Mid-Stage Validation as a Process Step in Simulation V&V

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DatapointLabs

EST 1995

ISO 17025 Quality

technical center for materials

matereality

software for materials

TestPaks

testing for simulation

picsci

electronic lab notebooks

knowmats

materials in simulation

Our Brands

DatapointLabs
technical center for materials

EST 1995
ISO 17025 Quality

Material testing for new product development

TestPaks
testing for simulation

Material parameters for CAE,
material model validation

matereality
software for materials

Store, analyze, compare any material data,
create CAE material cards, master material files

picsci
electronic lab notebooks

Record & analyze any experimental and simulation data

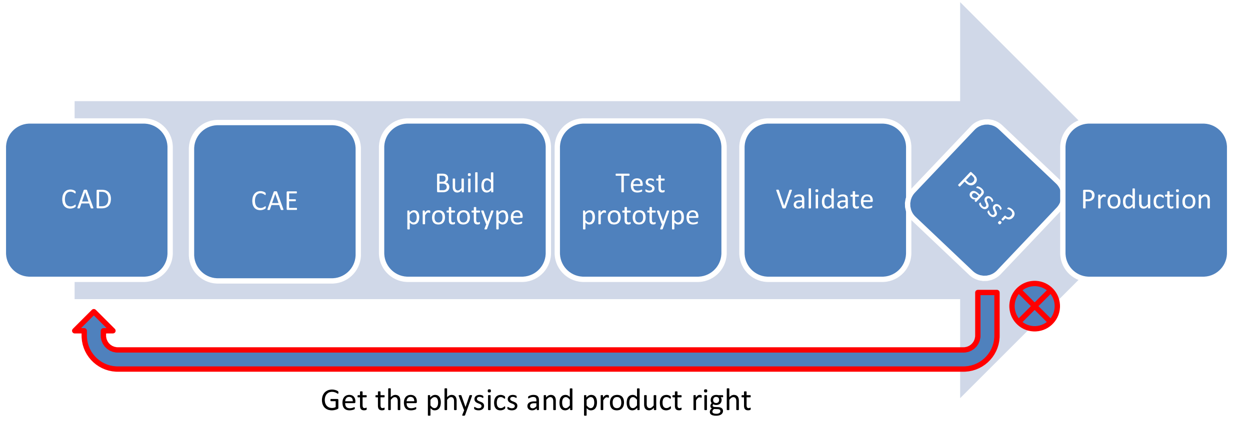
knowmats
materials in simulation

Knowledge resource for CAE users related to materials in simulation

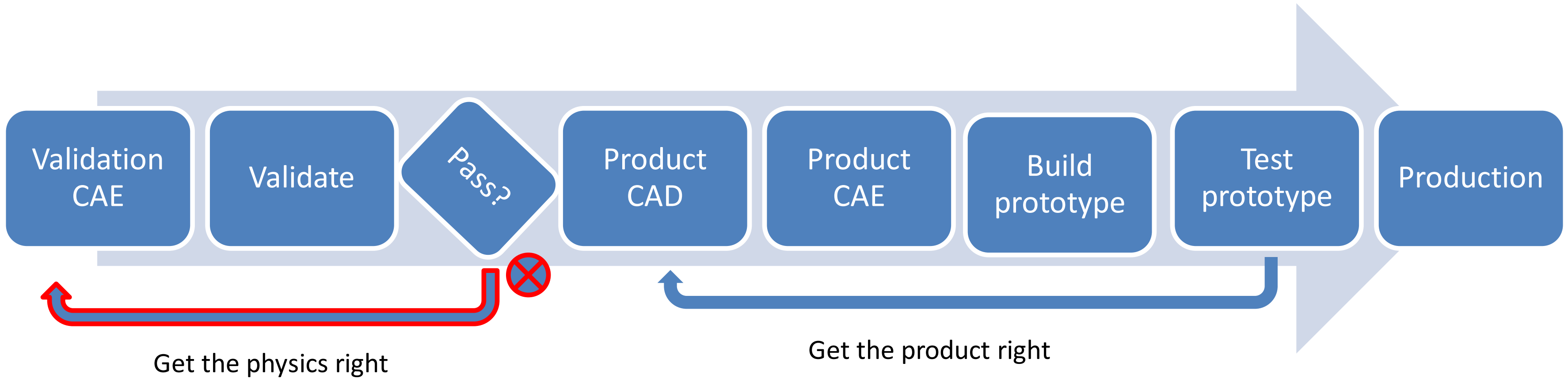
Mid-stage Validation

- Introduction to the concept
- Equipment and methods
- Case studies
  - 3D printed bike crank & extension to real life component
  - Ductile plastic
  - Rubber hyperelasticity
- Conclusions

Validation with actual prototype



Using mid-stage validation

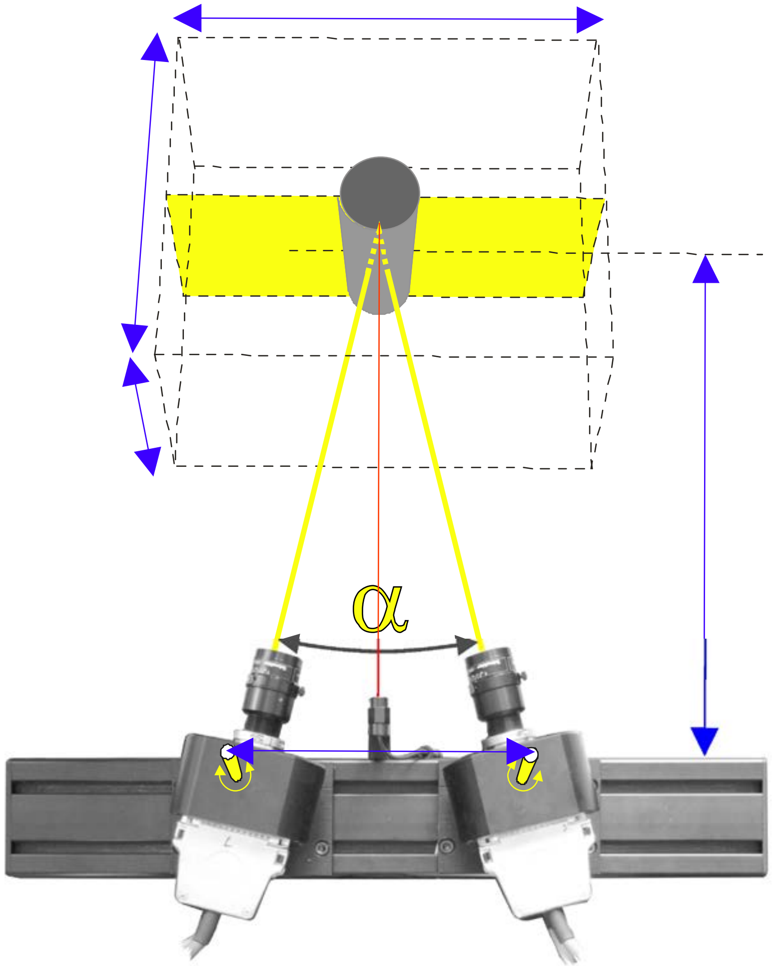


Mid-stage validation features

- Standardized geometry
  - Geometry is complex, easily made, not like real-life part
- Complex load case
  - Mixed mode, accurately reproduced in simulation
- Material model
  - Correct model, actual material, environment, exposure
- Accuracy measures
  - Force-displacement &/or DIC

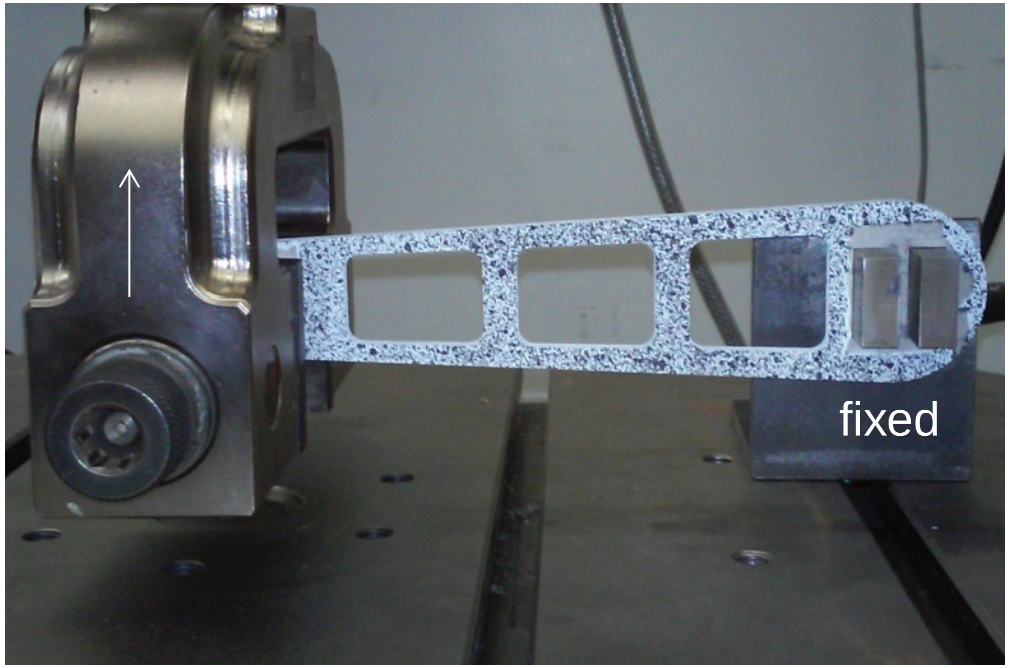
DIC Principle

- Speckle pattern is broken into facets (elements)
- Speckle pattern is tracked frame to frame
- Calibration of a volume is performed through measuring calibration panel in various orientations in the test space.
- Strains can be captured on the micro-strain level
- Strain field can be mapped over the actual part image



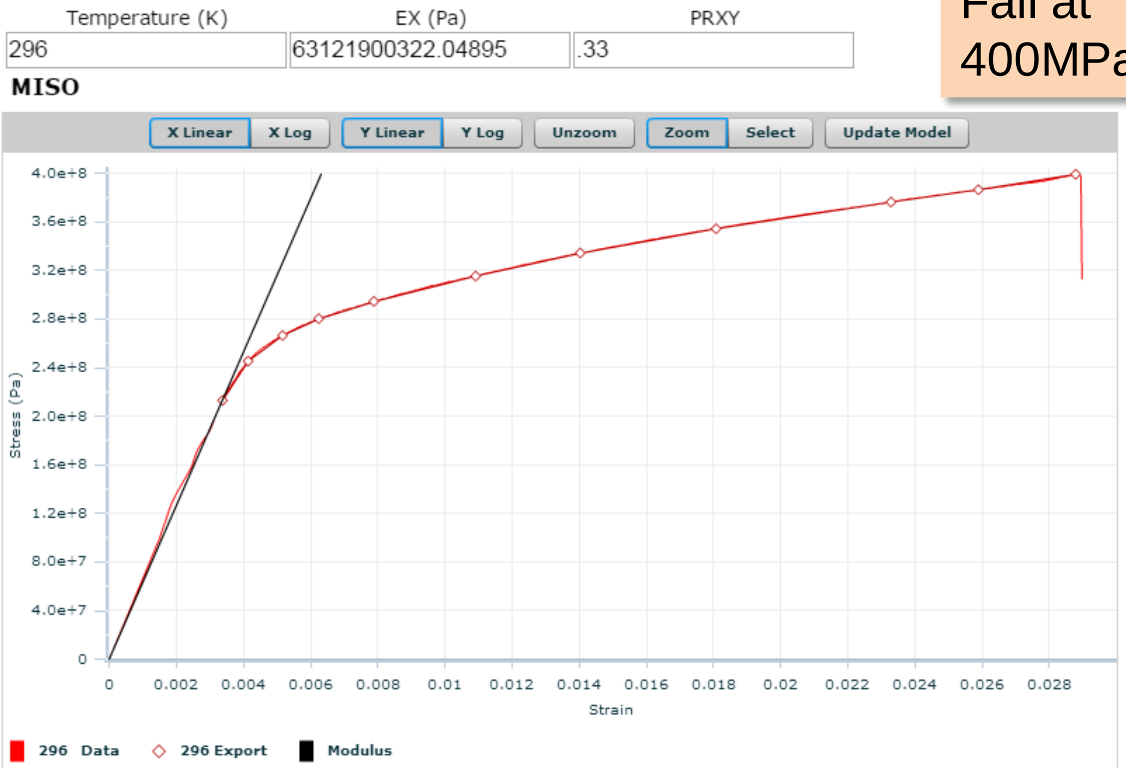
Case Study-1 3D printed bike crank

- Direct metal laser sintering
- Part features
  - No slip at fixed end
  - Rotation at load end
  - DIC for surface strain measurement
  - Tapered geometry to force failure in camera-viewable region



Material model

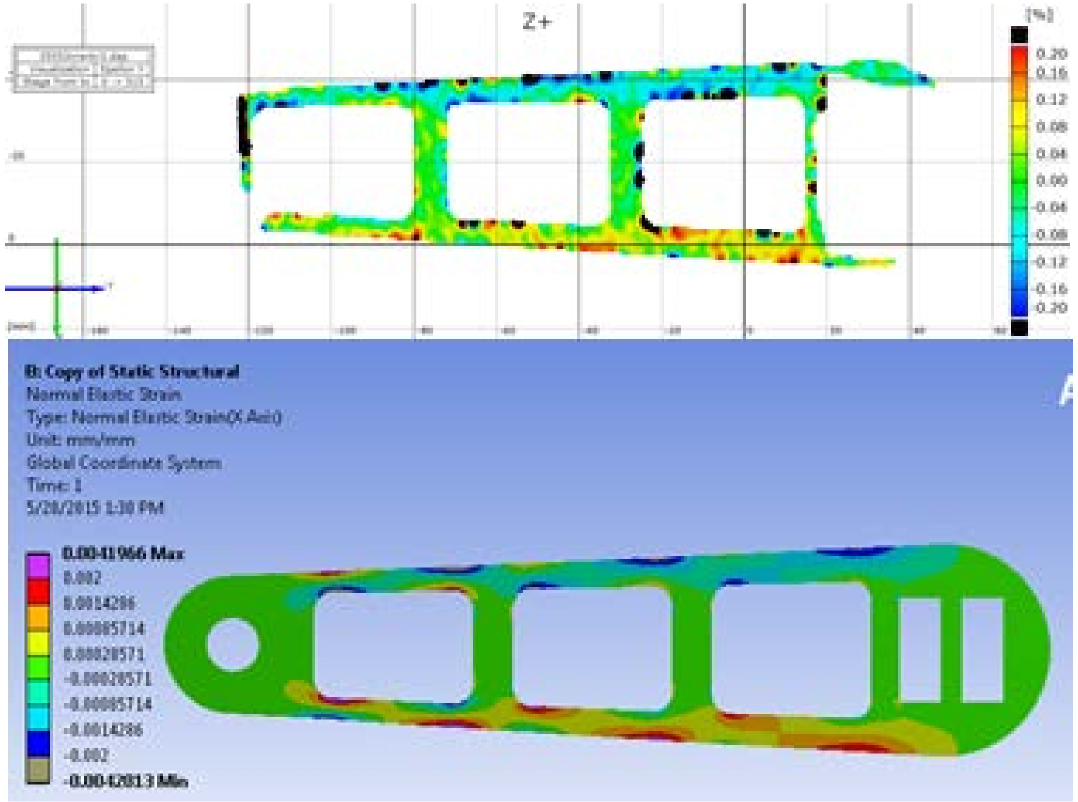
- EOS Aluminum AlSi10Mg
- Properties measured on 3D printed tensile bars
- Elastic-plastic material model
- Model fitted using Matereality
- Target solver = ANSYS



Fail at 400MPa

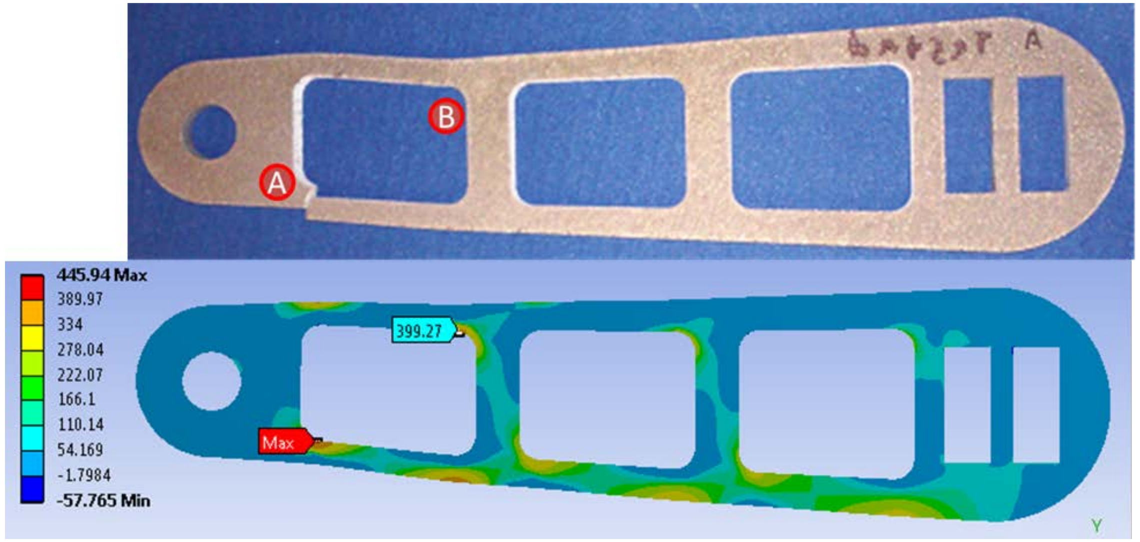
Linear analysis validation

- Quantitative and spatial match
  - Strain locations are correct
  - Strain levels are correct



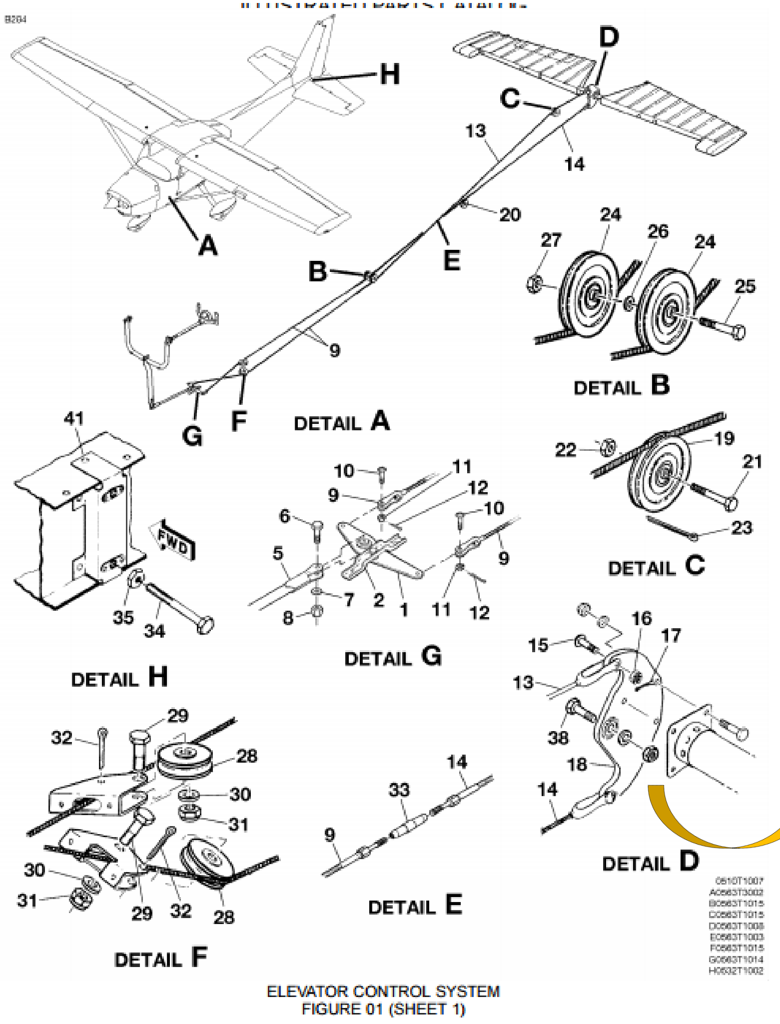
Failure validation

- Crank failed at 1800N
- Force of 1800N applied using ANSYS
- ANSYS predicted force at
  - A = 446 MPa
  - B = 399 Mpa
- Fail strain of material = 400MPa

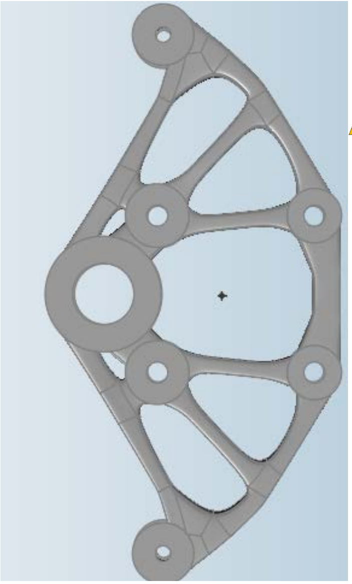


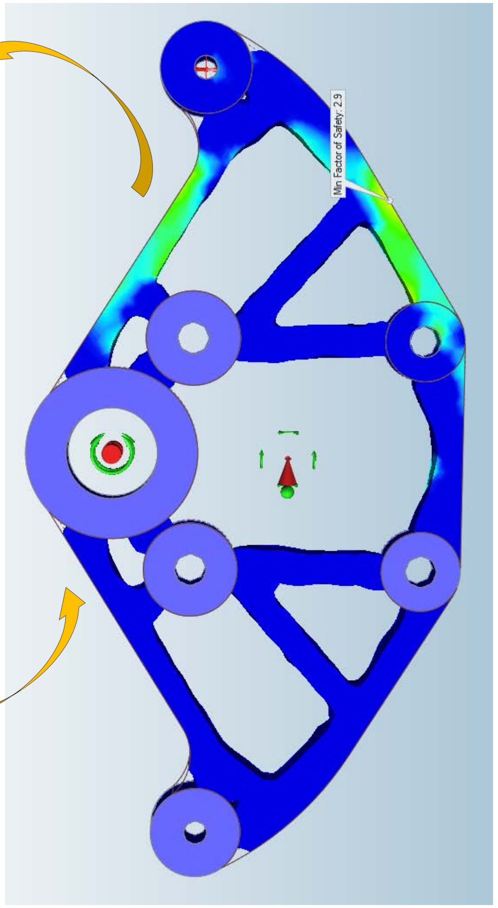
Real-life application

- Cessna bell crank
- Altair shape optimization
- DMLS laser printing
- EOS Aluminum AlSi10Mg



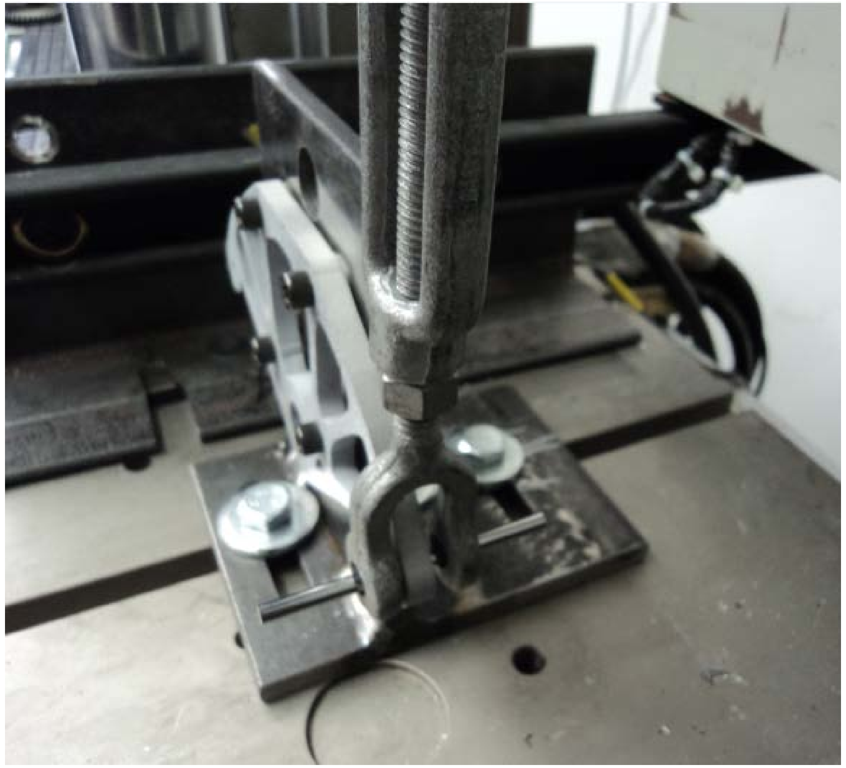
Shape optimized part

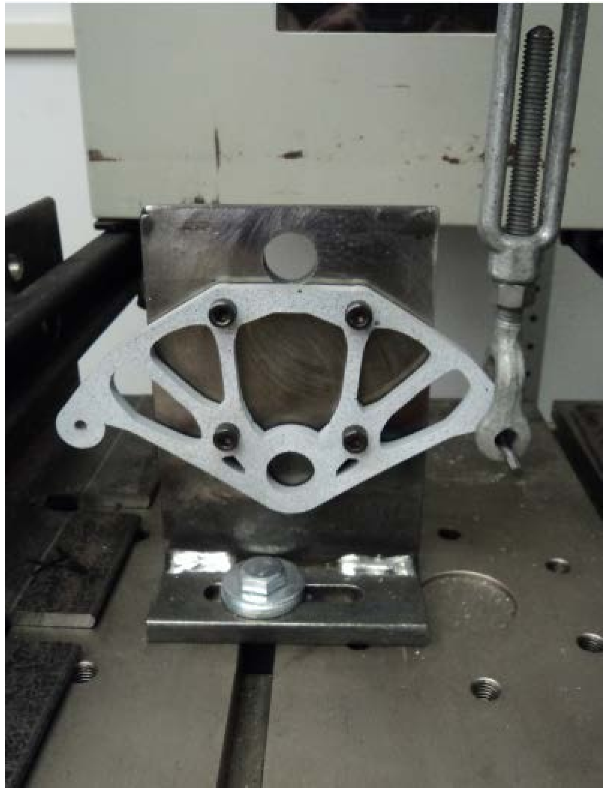




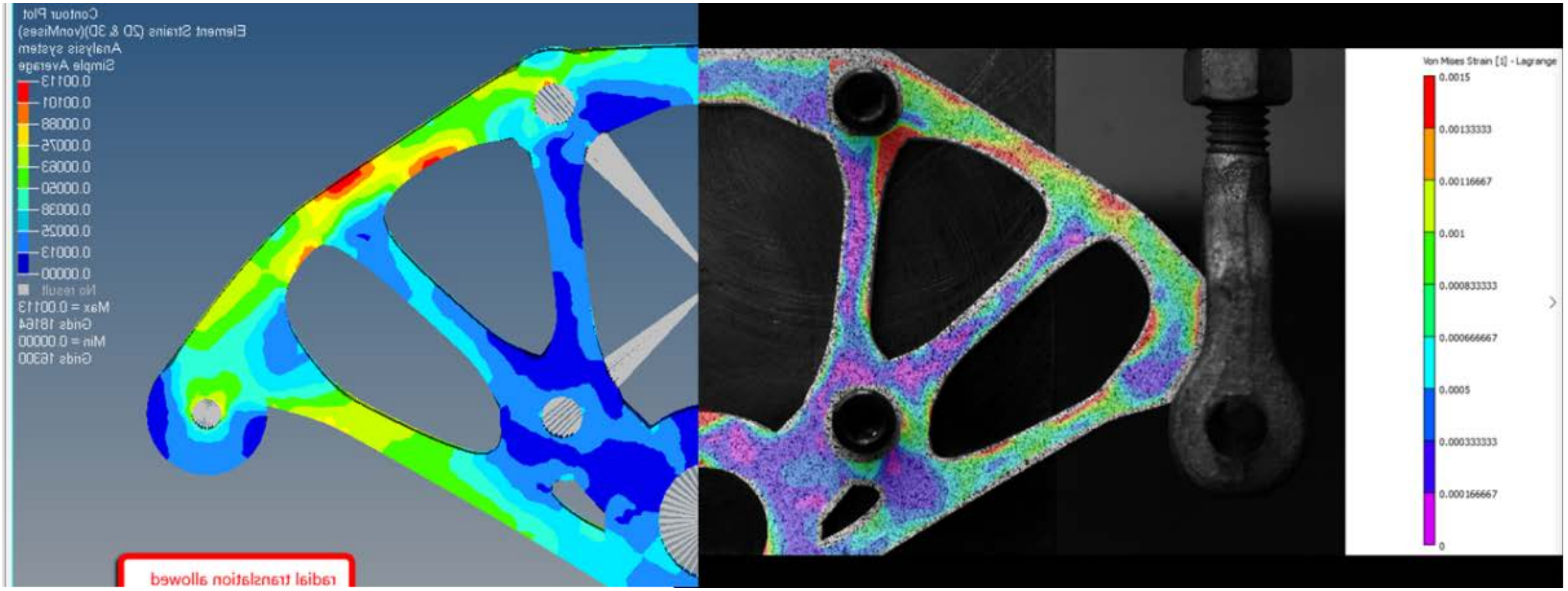
Original part

Prototype test



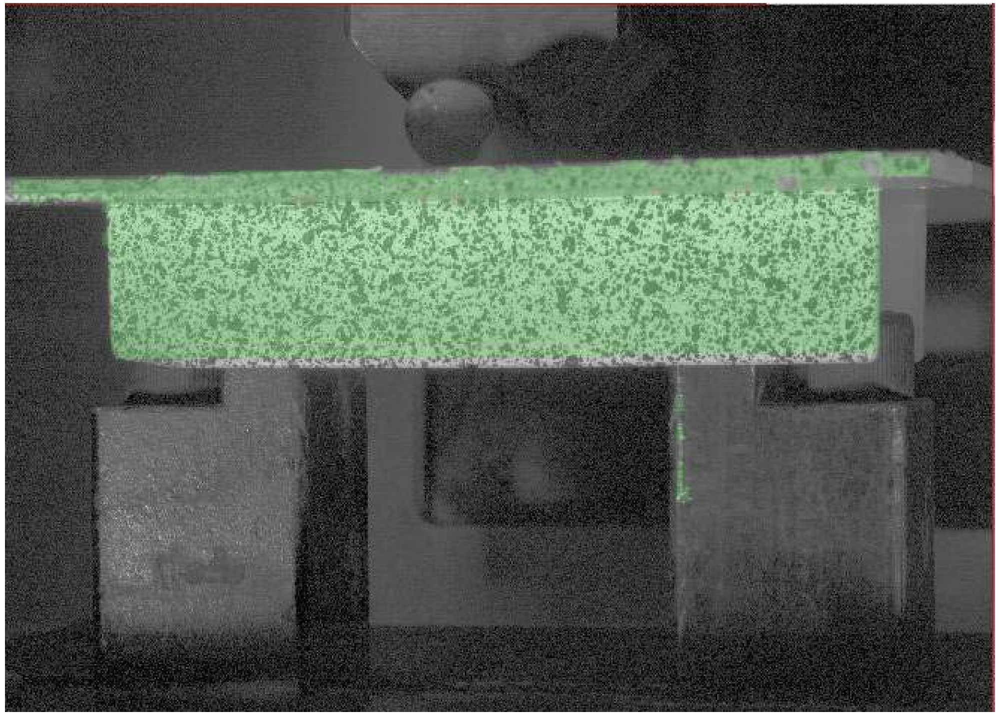


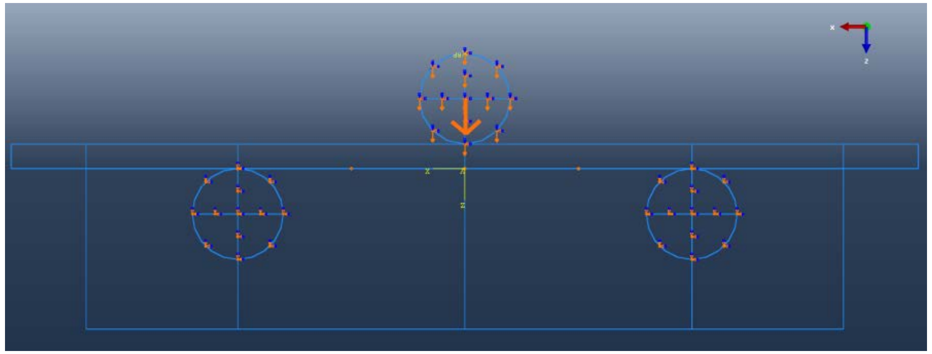
Comparing product test to simulation



Case Study-2 ductile plastic

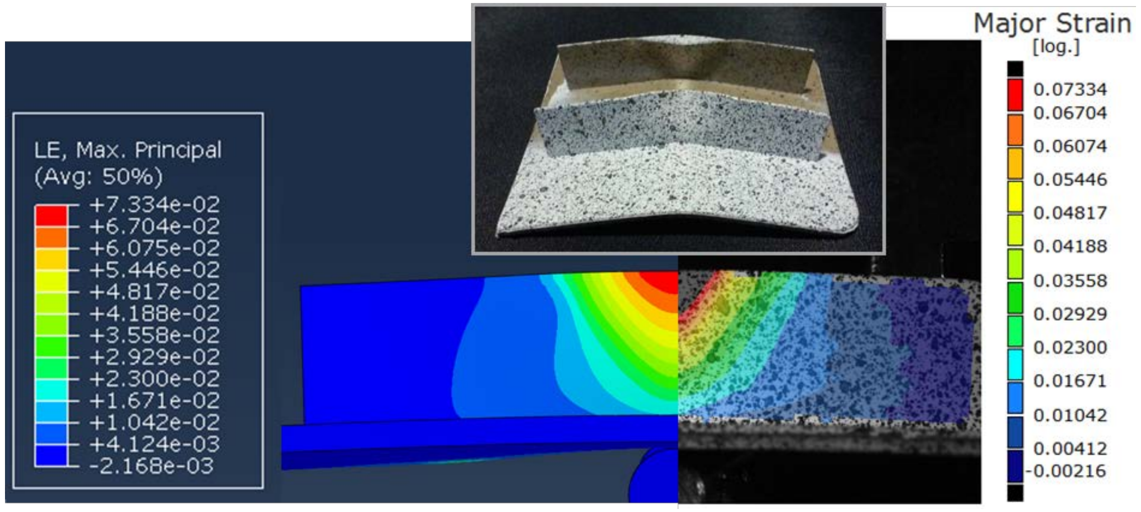
- Part features
  - Injection molded plastic
  - Complex flow pattern
  - Plate with 2 large fins
- 3 point bend test with UTM
  - 1 mm/min nose displacement
- Stereo-camera DIC to capture 3D strain





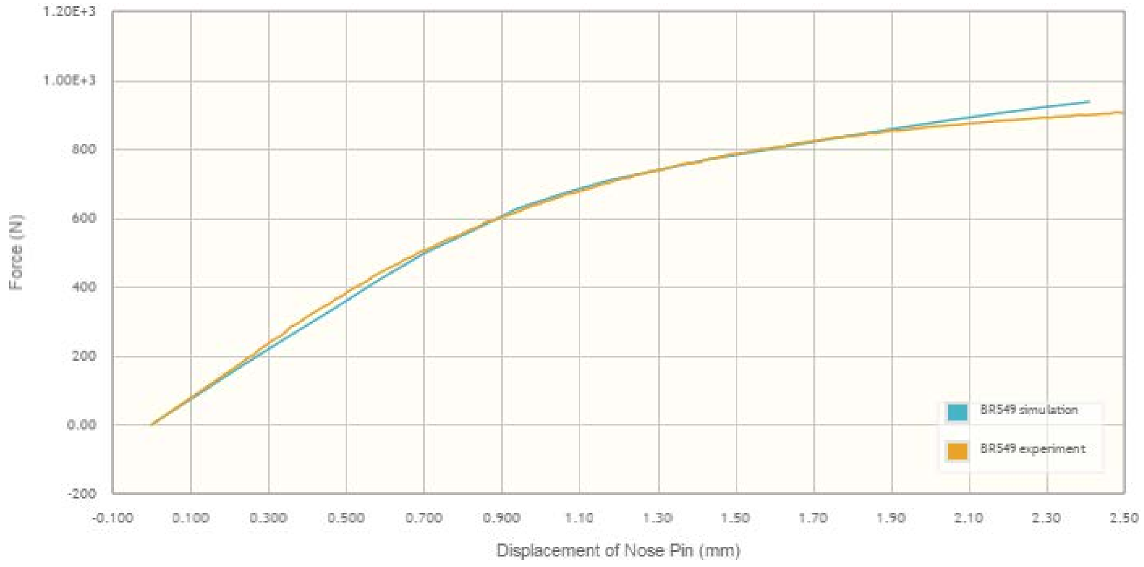
Validation Abaqus v. DIC surface strain

- Same contour scales used for test and simulation plots
  - Apples to apples comparison
  - Remarkable correlation except at high strain

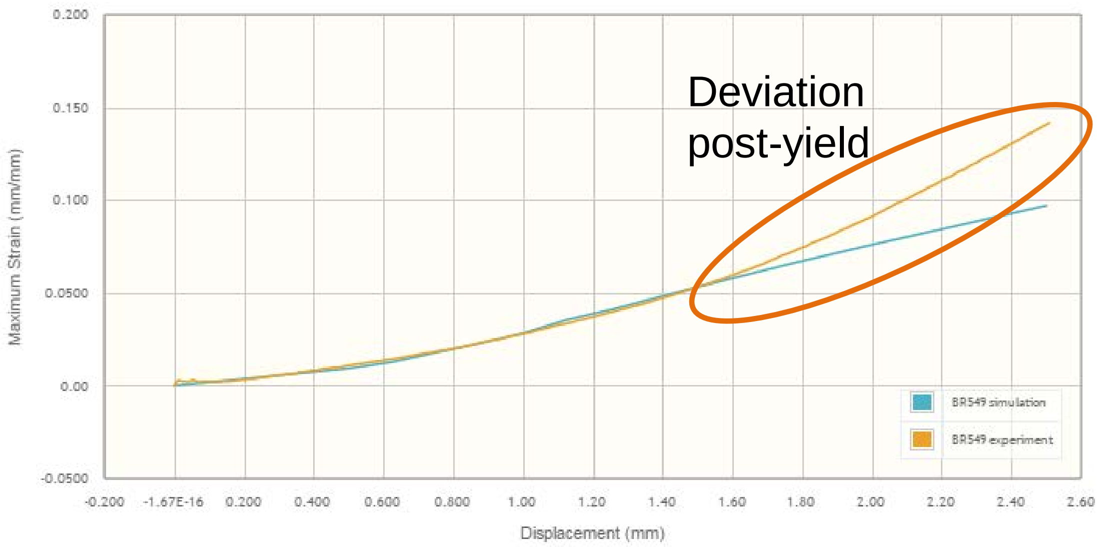


Validation

Force v. displacement comparison

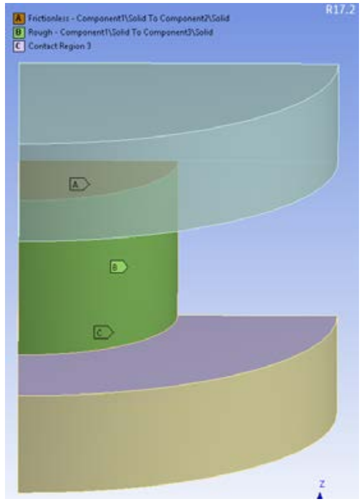


Localized DIC strain comparison



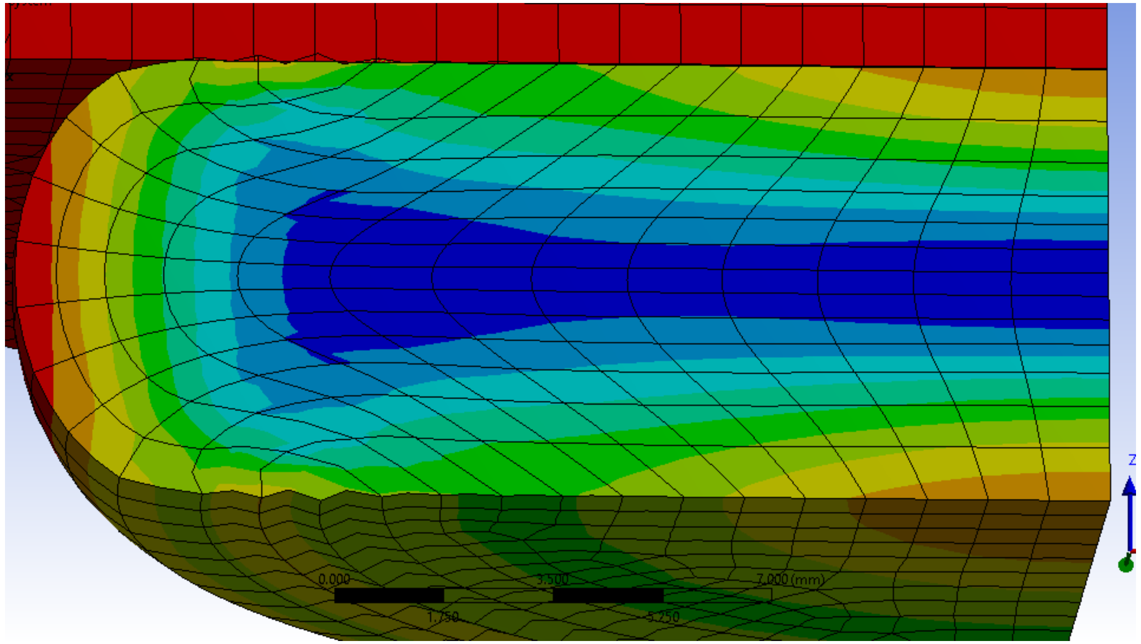
Case Study-3 rubber hyperelasticity

- Part features
  - “standardized” compression test
  - Both faces slipping (closed loop case)
  - Top face fixed (open loop)
  - Top and bottom faces fixed (open loop)
- Simulate and compare to experiment
- Quantify simulation accuracy

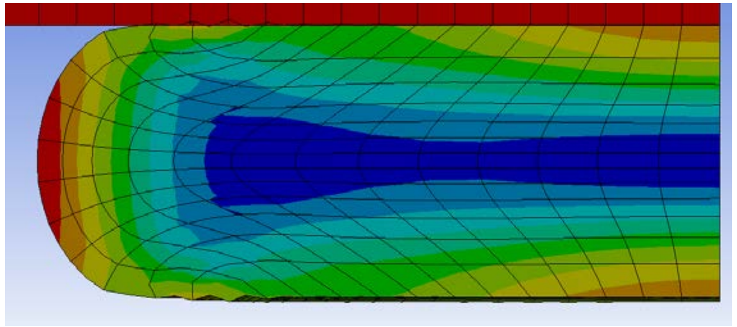


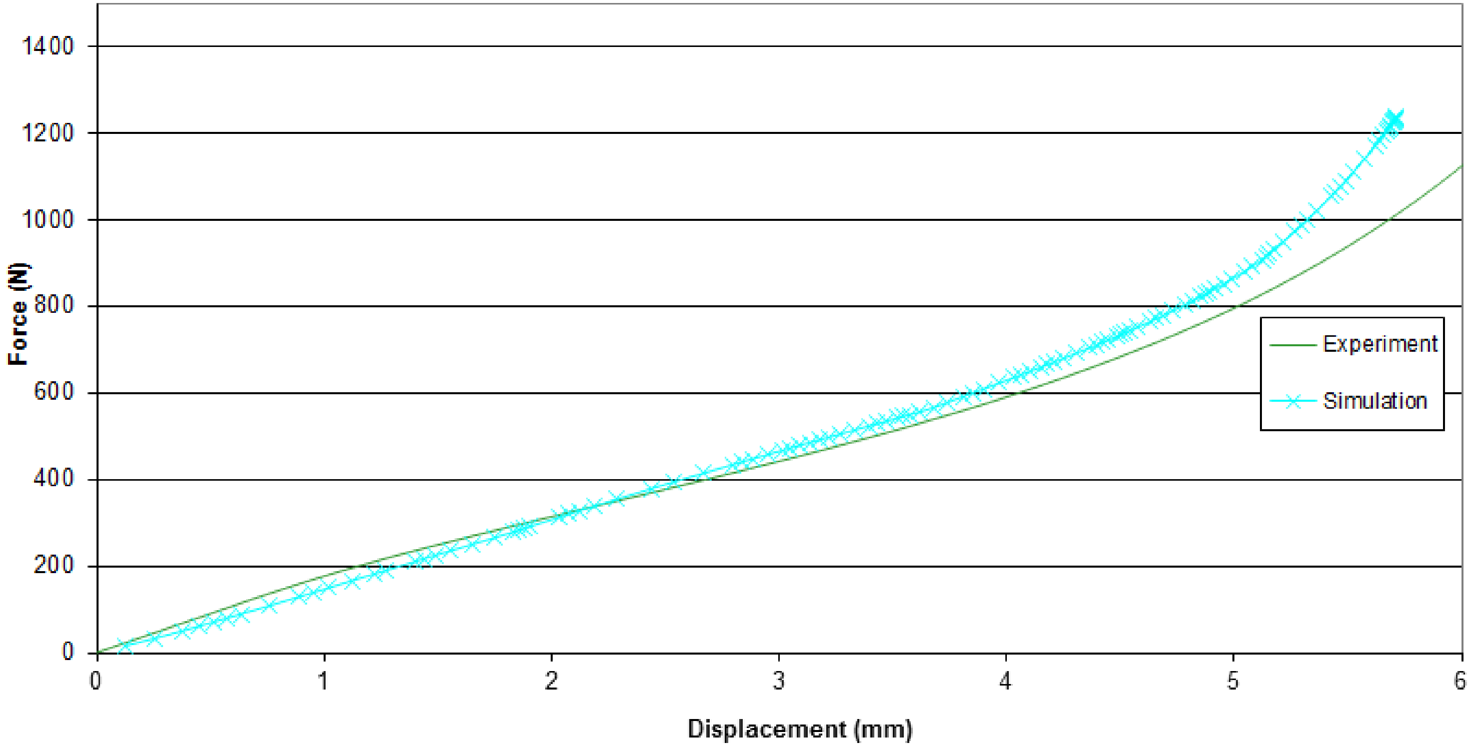
Simulation complexities

- Choice of material model
  - Mooney-Rivlin
  - Ogden
- Contact
  - Fixed boundary has roll over which is addressed with the rough contact
  - The corner element and nearby mesh are distorted



Validation: simulation v. ANSYS





Conclusion

- Mid-stage validation is useful for confirming simulation accuracy prior to start of real-life applications
- Determine simulation accuracy
- Identify simulation limits
- Essential pre-step for design optimization and additive manufacturing
- Can be useful for all materials and processes