



# Boeing's Certifiable Primary Structural Bonding Initiative

*March 16, 2010*

- |   |               |                   |
|---|---------------|-------------------|
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| • Robust Bonding Materials and Processes    | Kay Blohowiak | TF M&PT           |
| • Non-Destructive Inspection                | Dick Bossi    | STF NDE           |
| • Design and Analysis                       | Matt Dilligan | Senior Analyst    |
| • Sustainment / Repair                      | Rusty Keller  | TF Supportability |

## Additional Boeing Key Team Members

Will Grace, Gerry Mabson, Mark Wilenski, Derek Fox, Alan Prichard, Charlie Saff, Eric Cregger, Doug Frisch, Gerardo Pena, Eugene Dan-Jumbo

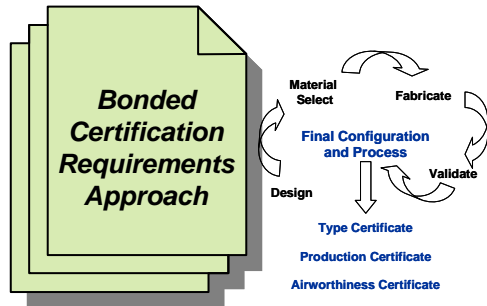
# Agenda

- **Bonding Certification Approach Development at Boeing**
- **AMTAS related tasks and their Impacts on Boeing**
  - UW Prof. Brian Flinn
  - FIU Dwayne McDaniel
  - UW Prof. Kuen Lin
  - (FAA Technical Monitors Curtis Davies, Larry Ilcewicz and David Westlund)
- **Bonding Path Forward in AMTAS-Boeing relationship**

# Boeing Approach to Bonding Certification

Engineering, Operations & Technology | Boeing Research & Technology

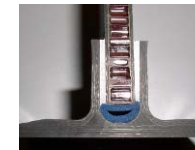
Structural Technology



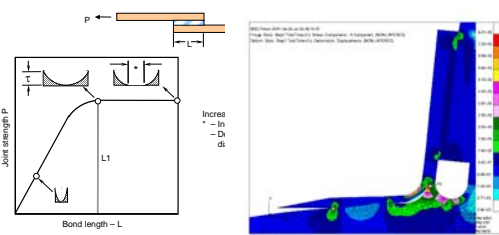
## Linked Requirements

Develop Comprehensive Certification Approach for Bonded Primary Structure

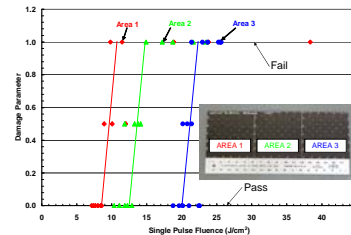
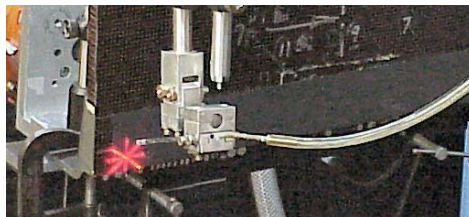
## Supportability and Repair



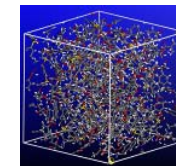
## Affordable Bonding Processes



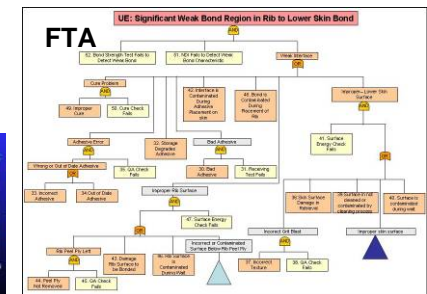
## Advanced Design / Analysis



## Advanced NDE Techniques LBID

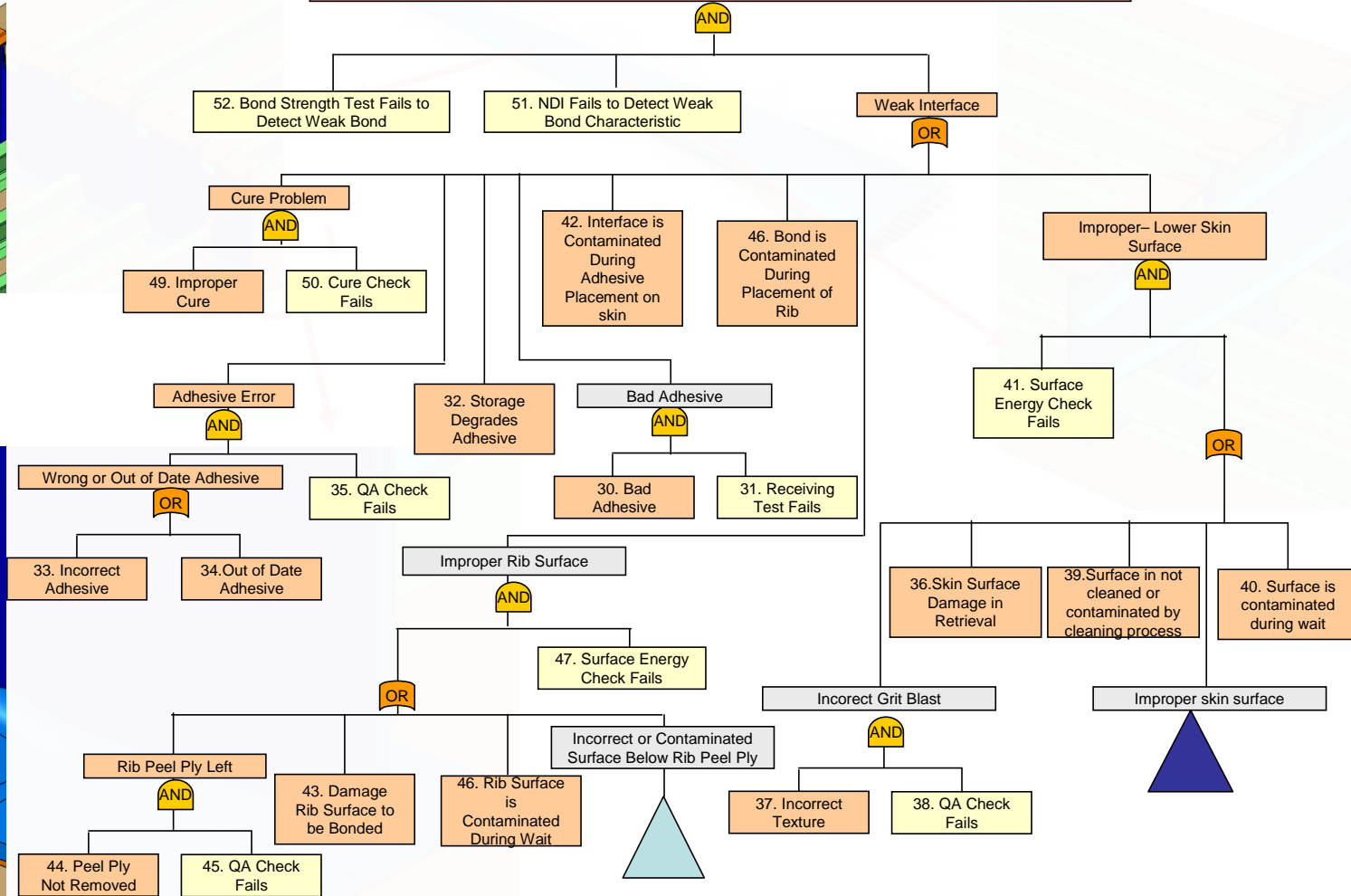


## Reliable Bonding Processes Parameters



# Fault Tree Analysis Bonded Skin to Rib Joint

**UE: Significant Weak Bond Region in Rib to Lower Skin Bond**



**Fault Tree Analysis provides both data to assess the critical bonding parameters and flexibility to optimize the reliability**

# Reliable Bonding Materials and Processes

## Boeing Need:

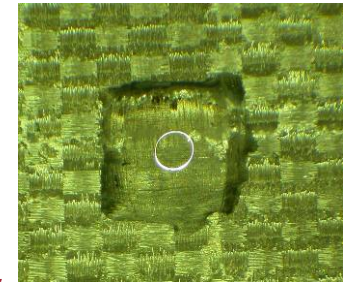
### Controlled Process Parameters

- Assess effects of process parameter changes
  - Materials aging: shelf-life and storage conditions
  - Batch-to-batch differences
  - Out-time effects
  - Tape vs. fabric
  - Thermal and hydrothermal conditioning
  - Cure conditions

## AMTAS Support:



- Define key factors for making good/poor bonds
- How to predict material surface prep compatibility
- Develop correlation between surface contact angle and bond quality
- In-line contact angle surface analysis

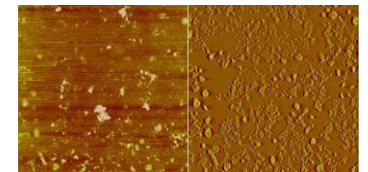


### Efficient In-Line QC Methods

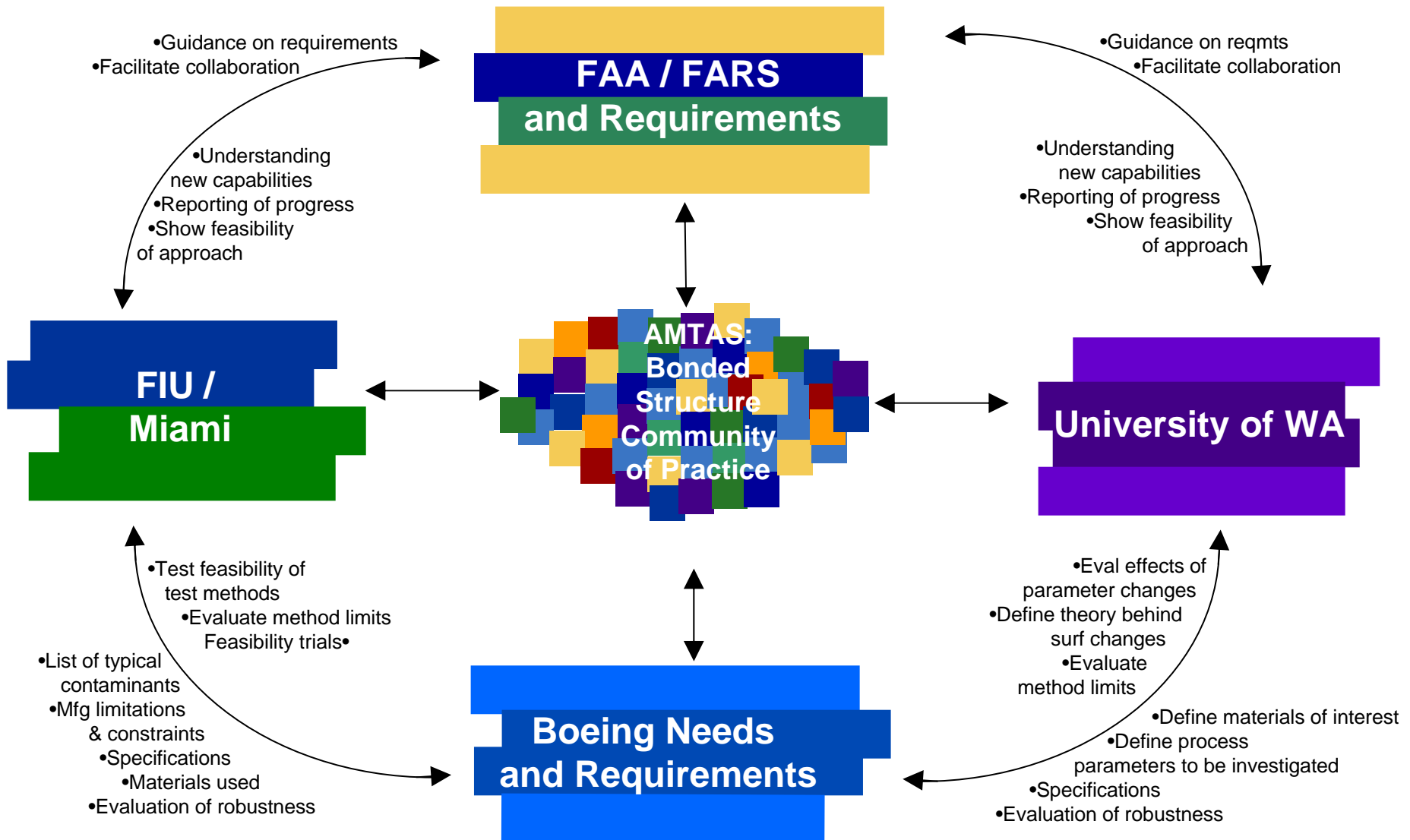
- Develop techniques to assess quality of bonding steps in mfg
  - In-line surface preparation assessment tools
  - Analytical tools to assess surface chemistry
  - Process control as measured by surface features or materials condition



- AFM Tool
  - Detect contamination on surface
  - Map laminate surface
- Electrochemical Tool
  - Contamination detection
  - In-field tool development



# Robust Bonding M&P Collaborative Activity

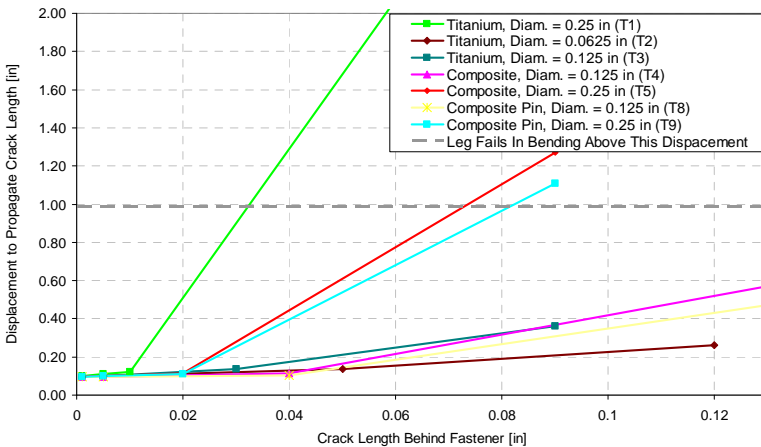
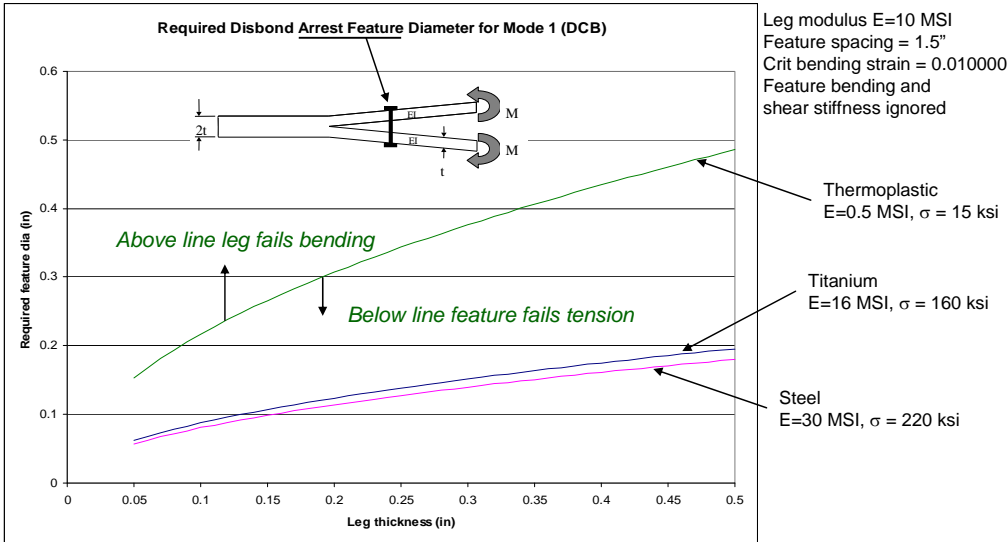




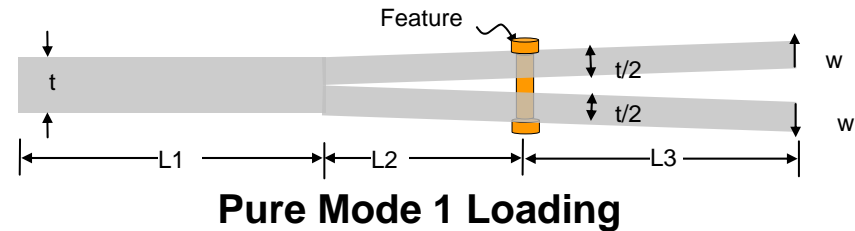
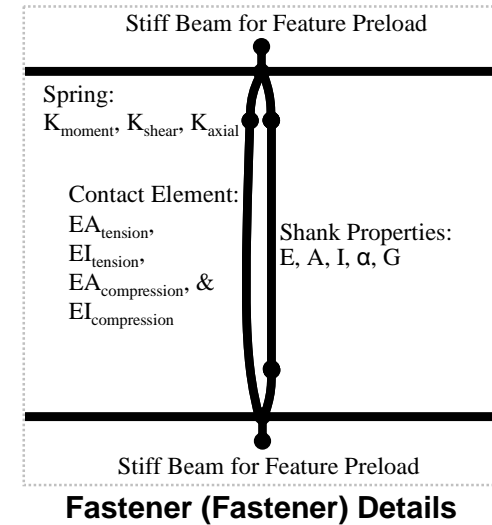
# Arrestment Feature Performance Advanced Analysis and Testing

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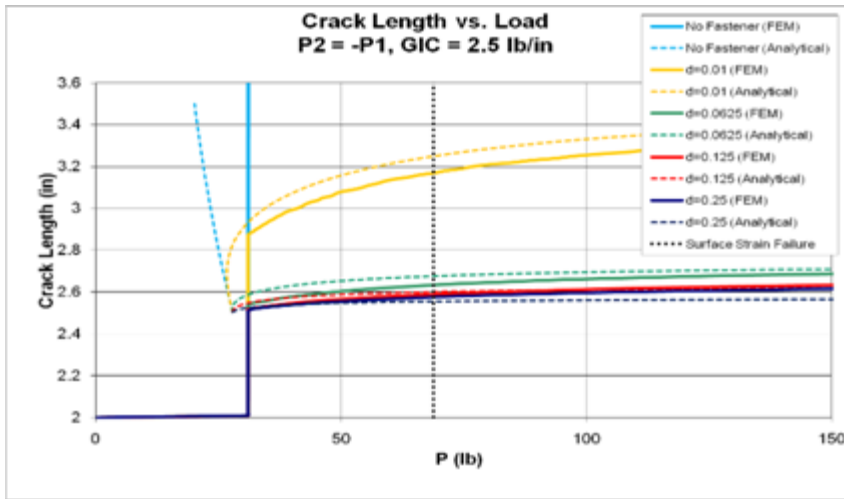
## Analysis Techniques for Arrestment Feature Performance



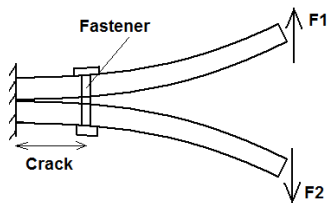
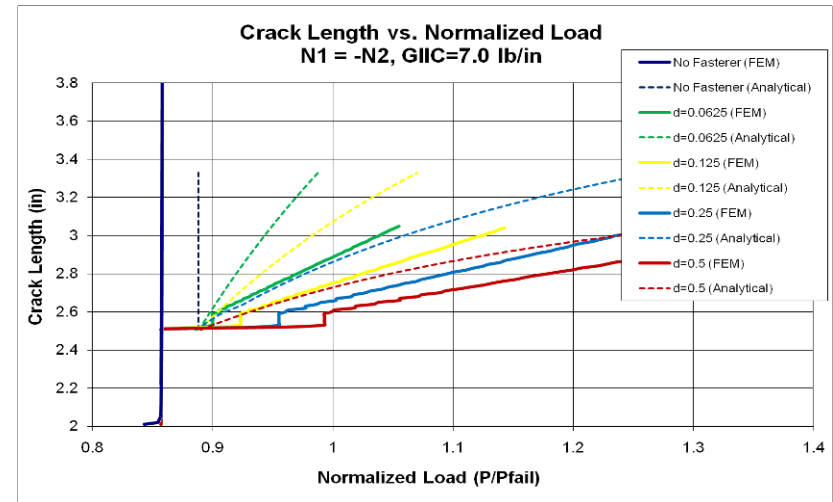
**Arrestment Features are a key parameter to certifying Transport Bonded Primary Structure**

# Disbond / Delamination Arrest Mechanisms

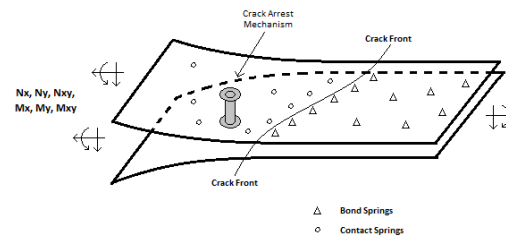
## Mode I: FEM vs. Analytical Fracture Analysis



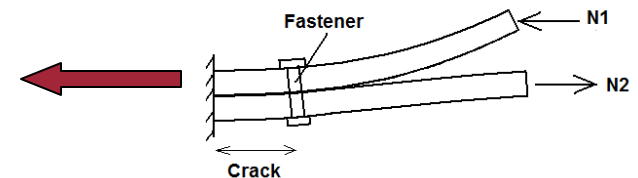
## Mode II: FEM vs. Analytical Fracture Analysis



Mode I



General Loading



Mode II

**Design Curves - Identify key variables for design, opt. and certification**



# Path Forward - AMTAS / Boeing Relationship

