Opportunities for benefit from NDT

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Purpose of session

• Set things up for discussion groups
• Give some background on drivers/ challenges
• Scope of discussions?
• Highlight some of issues - for groups address?
• Throw some ideas – stimulus to the discussions?
• Major Challenges across all sectors of market
  • Civil / military
  • Cost, Timescale ...
  • Weight (= cost!)
  • All phases lifecycle...design, build, support...

• To address... in design and manufacturing introduced
  • CAD, 3D modelling, analysis tools,
  • Automation manufacturing,
  • ATL (automated tape laying, FP (fibre placement)
  • Out of autoclave curing, resin infusion, bonded structures
  • Integration Design – Manufacturing interface
NDT for Composite Structures

- Principally ultrasound, some X-ray
- Integral part of process
- Principally production and QA
- Automated processes introduced
- Alternative methods eg laser NDT
- BUT
  - information generated, overall role
  - largely unchanged since 1970’s

- However:
- New analysis capabilities developing
  - Ultrasound, X-ray
- Potential to:
  - Identify defects not previously identifiable
  - Increased resolution
  - 3d images etc

What is most important? Where to target efforts?
What do we want from this new capability?

• Targetting?
  • More detailed definition / 3d plots of defects?
  • Ability to characterise defects/ locations that can’t currently be well characterised?
  • Ability to use NDT info to better support other phases of lifecycle?
  • Ability to feed into other software packages?
  • Other?

• For cured composite structures
  • Limited knowledge of parts below surface
    • Can only be achieved through part cut-up
  • Quality control for consistent parts
    • relies on process control
    • layup, handling, curing
Delaminations and Impact damage

- Voids, delaminations
- Currently:
  - External dimensions,
  - Single/multi-level
  - Depth from surface
  - Not detail characterisation below outer delaminations

- What level of additional information?
- Full 3D characterisation of multilevel defects through thickness?
Porosity, Cracks and Voids

- **Porosity?**
  - Currently - Percentage porosity
  - Want full 3D model of porosity?
  - Want Pore sizes / distribution etc?

- **Voids?**
  - Full 3D definition of void geometry?
  - Geometry issues?

- **Cracks?**
  - X-ray – currently crack length
  - Usually occur in complex geometry areas/ resin rich regions
  - Want better characterisation?
  - Full 3d imaging?
Fibre wrinkling / waviness

- Where to target efforts?
  - In-plane? / out of plane deviations?
  - Flattish surfaces from automated lay-up?
  - Radii and corners
  - Uncured part (using X-ray) to allow correction before cure
Fibre distortion

- Fibre distortion from layup around complex features?

Fibersim® model showing localized ply deformations – red most severe

Image courtesy of Siemens Industry Software Ltd

Top Hat Stiffener – fibre deformation

LHS - Creases

RHS – limited angular deviation but no creasing
• Concessionary Action on defects
  • Problematic
  • Defect acceptance curves generated simplistic situations
    • Artificially produced defects
    • Real parts – complex stress fields
    • Other structural features interacting with defect
    • Validity of such defect curves?
  • Acceptability of part produced?
**Composite fracture analysis?**

- FE Approach with cohesive/ interface elements
  - Crack progression
  - Delamination / voids/ bonding failures

- Feed NDT 3D analysis into fracture analysis?
  - Model defects on case by case basis?
  - Generate improved defect acceptance criteria?

- Can it be used to address effects kinks/ wrinkles?
- Discuss in section 4
Where in the life cycle?

- Focused traditional NDT role
  - Support production, concessionary action,
- Opportunities in different phases of life cycle?
  - Support Design? Qualification?
  - Can 3D NDT replace part up / ply by ply resin burn off?
  - Verify Fibresim predictions?
  - Identify fibre distortions?

### Product Lifecycle

<table>
<thead>
<tr>
<th>Design</th>
<th>First Article Manufacture</th>
<th>Product qualification, First Article Inspection</th>
<th>Production</th>
<th>Product QA</th>
<th>In service</th>
<th>Product Maintenance and Repair</th>
<th>Scrap</th>
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Options moving forward?

- Throw various thoughts into arena for discussion
- Where to target resources? Which has most benefit?
  - More detail information in traditional role? – particular problems?
  - Integrate with other automated systems?
  - Options to integrate with other areas of lifecycle?
  - Other ideas....?
- Ideally set targets - size, resolution etc....
With thanks to Prof Kevin Potter, BAE Systems and Siemens Industry Software Ltd for images to support this presentation.