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Engineering and Physical Sciences Research Council

NATIONAL COMPOSITES CENTRE

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THE BRITISH INSTITUTE OF NON-DESTRUCTIVE TESTING

Session 4: 3D characterisation and materials modelling

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- Full 3D mapping of material properties
- As-manufactured components or test coupons
- NDT-based performance modelling to determine residual strength
- Use of FE models to determine the important metrics for NDT to measure

Session 4: 3D characterisation and materials modelling

- NDT Requirements, or what is needed to define them?
  - What do we need to achieve to provide benefit?
  - Or, what work should we do in order to be able to answer that question?
- Example: Wrinkles. What parameters should we measure?

- 3D Fibre-tow orientation. We need to know…
  - what metrics (eg angle, volume, shape)
  - with what accuracy (eg +/- 1 degree)
  - with what 3D spatial resolution (every 0.5 mm?)
  - how fast? (eg. Process whole wing spar in 24 hours)
  - on what components (curvature, thickness, etc)
  - under what constraints (without removing paint, in the dark, on the ramp, from the external surfaces only, etc),
  - at what stage in the life cycle (maintenance intervals, between flights, at manufacture, on repairs, etc)
  - is there a need to feed NDT data directly into FE models? (eg only at design stage, at manufacture, or in-service?)

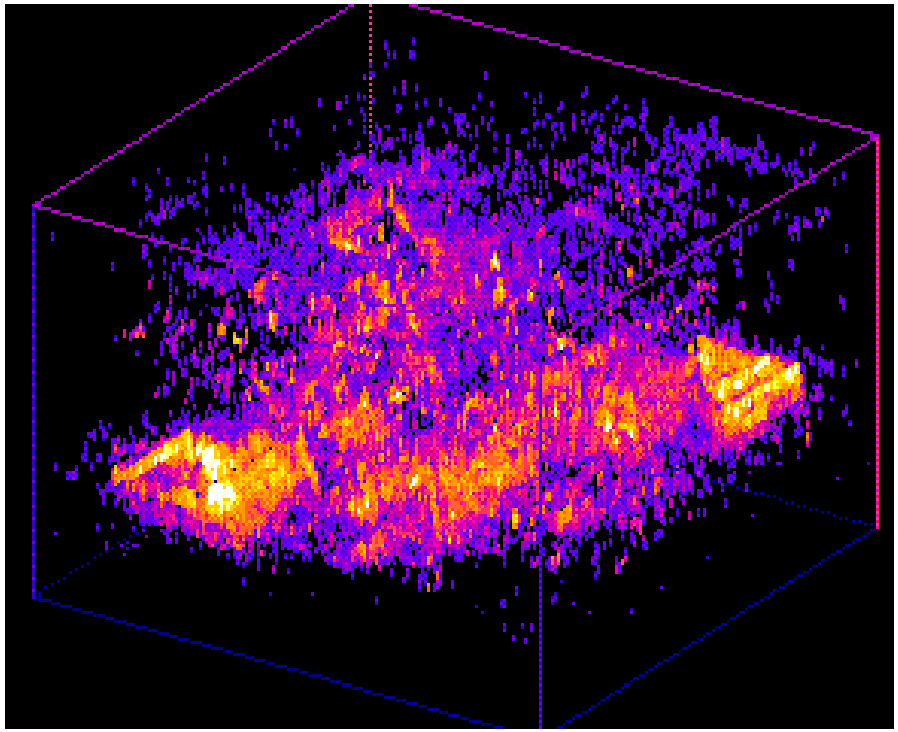
- 3D Fibre-tow orientation
  - But before we can find out these answers, we need…
    - more modelling of the effect of in-plane and out-of-plane wrinkles
    - especially determining the dependence of strength on:
      - maximum angle,
      - maximum displacement of fibres (amplitude),
      - volume of wrinkled area,
      - cross-sectional area of non-wrinkled fibres perpendicular to load,
      - etc.

- 3D Porosity
  - Mapping of 3D porosity would provide benefit for wedge-shaped components with no back-wall echo.
  - It might enable *allowables* that vary with
    - depth in the laminate,
    - proximity to bonds, etc.
  - It could reduce the uncertainties in the current through-thickness average porosity estimation where the 95% confidence is a long way from the mean (ie the measurement has a high uncertainty).

- 3D Porosity. We need to know…
  - what we need to measure (eg % porosity ply-by-ply, % porosity between plies, size distribution, location)
  - with what accuracy (eg +/- 2% in each ply)
  - with what 3D spatial resolution (every ply in depth but only every 1 or 2 mm laterally)
  - how fast
  - on what components
  - under what constraints (from the external surfaces)
  - at what stage in the life cycle
  - is there a need to feed NDT data directly into FE models? (at design stage, manufacture, in-service?)

- 3D Porosity
  - Before we will know the answers, more modelling work will be needed on the effect on the ILSS strength of:
    - % local porosity,
    - size distribution and
    - 3D location.
- Current work at University of Bristol suggests that maximum ply-porosity correlates better with ILSS than through-thickness average.

- 3D Porosity
  - Previous attempts at decomposing ultrasonic response to give % porosity (PhD, Nottingham):



- Impact Damage
  - Compression strength after impact depends on various parameters characterising the spread of delaminations and matrix cracks, but which parameters?
  - If we could characterise the damage in 3D and create a 3D FE model of it, would that provide a benefit in determining remanent life or deciding whether to repair immediately, or wait until a maintenance check?

- Impact Damage
  - This 3D imaging was developed 25 years ago…