COMPOSITE MATERIALS HANDBOOK MIL-17
DELAMINATION AND DEBONDING TASK GROUP

NATIONAL INSTITUTE OF AEROSPACE

- **Chairs:**
  - **T. Kevin O'Brien - ARL/VTD at NASA Langley Research Center**
  - **Keith Kedward - Univerity of California at Santa Barbara**
  - **Hyonny Kim - Purdue University**
- **Write handbook sections**
  - **Fracture Toughness Testing - James Reeder, NASA LaRC**
  - **Fatigue Testing - Isabelle Paris, Composites Innovations Inc.**
  - **Fatigue Damage Onset - T. Kevin O'Brien, ARL/VTD at NASA LaRC**
  - **Damage Growth under Cyclic Loading - D.M. Hoyt, NSC Composites**
  - **VCCT - Jeff Schaff, Sikorsky Aircraft**
- **Interface with ASTM Committee D30-06 on Interlaminar Properties James Reeder, NASA LaRC**

SUMMARY

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- A methodology based on fracture mechanics was demonstrated for a laboratory size coupon type specimens based on airframe components
- Fracture toughness testing for static and cyclic loading was discussed
- Virtual Crack Closure Technique was applied during analysis of to skin/stringer debond problem
- Feasibility of shell/3D modeling technique was demonstrated
- Shell/3D modeling technique likely to offer accurate results and affordable computational effort for models of large built-up composite structures
- Methodology is maturing, however until recently has only been used in a research environment - not during design or certification.

OUTLOOK

LARGE SCALE VERIFICATION OF METHODOLOGY

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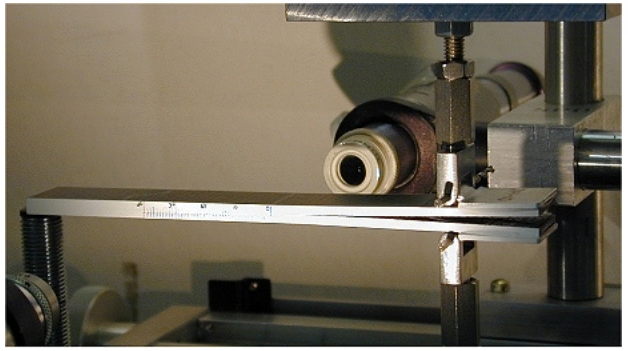
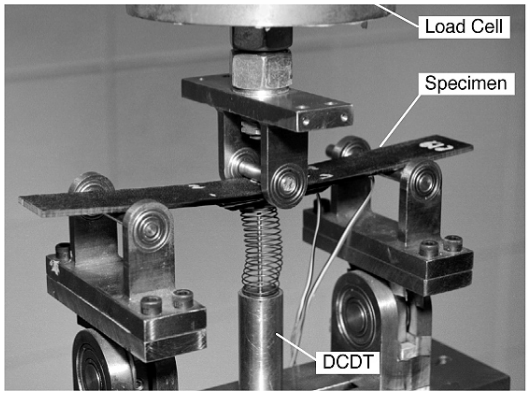
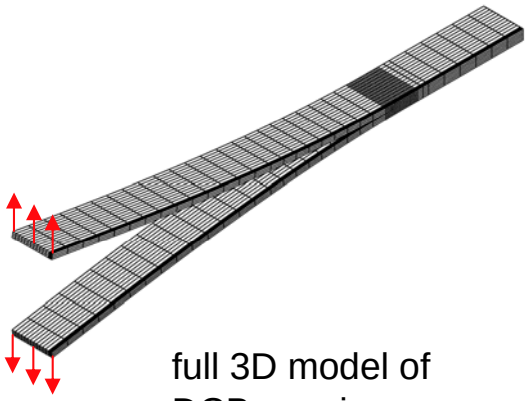




testing

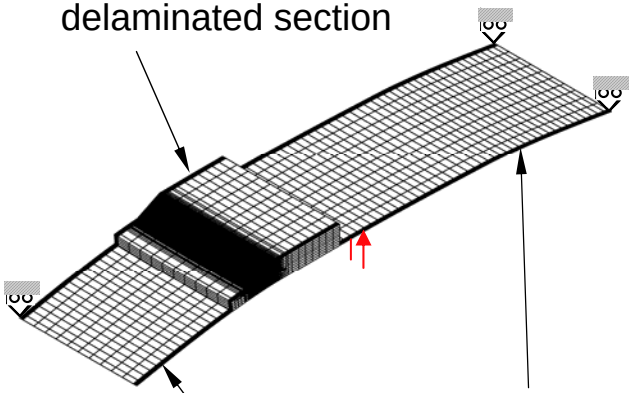
increased complexity

characterization specimen → coupon test → structural component

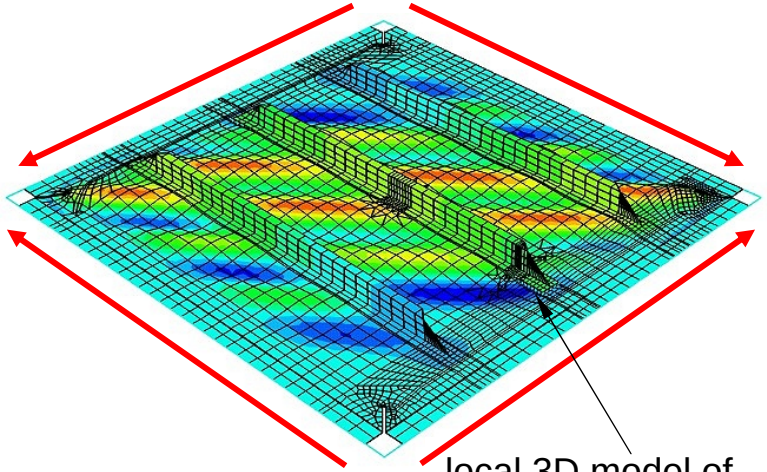


full 3D model of
DCB specimen

local 3D model of
delaminated section



global shell model of
unfractured section



local 3D model of
delaminated section

analysis

OUTLOOK
SHELL FE-MODEL WITH LOCAL 3D INSERT

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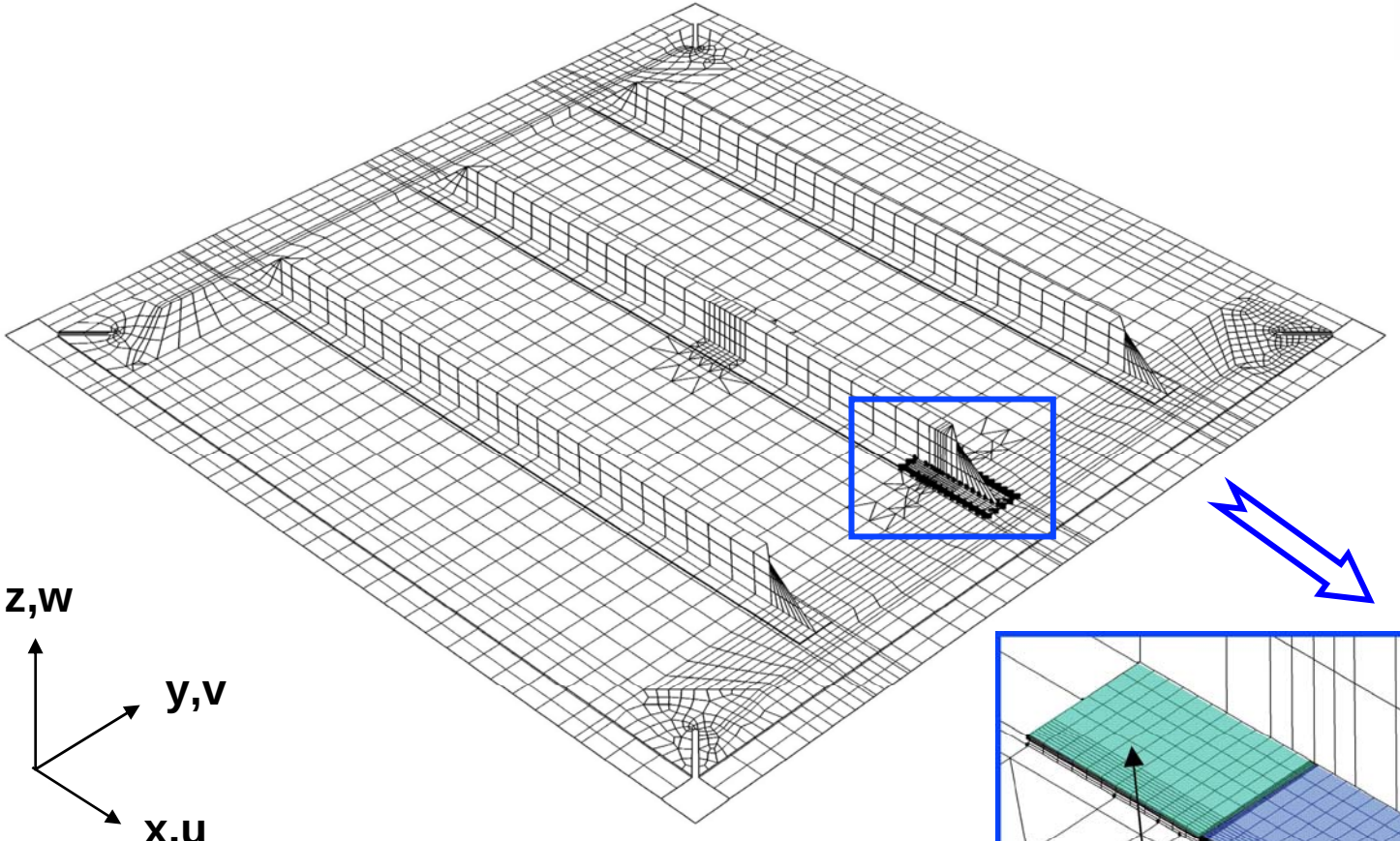
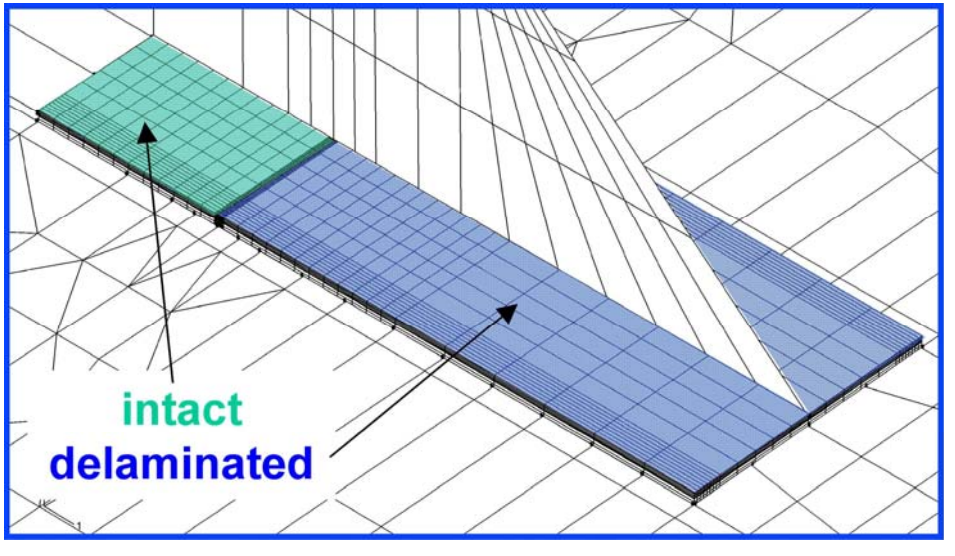


shell replaced by local 3D model (C3D8I)



OUTLOOK
USE OF ADVANCED STRUCTURAL COMPOSITES

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- **Boeing 7E7**

- **Planned 50% of structural weight consists of advanced composites**
- **Substantiated analysis methods reduce testing**
- **Application of fracture mechanics for structural analysis of composite parts**
- **Development of VCCT interface element. Integration into ABAQUS announced for the end of 2004**

WORKSHOP SUMMARY

Computational Fracture Mechanics for Composites

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- **Held in Salt Lake City, UT, March 22 -23, 2004 in conjunction with ASTM Committee Week and ASTM Committee D30 meetings**
- **19 presentations in four sessions**
- **Two discussion sessions**
- **80 participants from**
  - **United States, Canada, Belgium, Denmark**
  - **Aircraft Industry, Government, Software Companies, Composite Industry, Consultants, Research Institutes, Universities**
- **Brought together representatives from academia, industry, government, software companies and certifying authority**
- **Discussed one single topic: Computational Fracture Mechanics for Composites**
- **Discussed a road map to certification**
- **Made FE software developers aware of customer needs**
- **Announced ABAQUS/Boeing collaboration on VCCT routine**

REMAINING CHALLENGES

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- **Complete development of test standards for delamination fracture toughness testing**
- **Develop test standards and methodology for fatigue delamination growth**
- **Define fracture mechanics benchmark tests for FE software developers**
- **Consider methods other than VCCT to calculate/compute mixed-mode strain energy release rates**
- **Include methods such as damage mechanics and progressive failure to determine the damage state of a composite structure**
- **Get other industries (automotive, marine) interested and involved**