Characterization and modeling of large collapsible tubular mast booms

Olive Stohlman (NASA), Martin Zander (DLR), and Johnny Fernandez (NASA), 14 January 2021

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Outline

- Background: about the booms
- Boom experiments
- Boom models

~7 minutes

- Filling in the gaps
- Future work and open questions

~3 minutes

Deployable Composite Booms (DCB)

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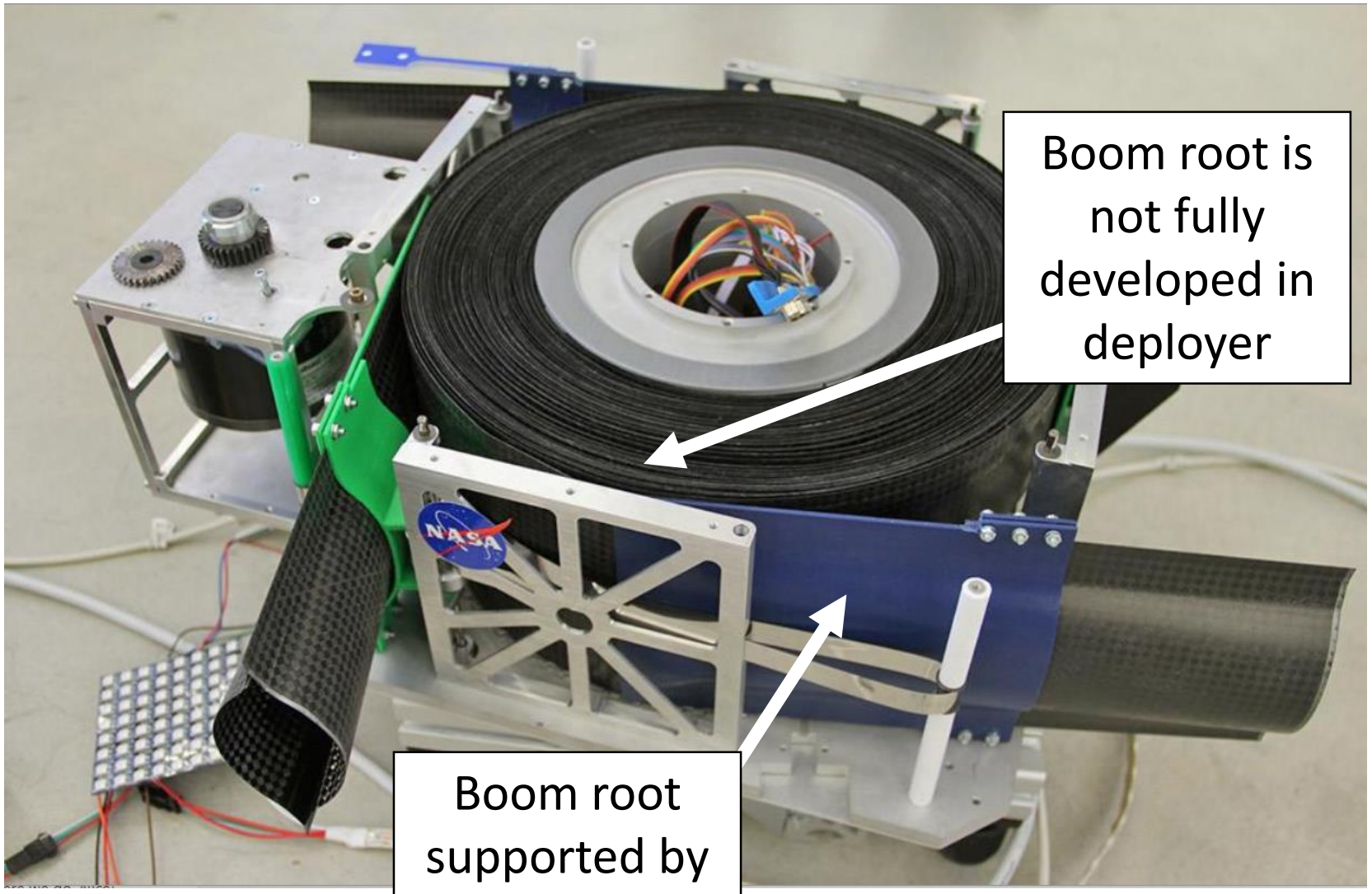
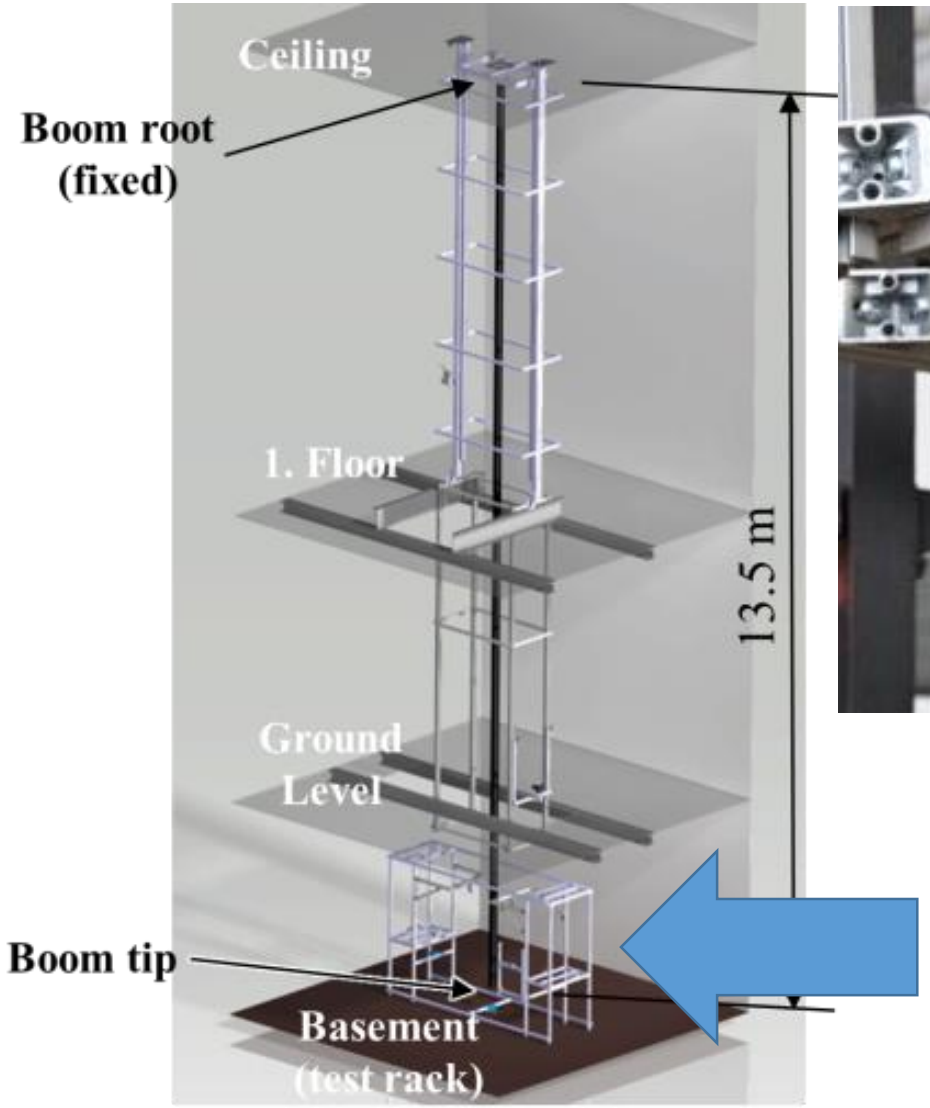
- Rollable carbon fiber reinforced composite booms
- 5-20 m length range
- “Omega-shaped”/lenticular closed cross-section
- Joint NASA/German Space Agency (DLR) project
  - NASA: booms, analysis
  - DLR: deployer, testing

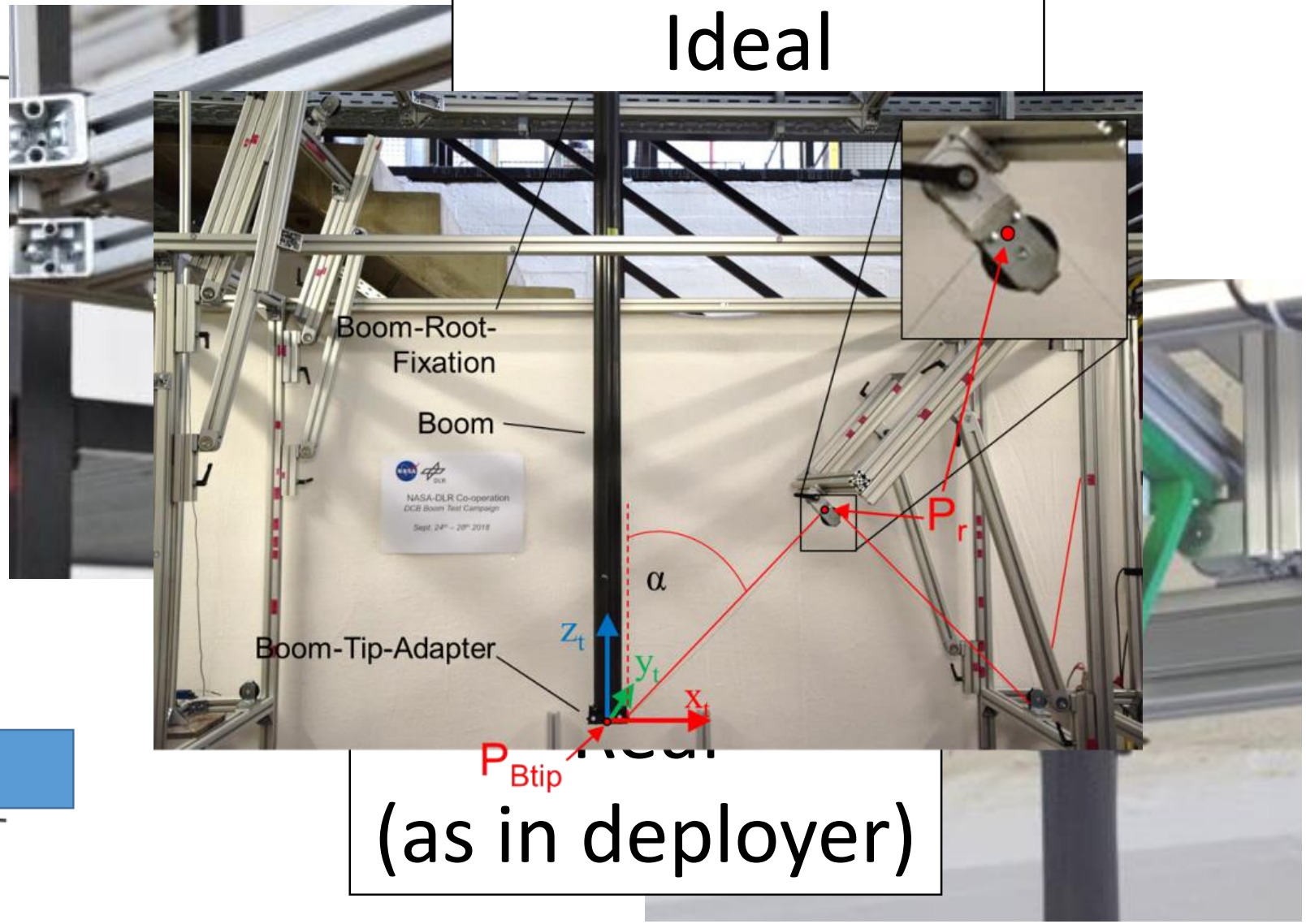
Experiment goals

- Beam properties with ideal boundary conditions
- Difference between ideal boundary performance and performance in a deployer
- Empirical boom failure load



Experiment

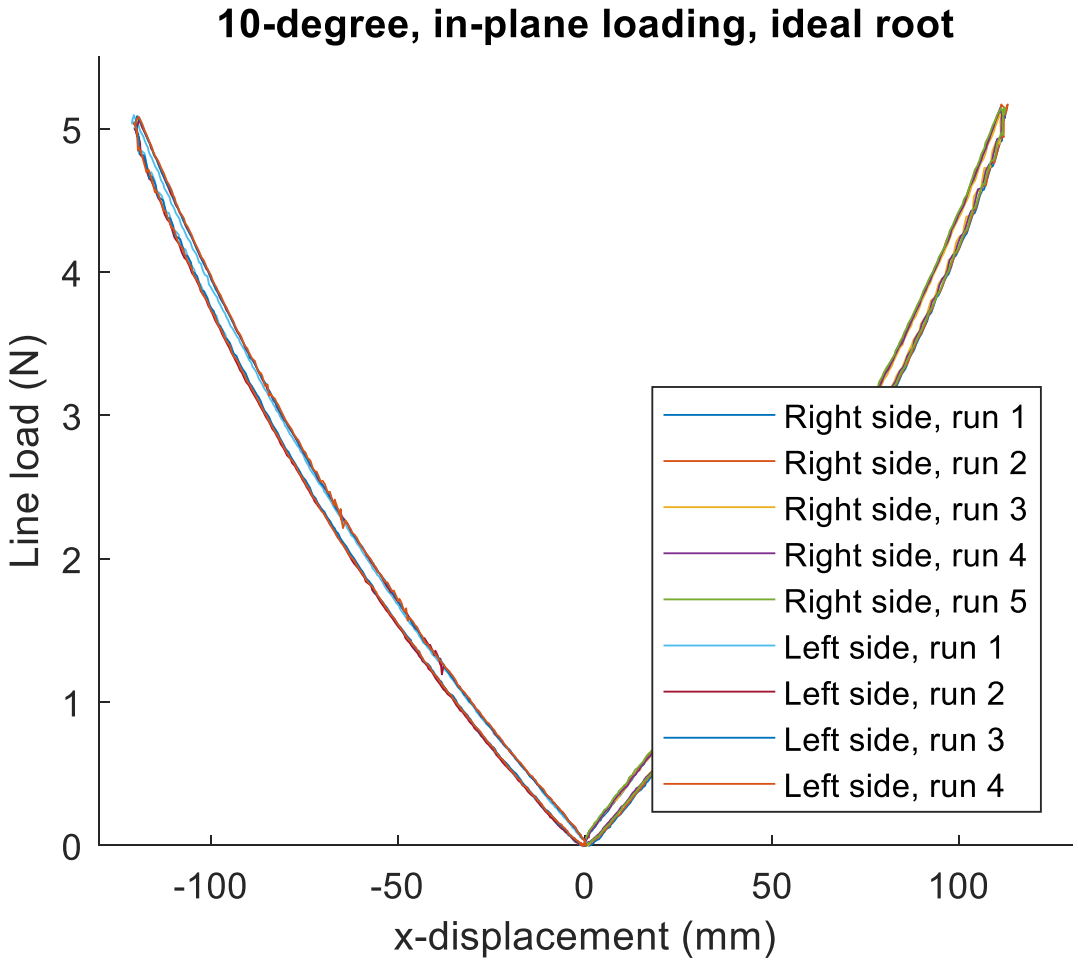




Ideal

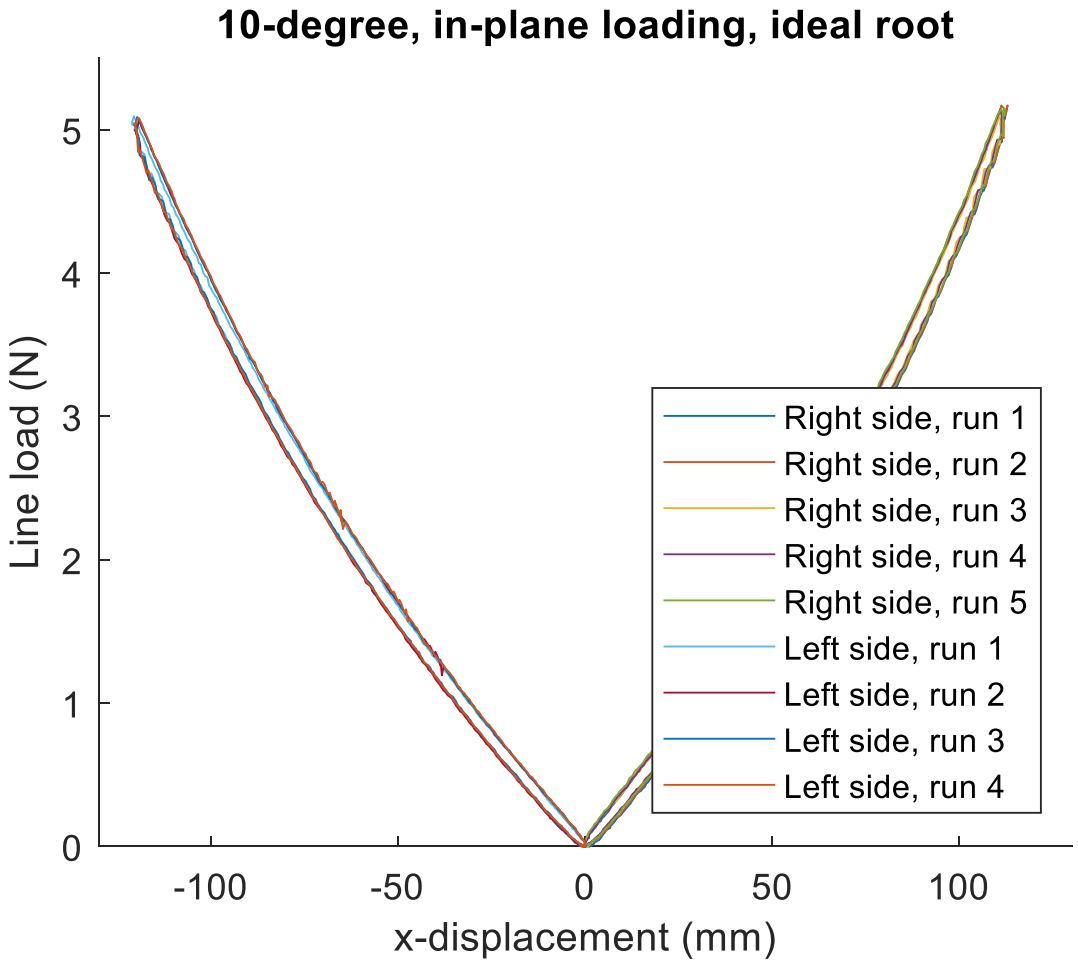
(as in deployer)

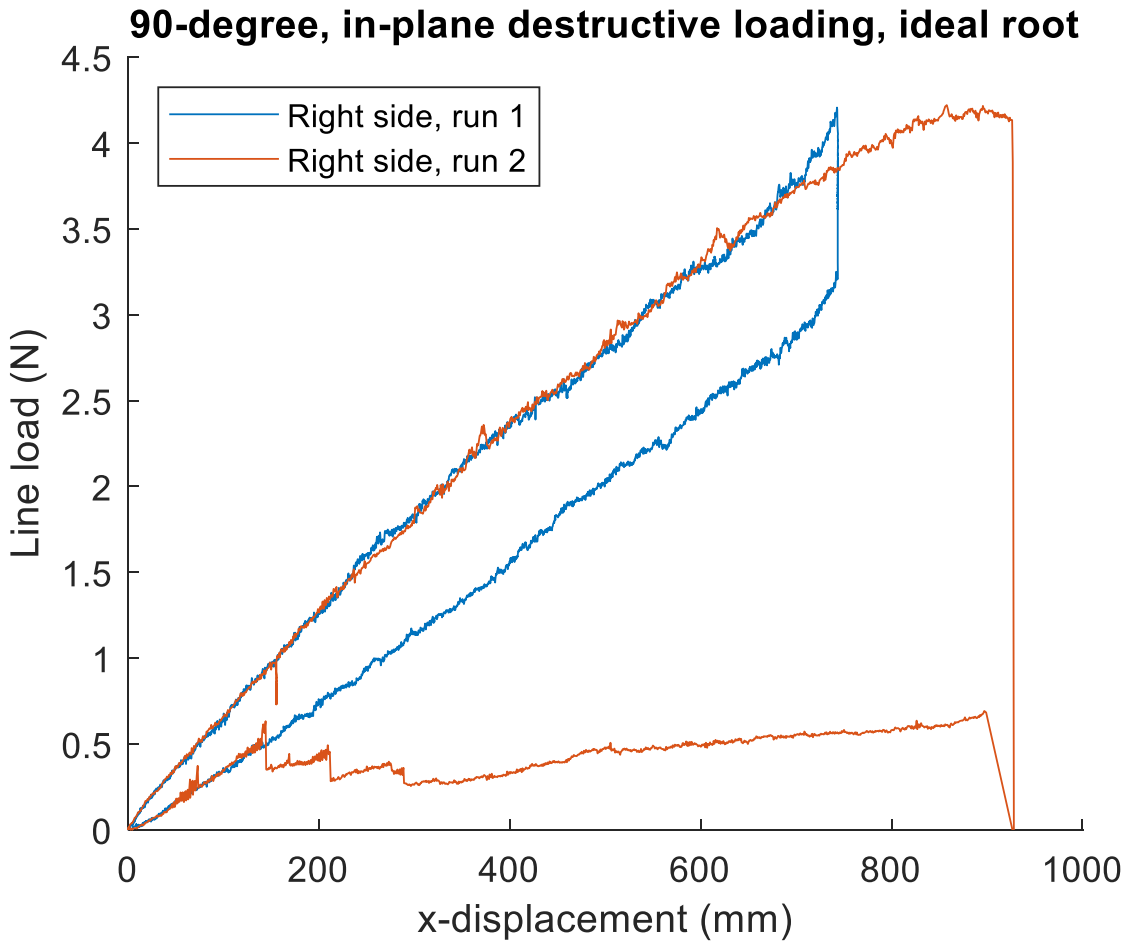
Experiment results



Read the paper

Experiment results





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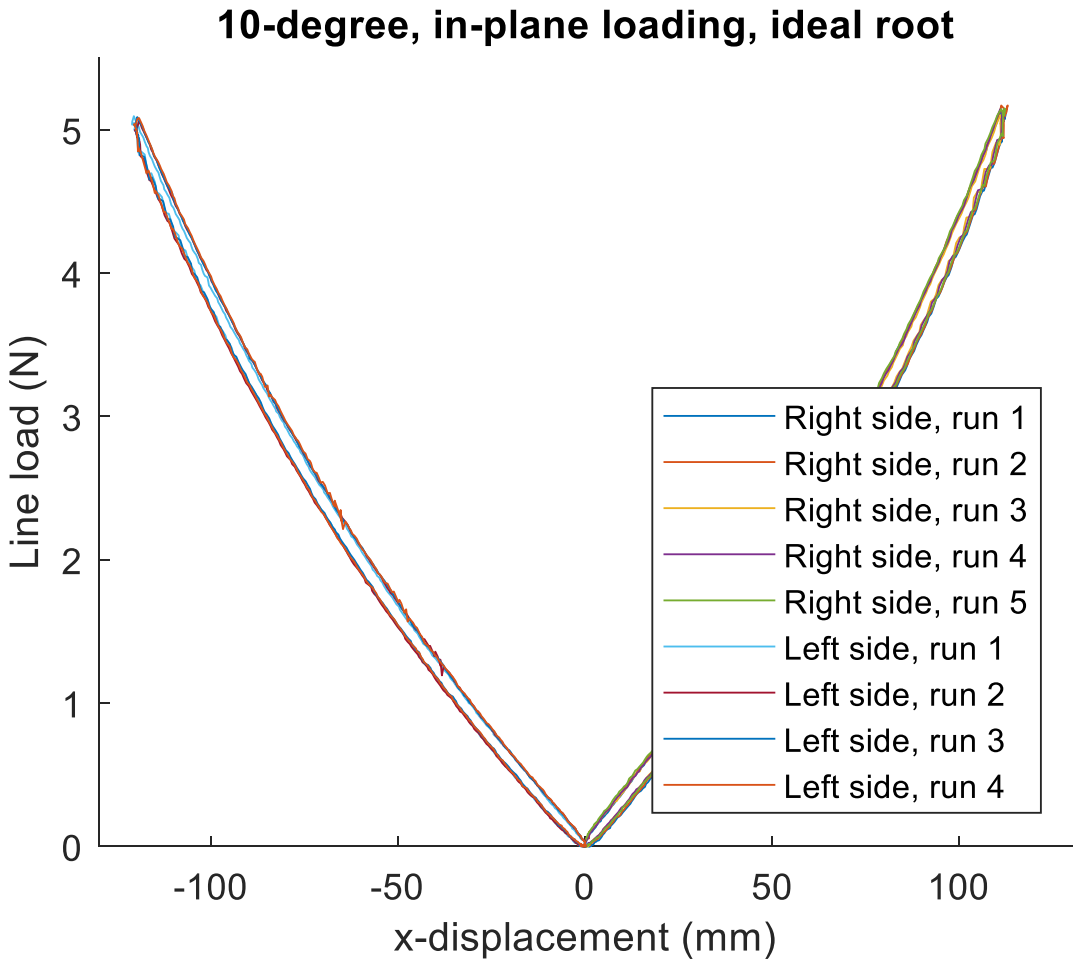
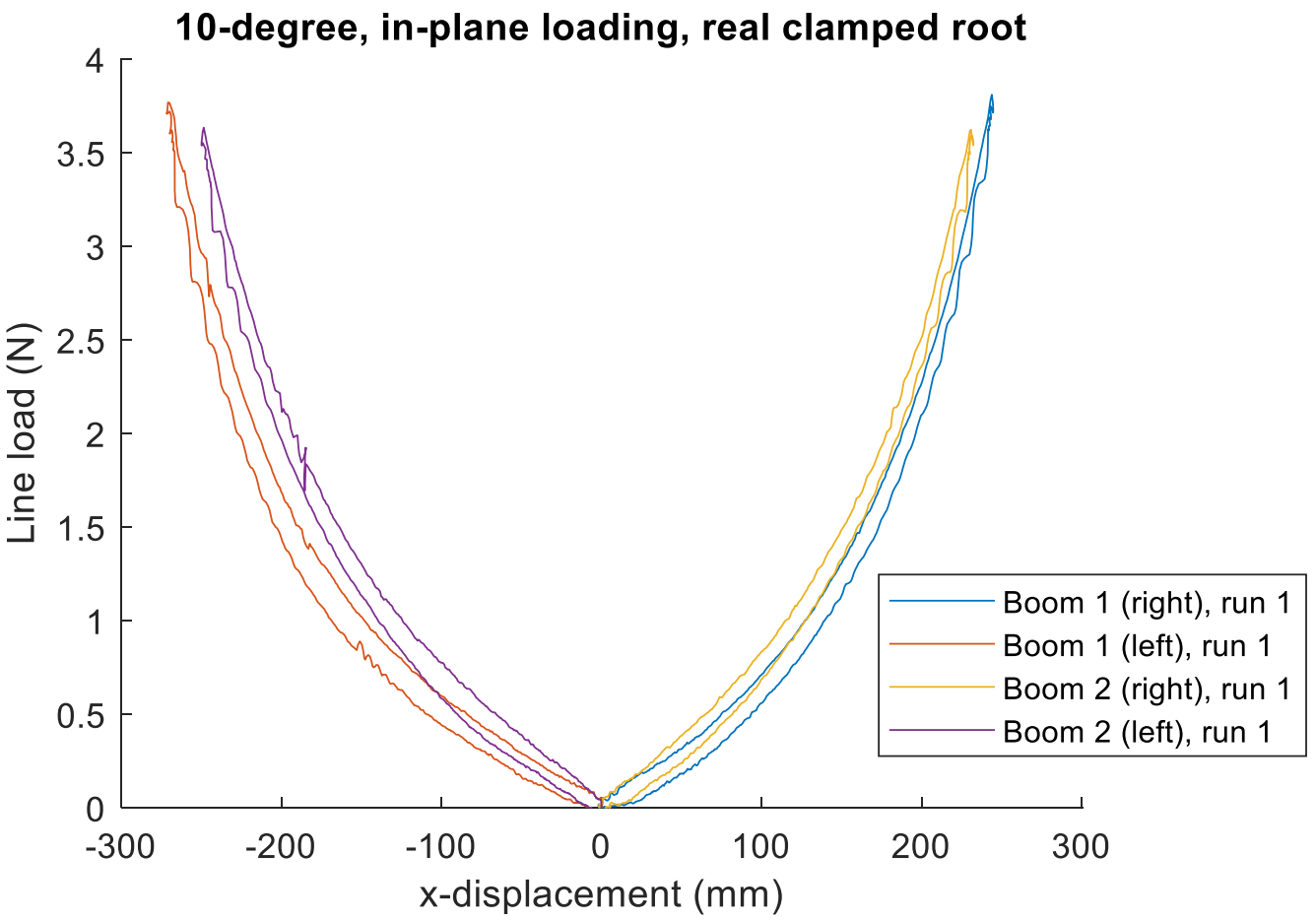
Experiment results





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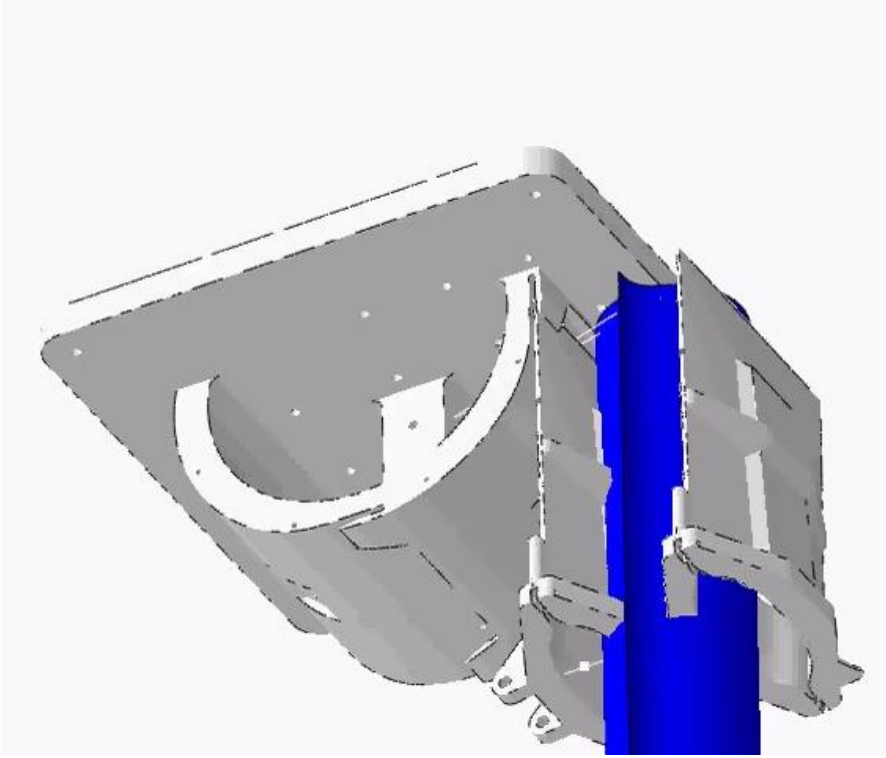
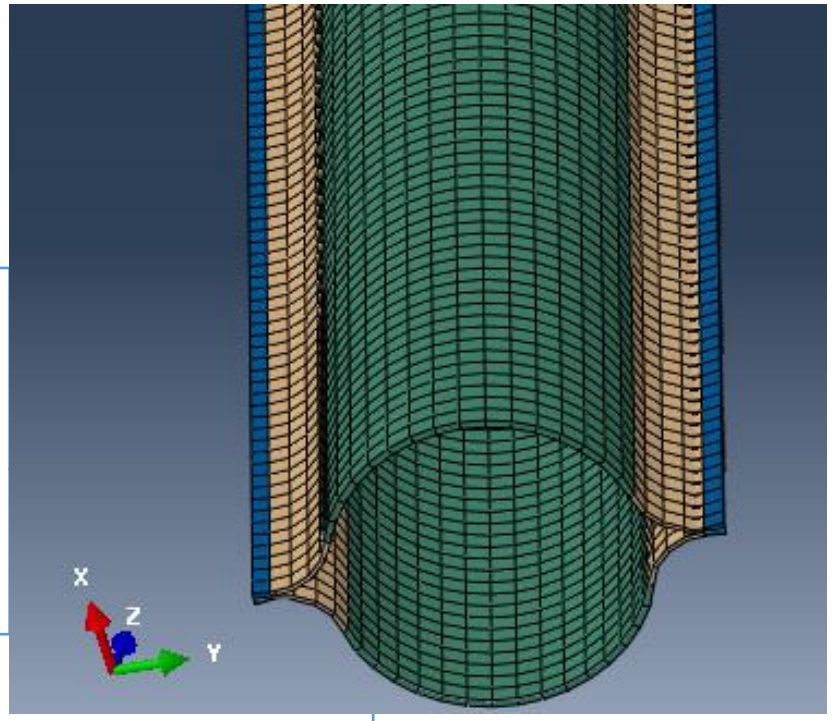
Plan A



Calibrated shell model simulation

Experimental data: complex boundaries



Derived beam model

~~Plan A~~

Experimental data: ideal boundary

Parametric simulation with variable width and ~~two material options~~

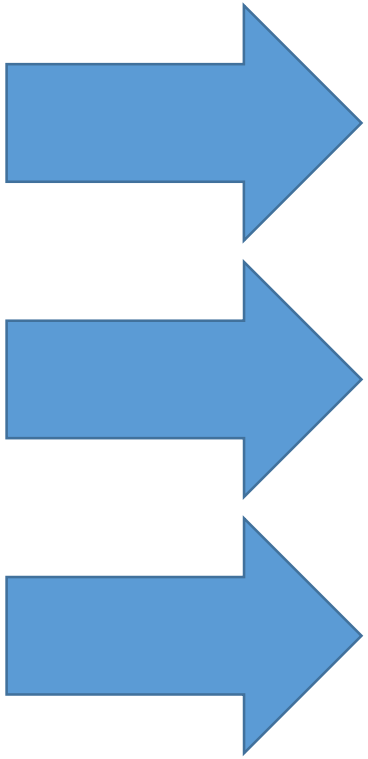
More material model parameters

Experimental data: failure load

Derived beam model

What went wrong?

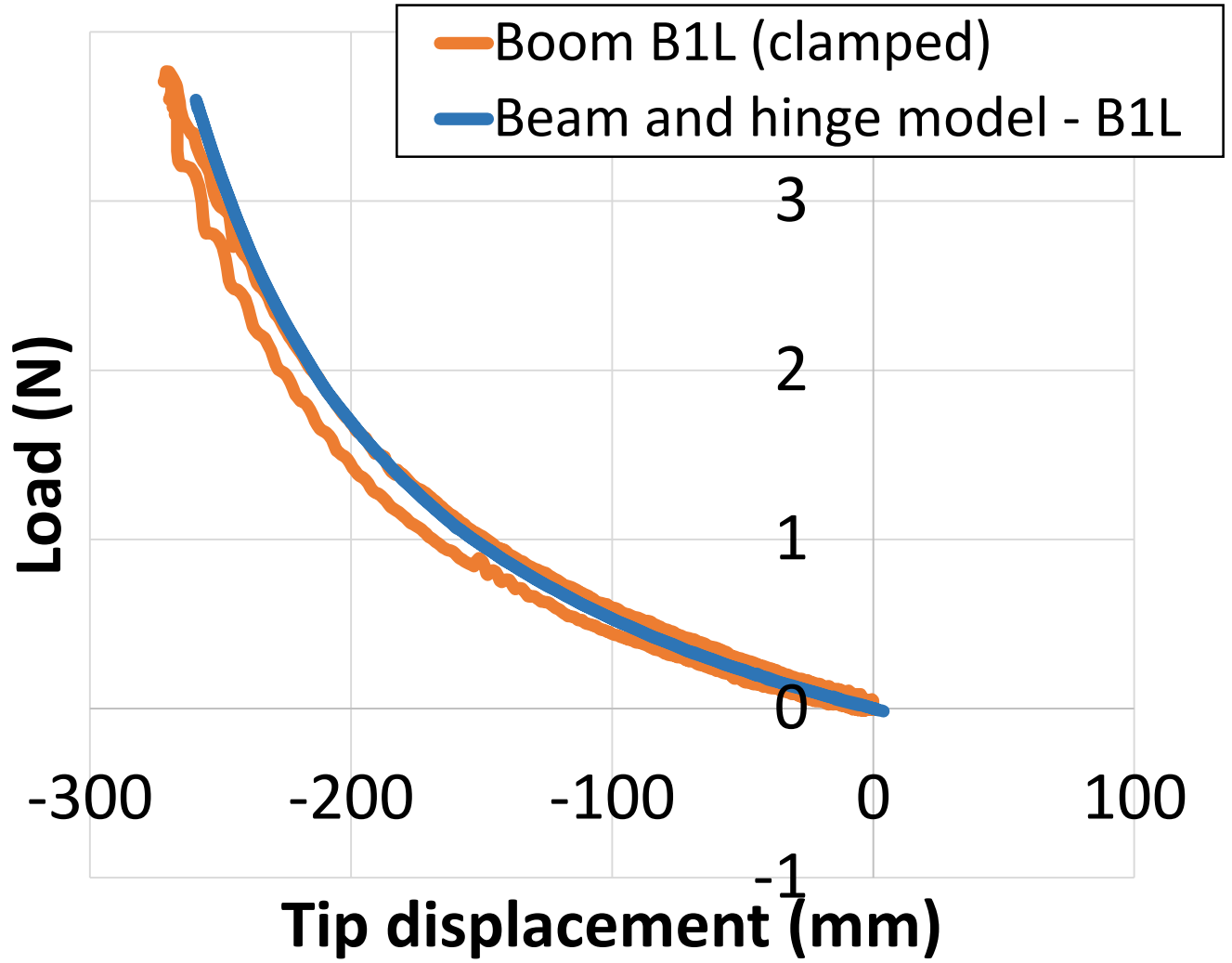
- Uncertainty too large in material models
- Uncertainty too large in cross-section
- Shape discrepancy of fit in sleeve



- More material characterization
- More shape characterization
- Let’s talk about this

(What went right?)

- A usable beam behavior model that reproduces the ideal beam behavior
- An elastic hinge that reproduces the real root behavior
- This is enough to roll the boom work into solar sail design!



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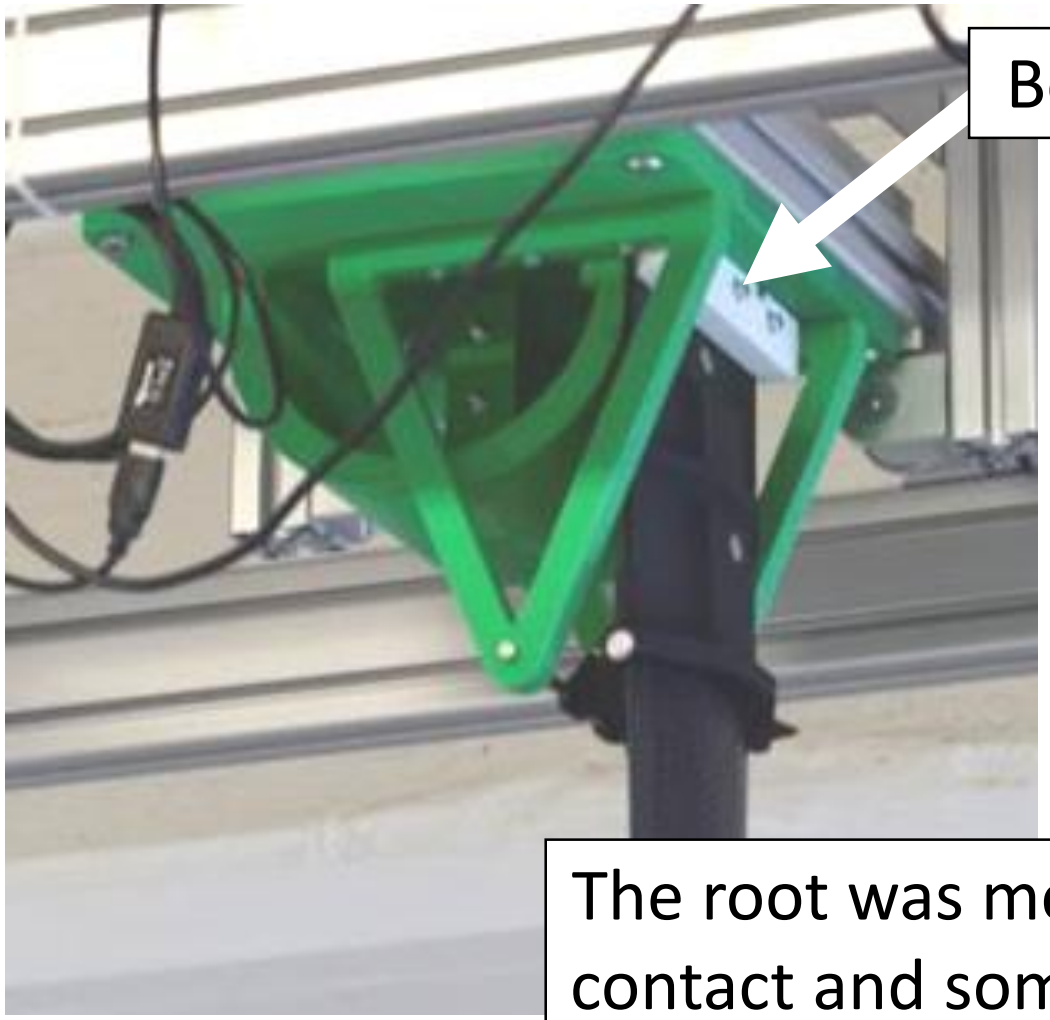
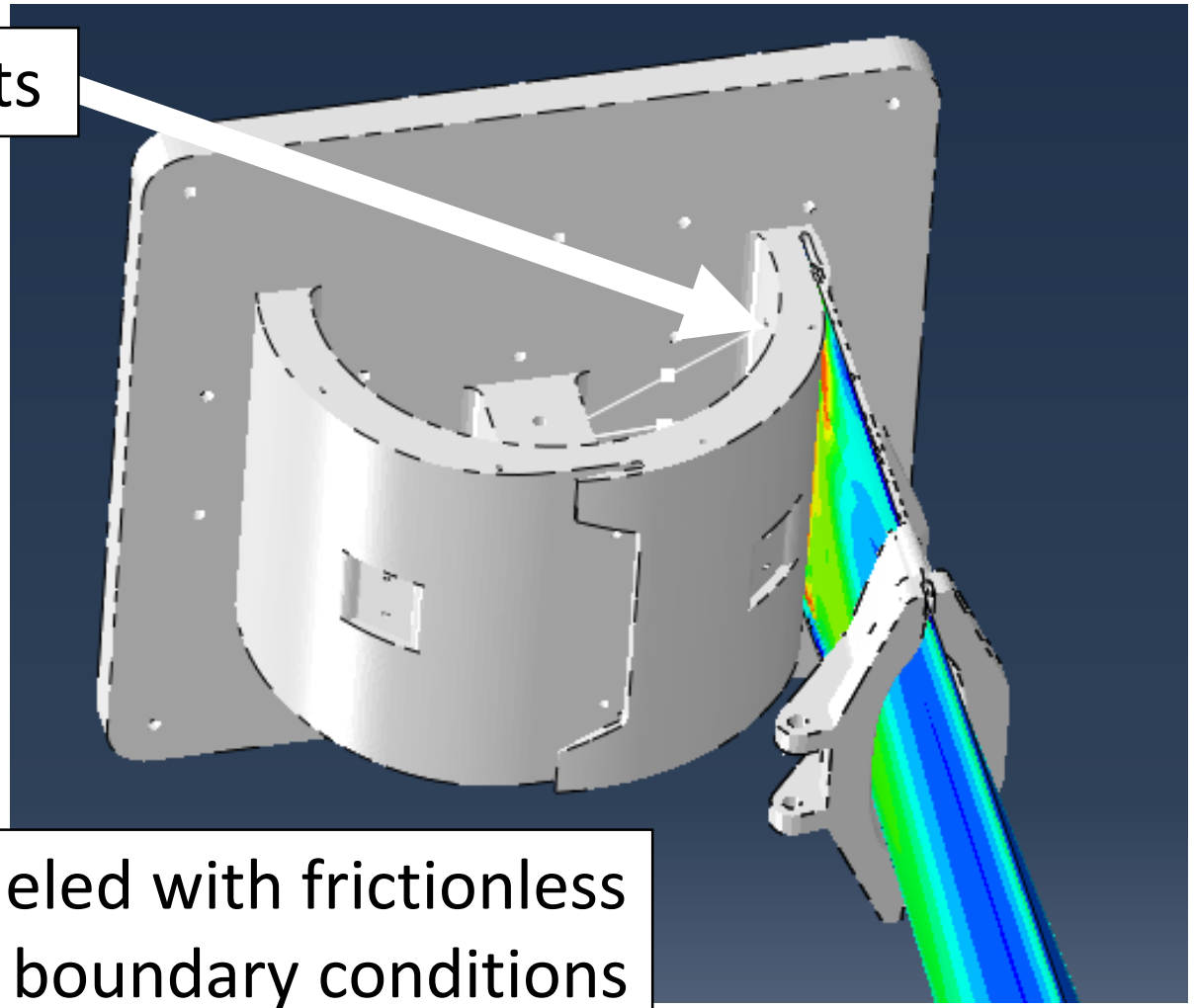
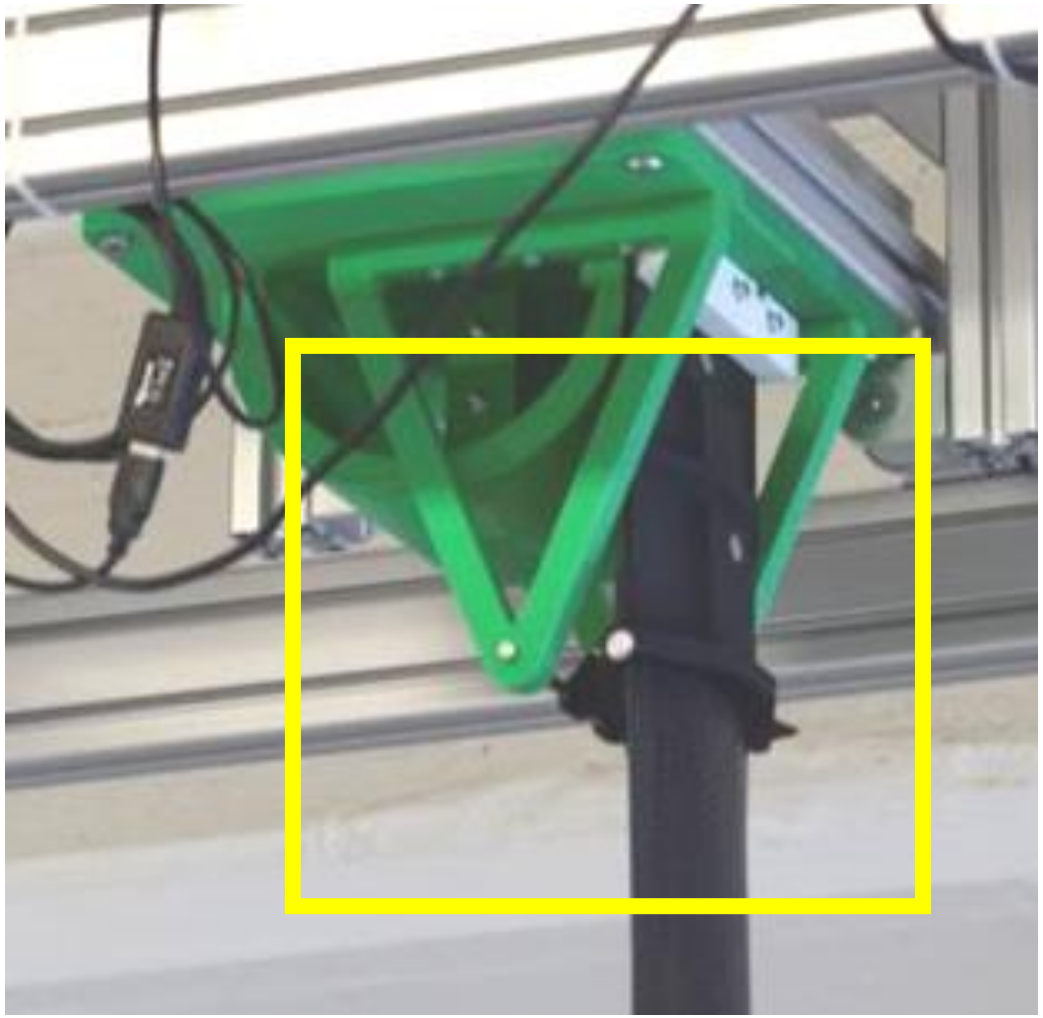
Sleeve fit problem

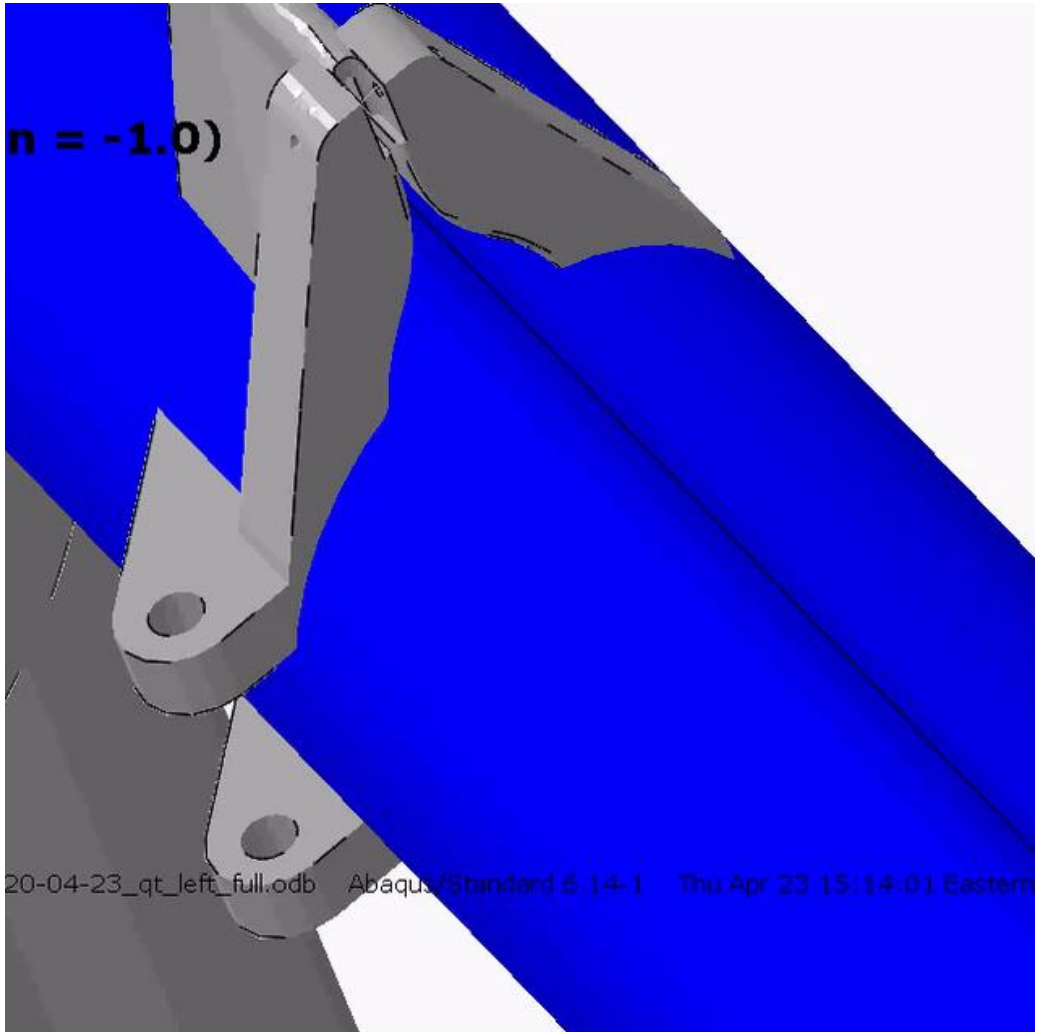




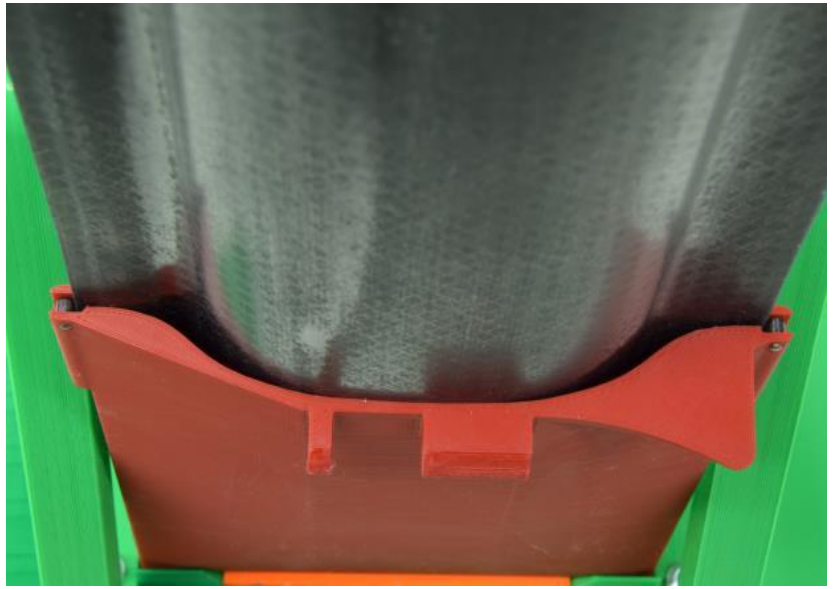
The root was modeled with frictionless contact and some boundary conditions representing the bolts

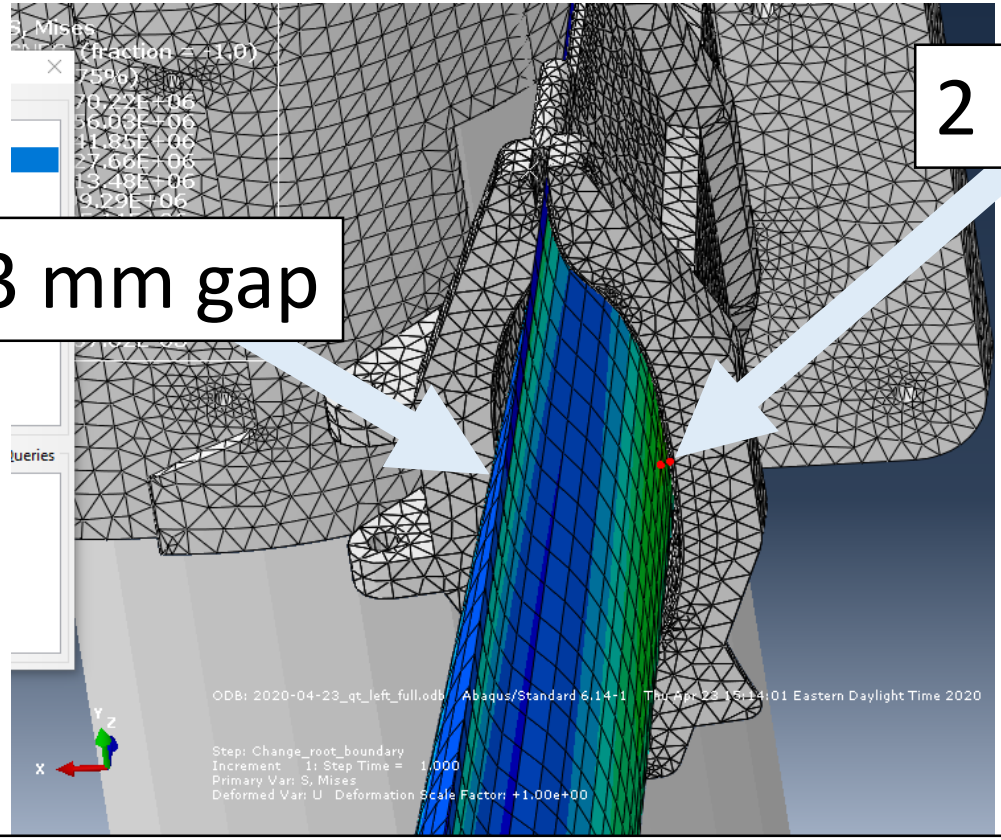
Sleeve fit problem





Sleeve fit problem

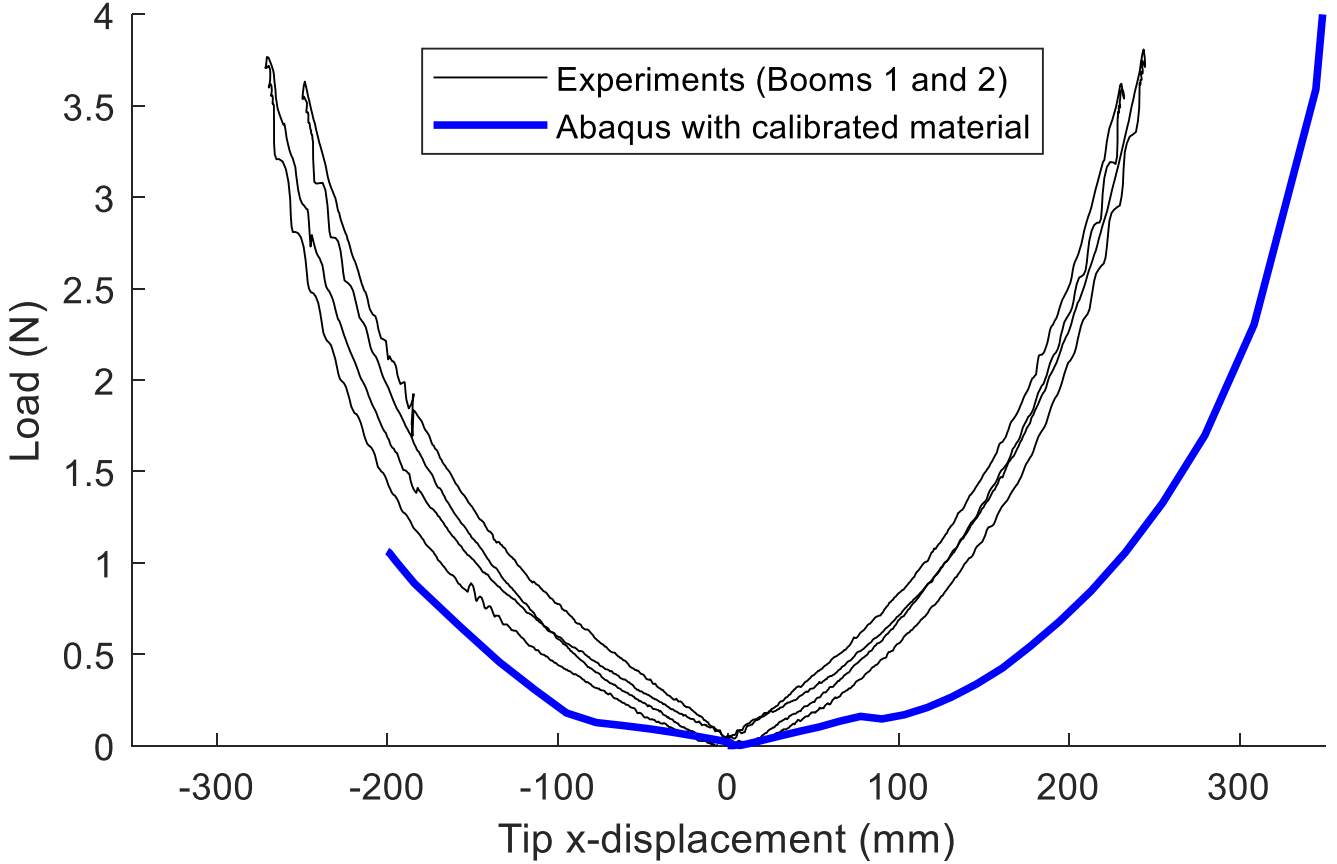




Simulation transition length is too long

Sleeve fit problem

- The real boom fills the sleeve, but the modeled boom does not
- Causes a “deadband” in the model stiffness that isn’t present in the experiments
- Insensitive to modest changes (20%) in material properties
- Proportionately sensitive to changes in cross-section
- It might work out as we refine our material and shape models, but
- **We’d love to hear advice**



Conclusion

In the paper:

- More about the material model
- More about the experimental work at DLR
- More about the beam model derivation

Forward work:

- Tighten precision of material models
- Identify reasons for the poor shell model results in the “real root” condition simulation
- Refresh the simplified beam model with a validated shell model

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