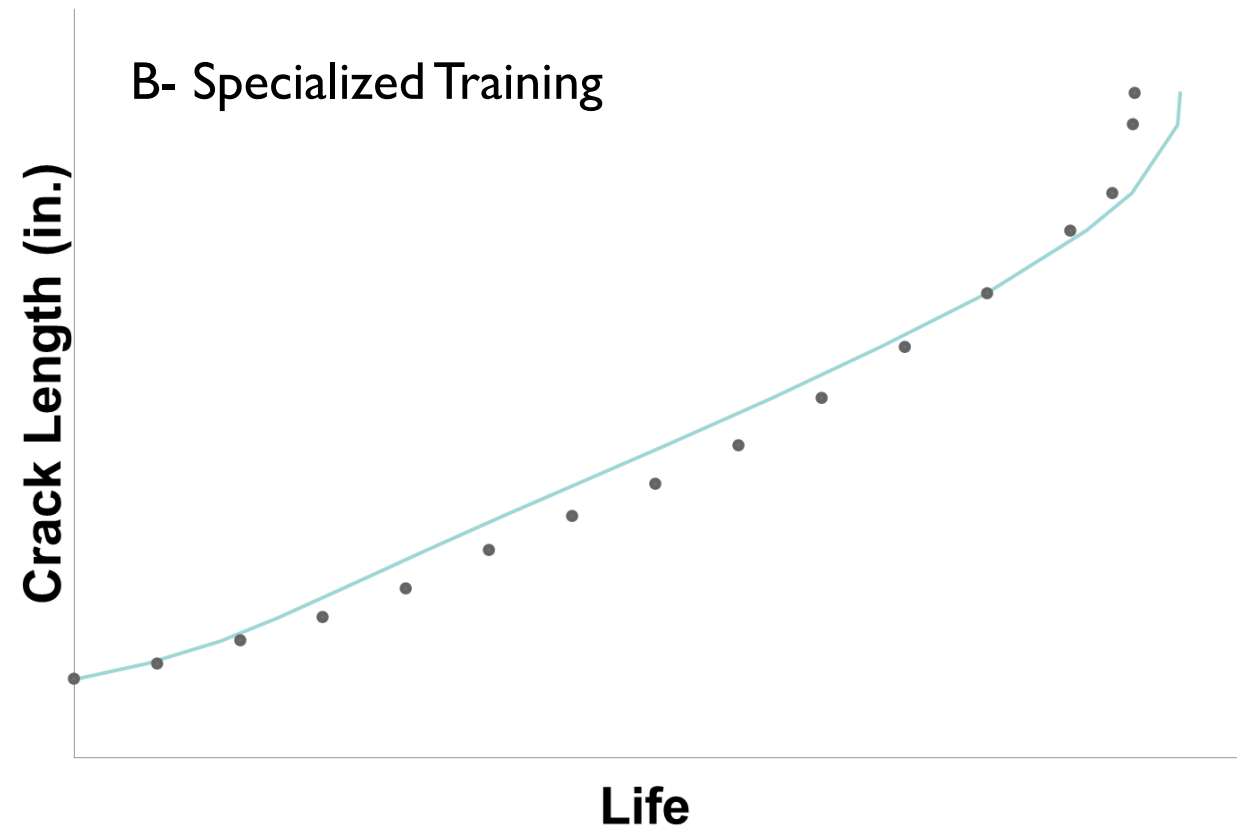
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B- Initial Training



• Test Data — Analysis: SOLR = 3.59, MSE = 9.6

B- Specialized Training



• Test Data — Analysis: SOLR = 3.73, MSE = 13.5

Steps:

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1. Testing
2. SOLR Correlation
3. **Damage Tolerance Analysis (DTA)**
4. Conclusions
5. Recommendations

Damage Tolerance Analysis (DTA)

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Inputs

FCL	Material Code	Crack Geometry	Width (W)	Thickness (T)	Hole Diameter (D)	Hole Offset (B) or fastener spacing	Crack Length - 'C' Direction	Crack Length - 'A' Direction	Bearing Stress Ratio	Stress Multiplication Factor (SMF)	Residual Strength Requirements (Pxx)	Cycles in sequence	Retardation Parameter
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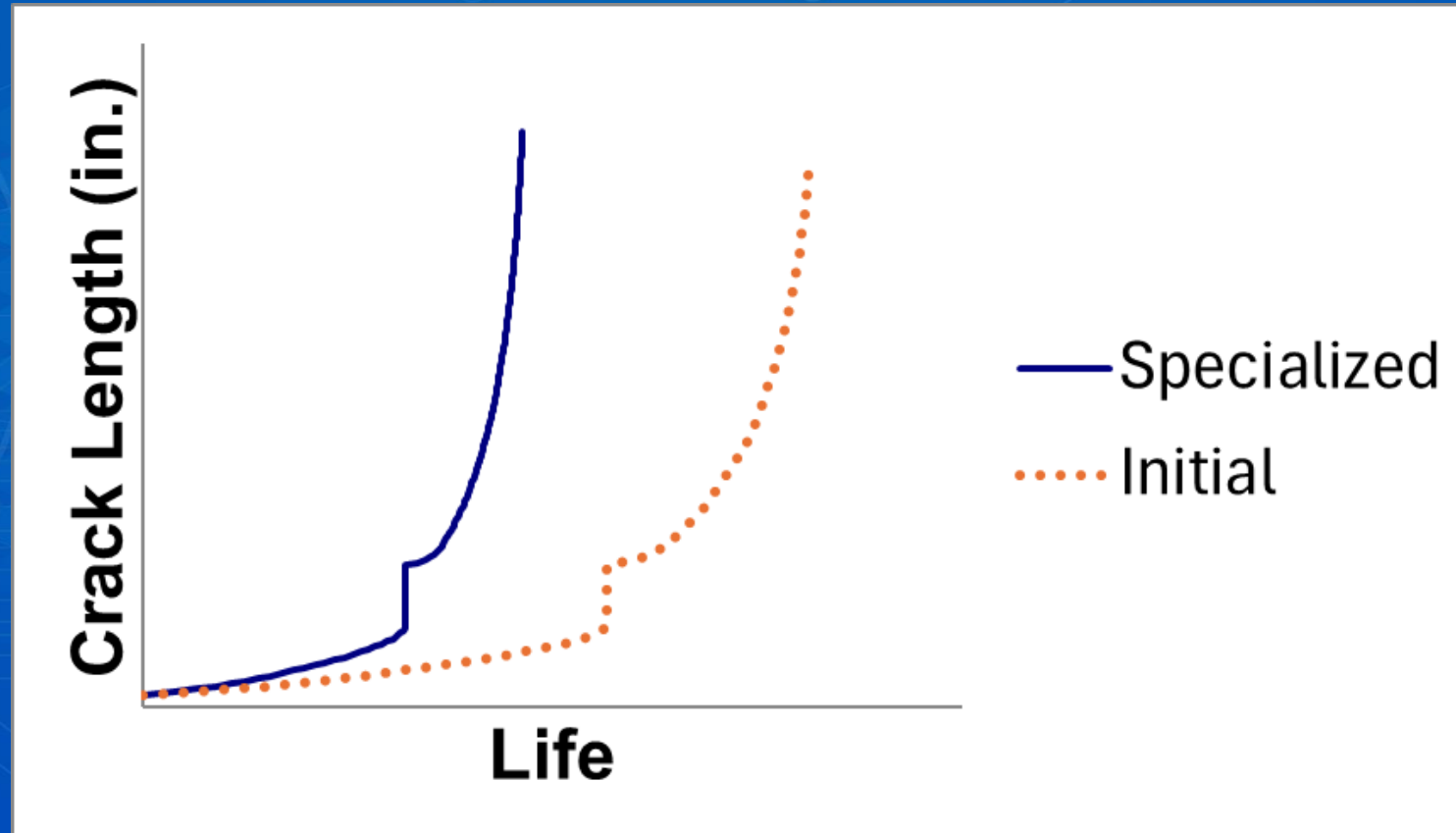
Outputs

	Results:	Inspection Interval Data:					Continuing Damage Data:			
FCL	Life	Detectable Crack Size	Initial Inspection Interval	Recurring Inspection Interval	Field Safety Limit	Critical Crack Size	Total Life	Total Initial Inspection Interval	Total Recurring Inspection Interval	Total Field Safety Limit

DTA Outputs: A- Old Wing

Specialized/Initial Training Usages

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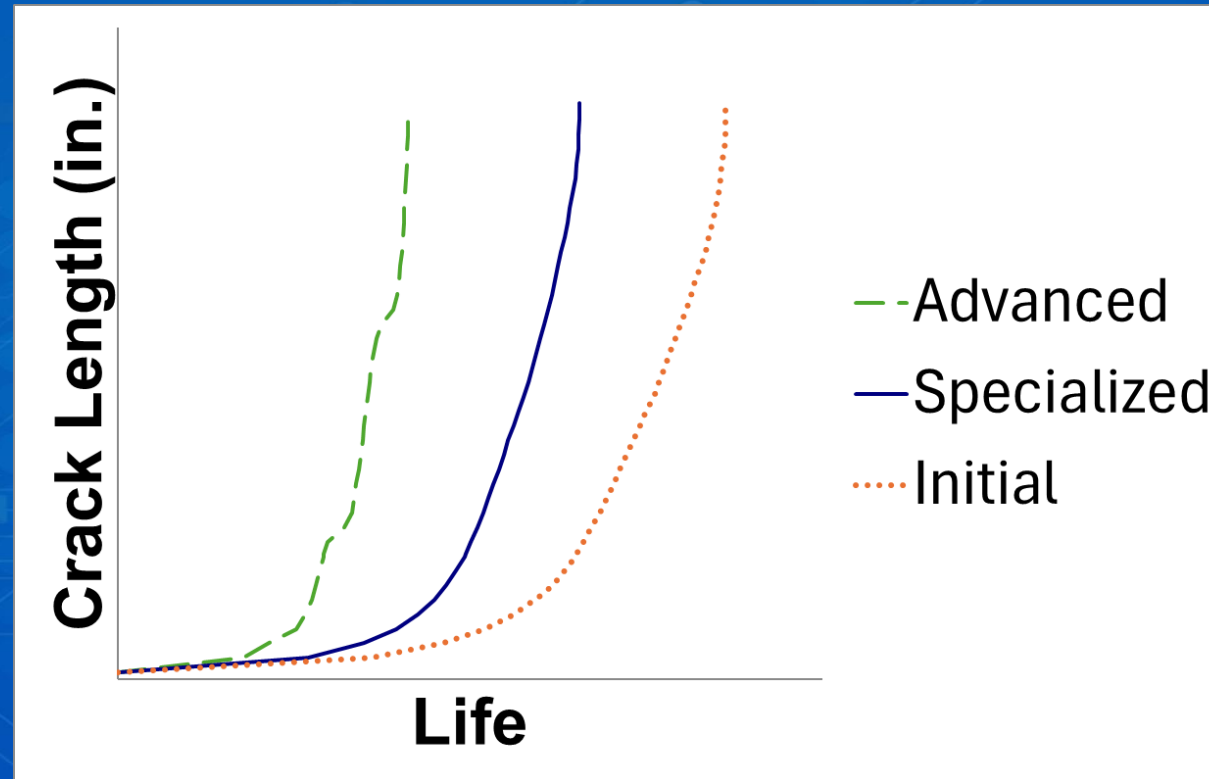


% Diff. Specialized/Initial = 76.24%

DTA Outputs: A- New Wing

Advanced/Specialized/Initial Training Usages

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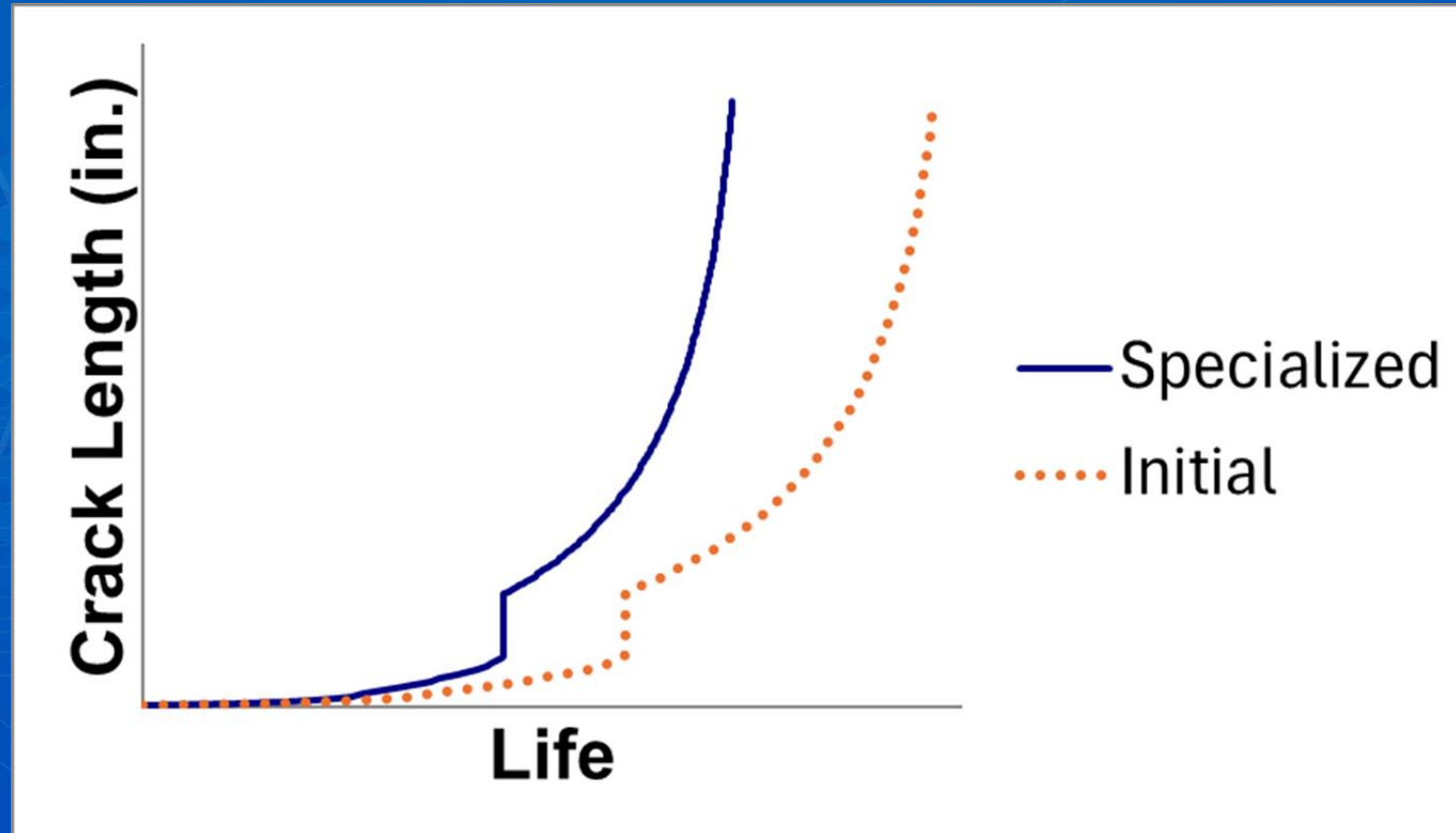
% Diff. Advanced/Specialized = 59.20%

% Diff. Specialized/Initial = 31.76%

DTA Outputs: B

Specialized/Initial Training Usages

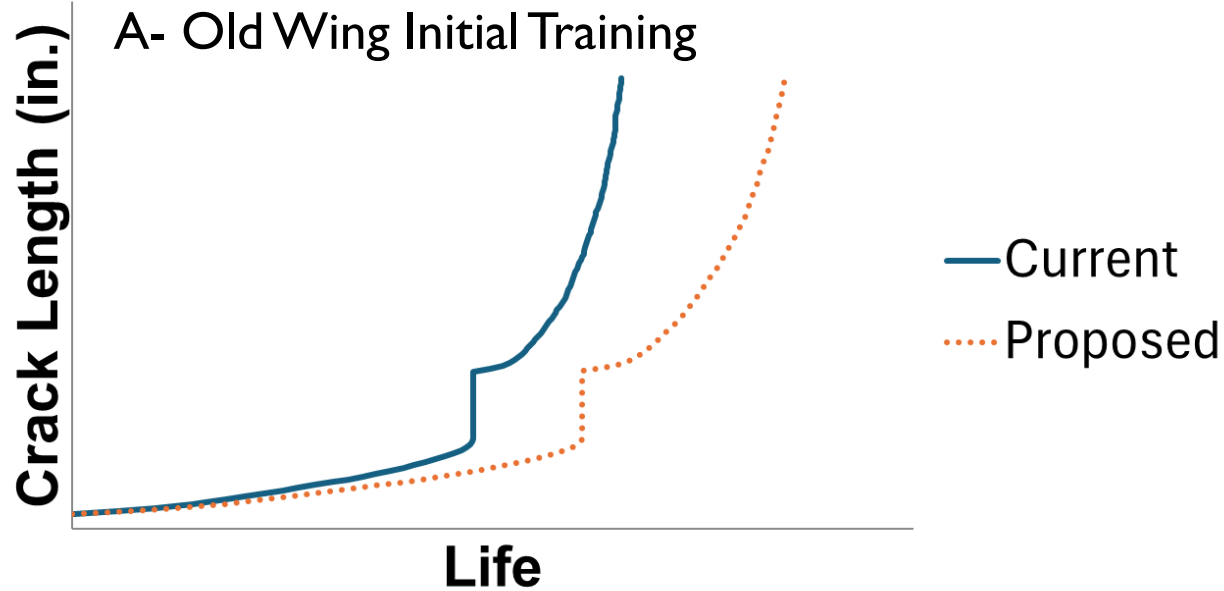
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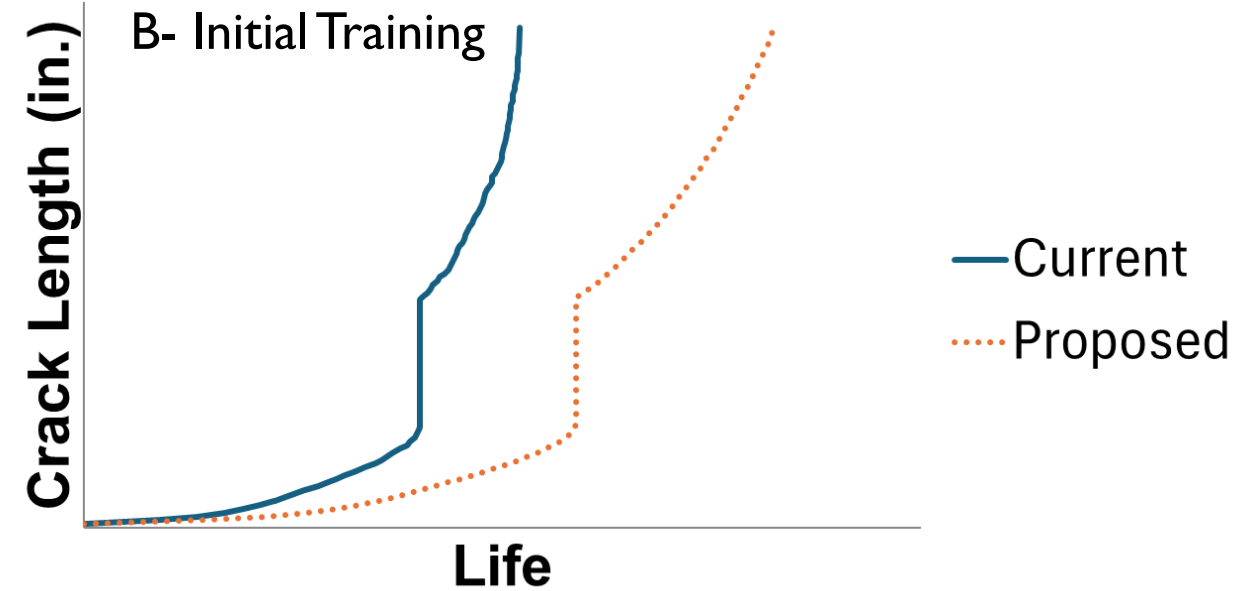
% Diff. Specialized/Initial = 34.15%

DTA Outputs: Current/Proposed Spectra

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% Diff. = 29.72%



% Diff. = 58.29%

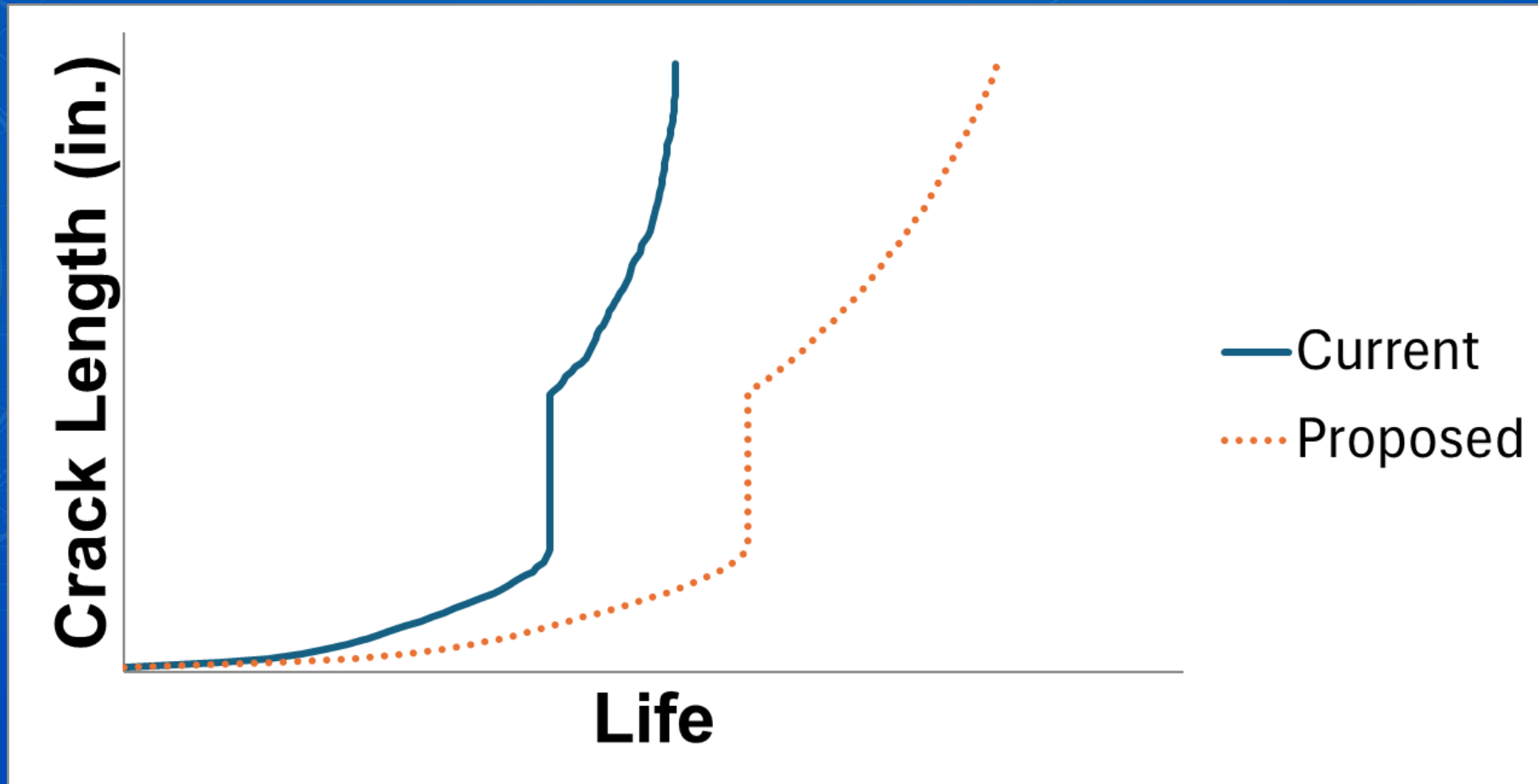
Steps:

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3. DTA
4. **Conclusions**
5. Recommendations

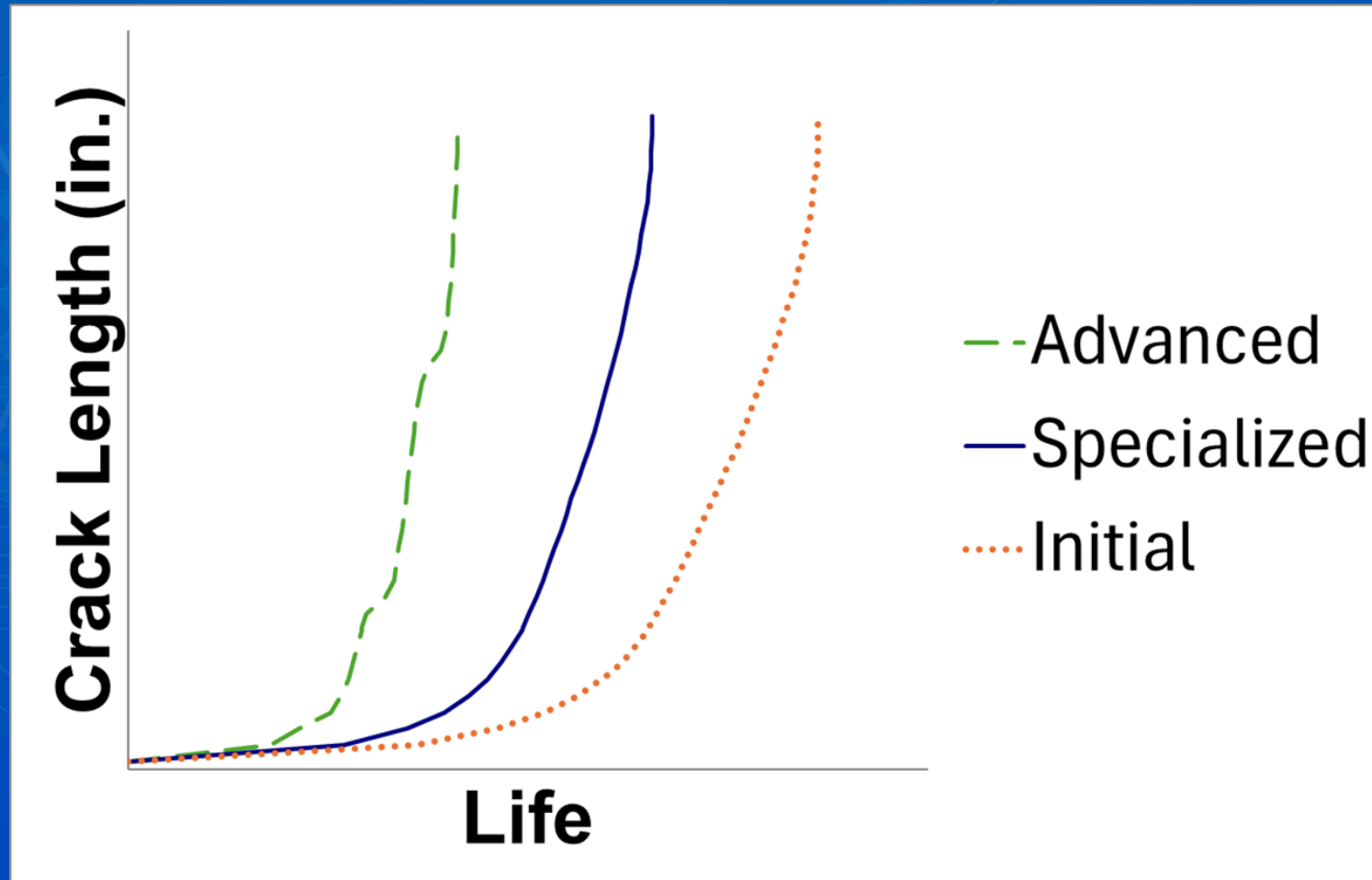
Conclusion: Current/Proposed Spectra

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Conclusion: Advanced/Specialized/Initial Training Usages

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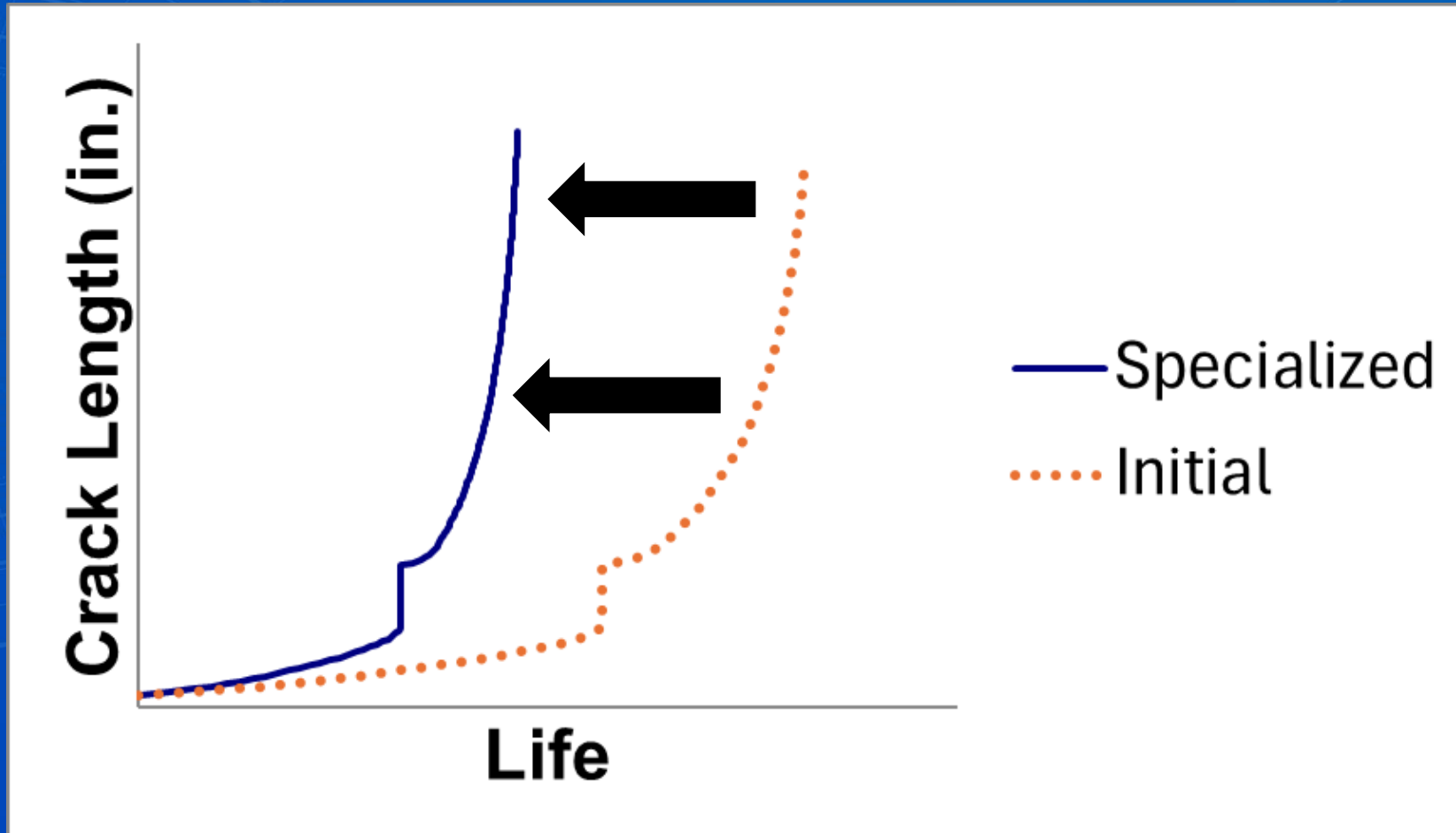
Steps:

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I. Treat Initial Training like Specialized Training Usage

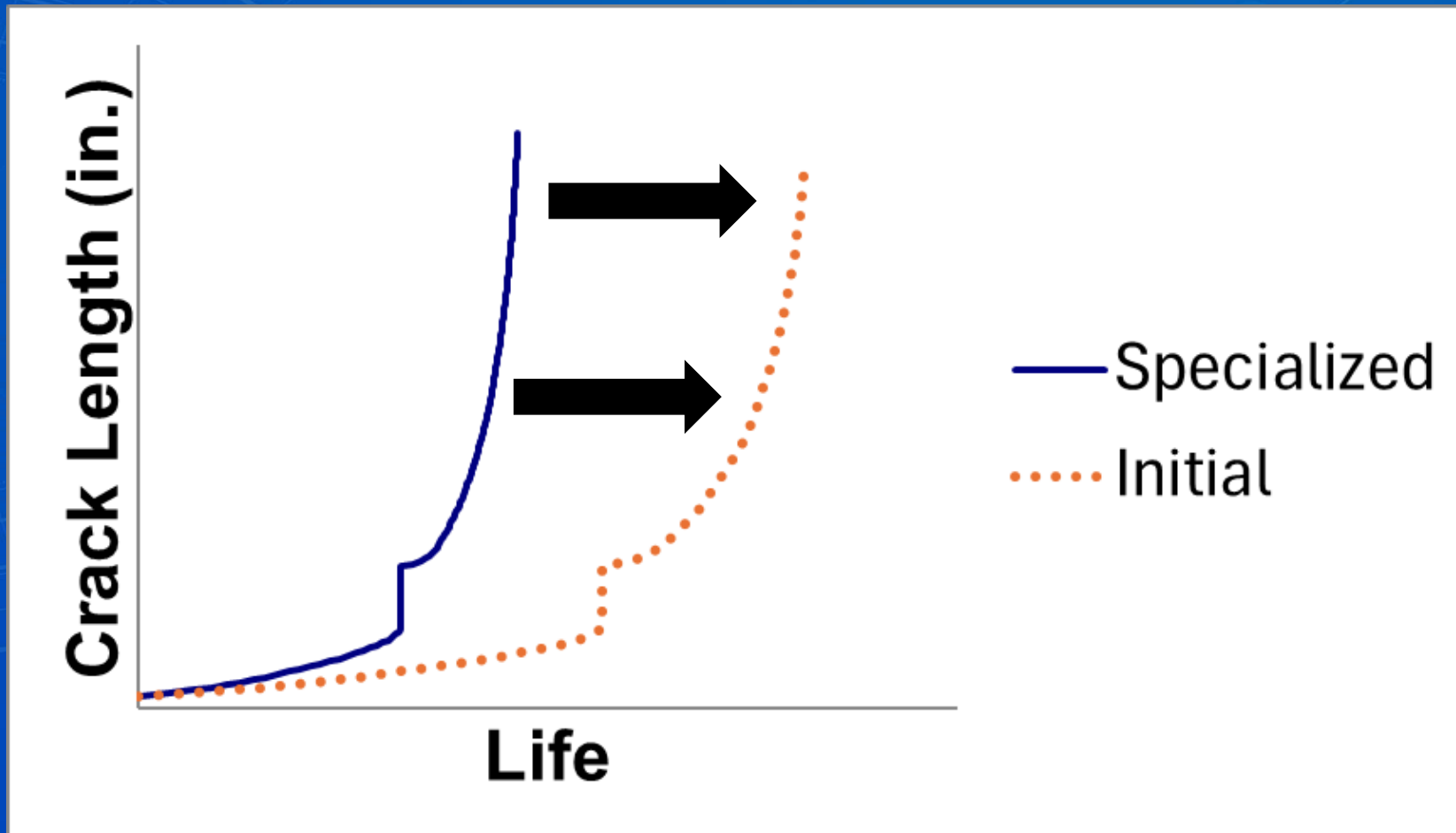
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- Sooner Inspection Intervals
- Causes more work for maintainers

2. Treat Specialized like Initial Training Usage but Perform a Risk Assessment on the Specialized Usage

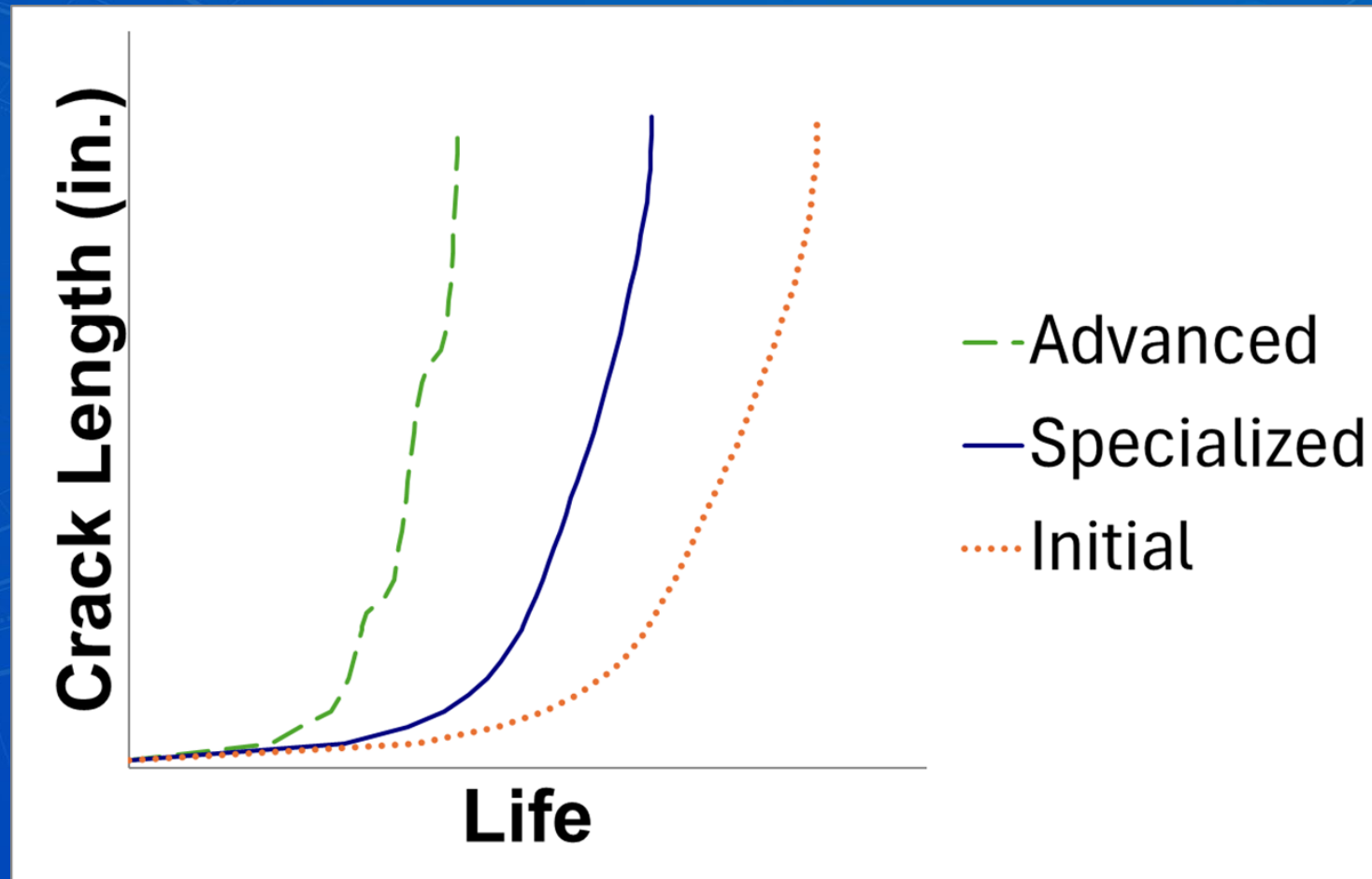
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- Later Inspection Intervals
- Causes less work for maintainers
- The risk assessment is to find the single flight probability of failure this will cause for the specialized training usage.

3. Return to Using 3 Separate Training Usages

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1. Advanced Training
2. Specialized Training
3. Initial Training

Questions?



National Air and Space Museum: <https://airandspace.si.edu/stories/editorial/10-highlights-new-air-and-space>

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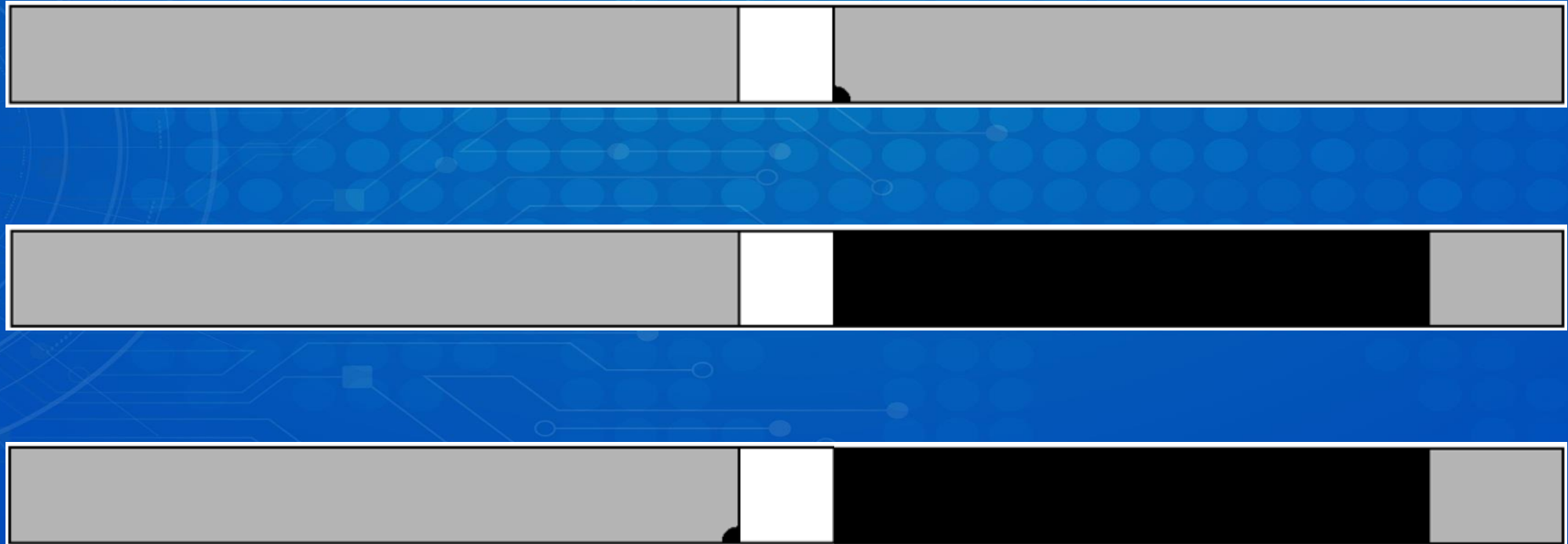


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Continuing Damage Crack Growth

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AFGROW:

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- Retardation = Willenborg Model
- User Defined Betas Classic Model Driving Size of the crack to match test data..
- Through Crack (User Defined) Advanced Models
- Material = Tabular Lookup Aluminum

Continuing Damage Crack Growth

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