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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?

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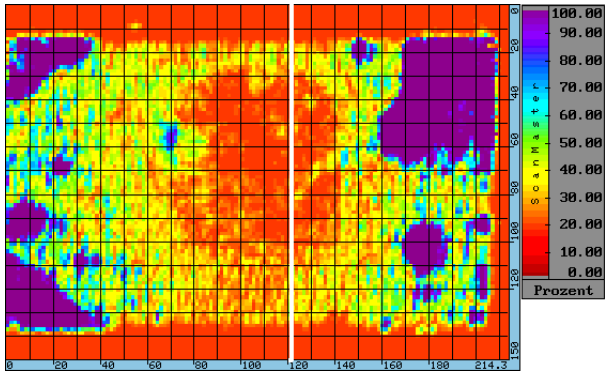
Current challenges

- 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?

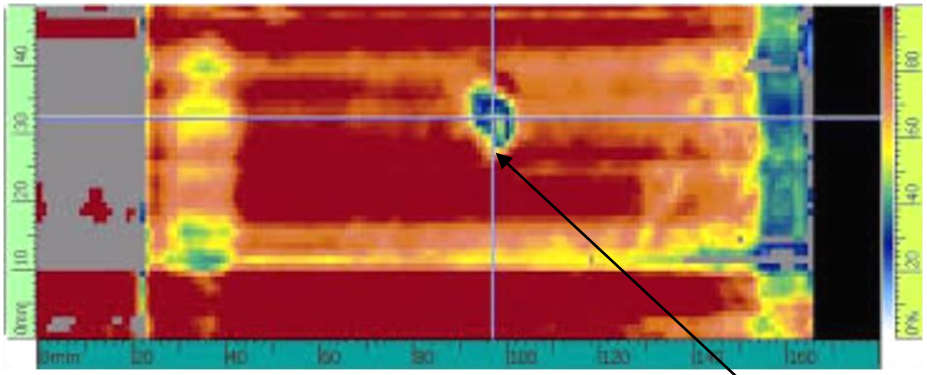
What do we want from this new capability?

- 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

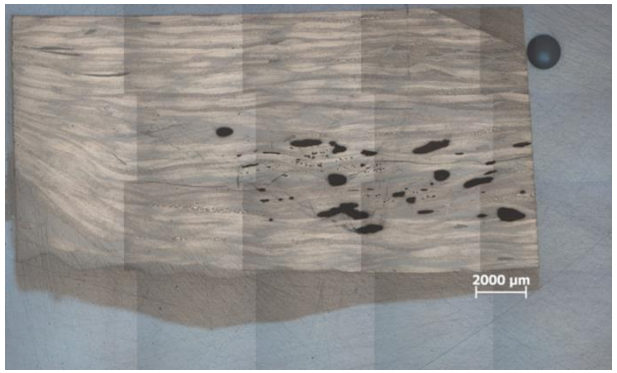
- Voids, delaminations
- Currently:
  - External dimensions,
  - Single/ multi-level
  - Depth from surface
  - Not detail characterisation below outer delaminations



- 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?

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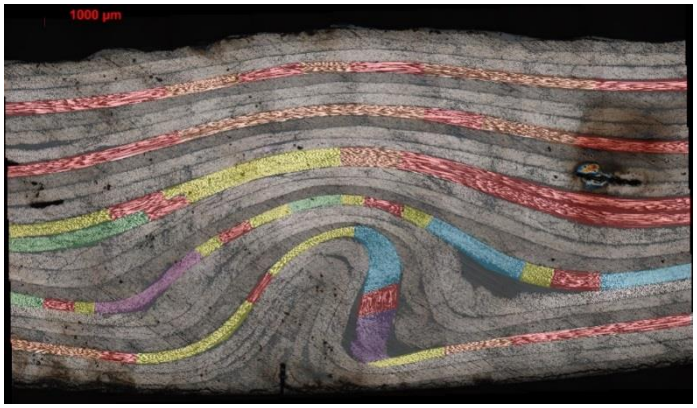
Fibre wrinkling / waviness

- 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 waviness or wrinkling



Fibre distortion

- Fibre distortion from layup around complex features?

Fibersim® model showing localized ply deformations – red most severe

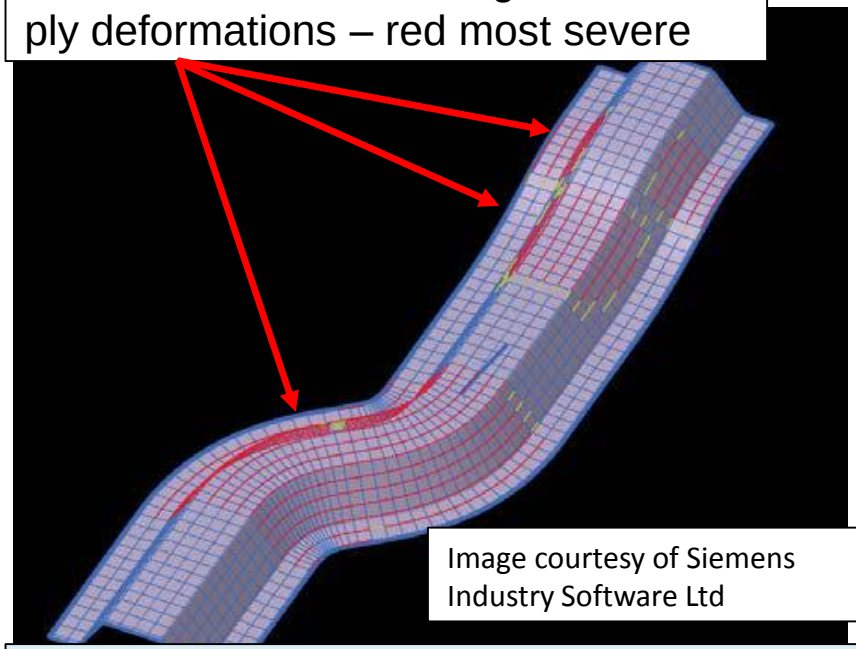
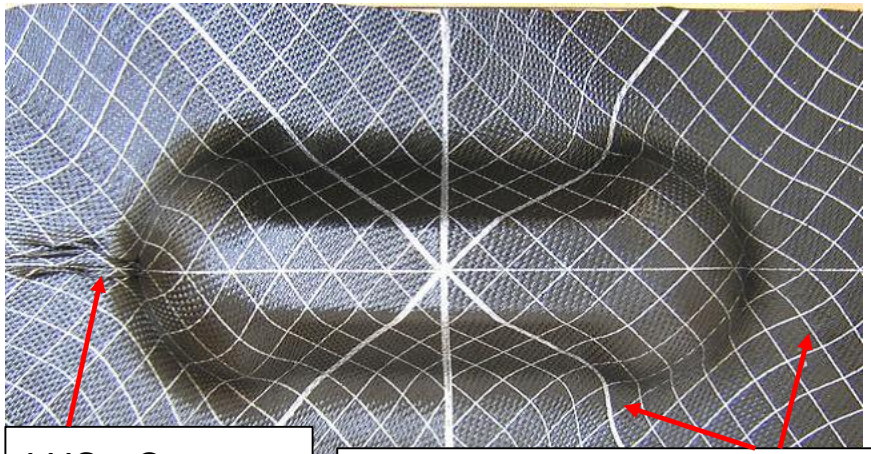


Image courtesy of Siemens Industry Software Ltd

Top Hat Stiffener – fibre deformation

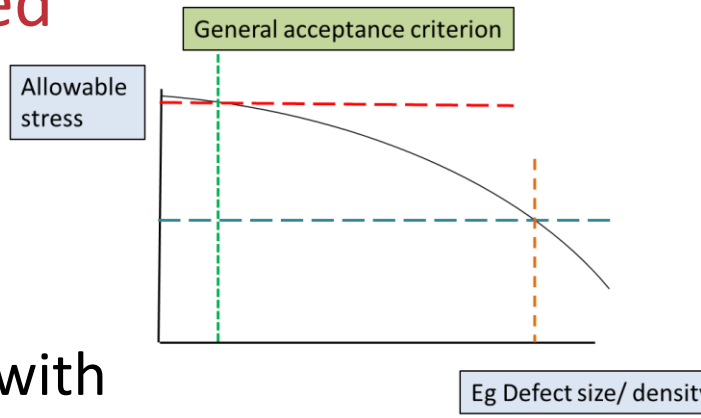


LHS - Creases

RHS – limited angular deviation but no creasing

Defect Analysis

- 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?



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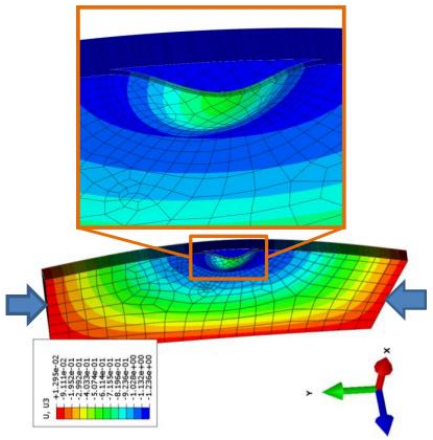
Composite fracture analysis?

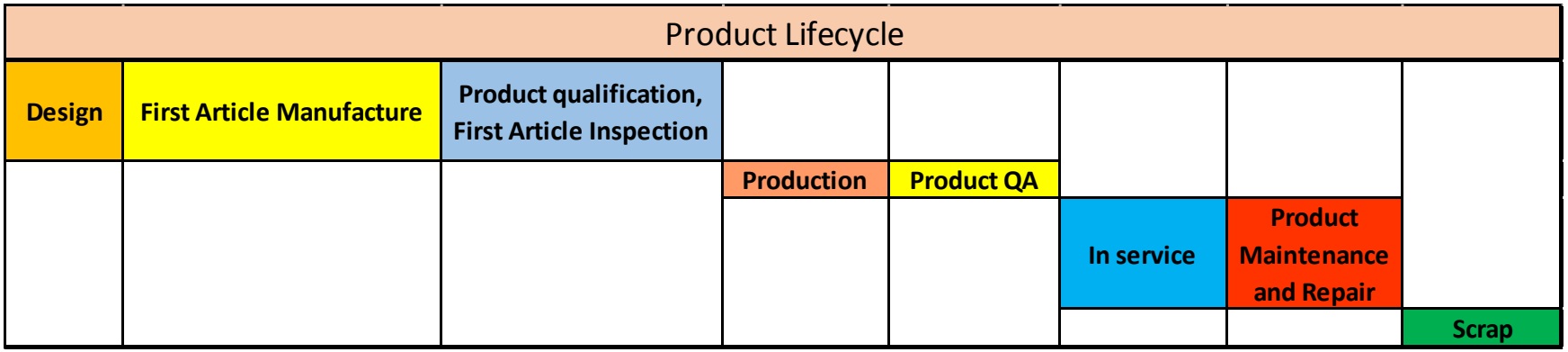
- FE Approach with cohesive/ interface elements
  - Crack progression
  - Delamination / voids/ bonding failures



- 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?



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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….

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Acknowledgements

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