Cable Resistance in Spacecraft Deployable Mechanisms

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Introduction

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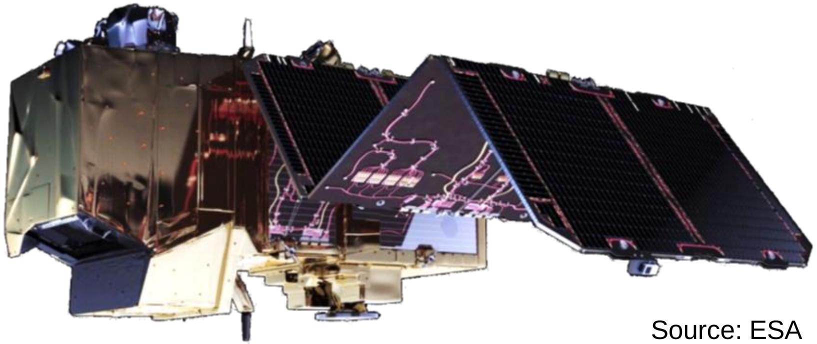
- **Objective:** Provide the space engineering community with a reliable and methodical way to predict these forces early in the mechanism design process
- **Approach:** Layout a methodology to characterize cables and record their torque response in deployment systems



Source: ESA

Why Does This Matter?

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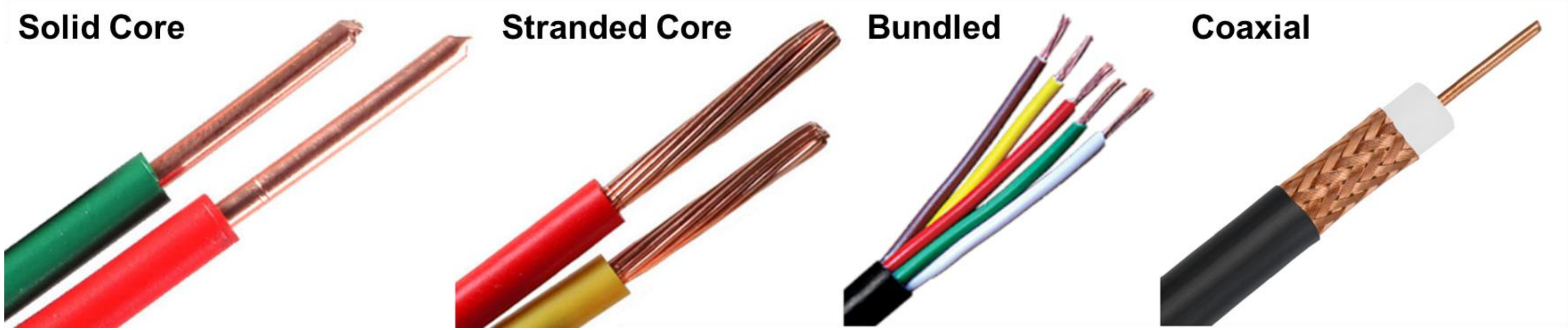
- Resistive torque defined late in the design cycle
- High margins are applied to account for uncertainty
- Cables experience creep effects from long term storage



Methodology

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Identify cable effective material properties with cantilever bending test

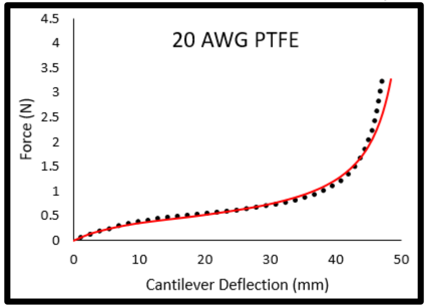
Best fit analytical beam bending model to experimental results to define elastoplastic parameters

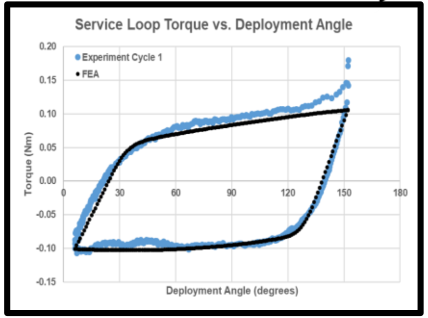
Generate resistive torque prediction with FEA model of a representative deployment system

Validate predictive model with a representative two-panel deployment test

K = strength coefficient

n = strain hardening exponent





Cantilever Bending Experiment

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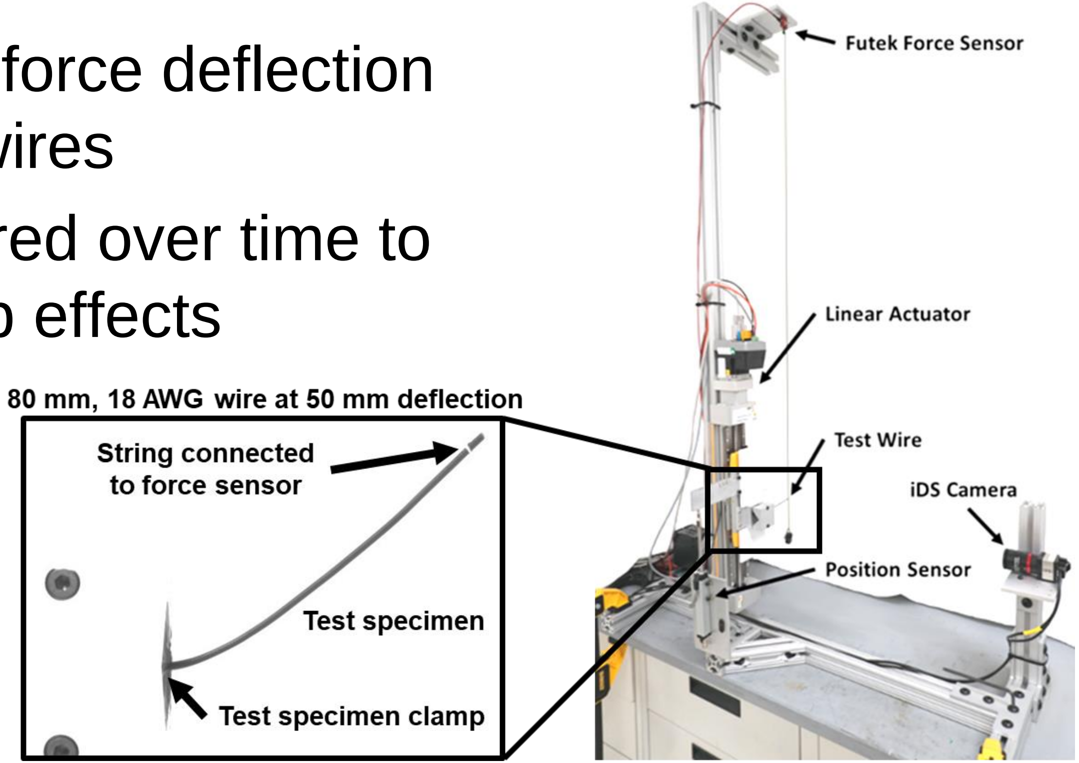
- Captured the force deflection response of wires
- Force measured over time to quantify creep effects



Cantilever Bending Experimental Results

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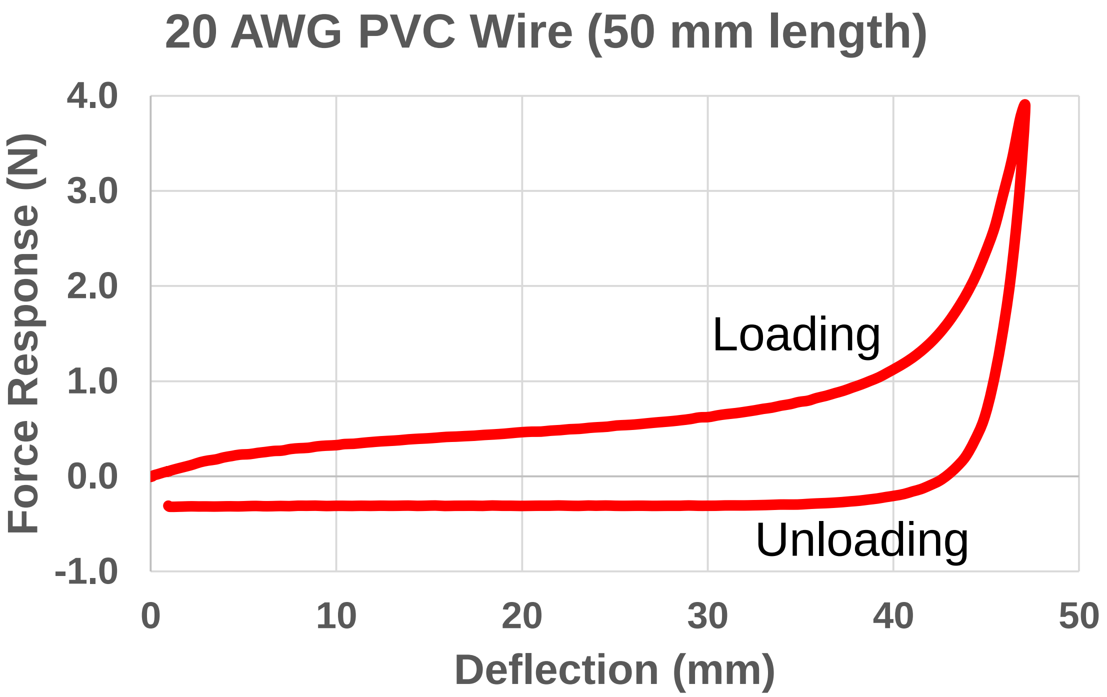
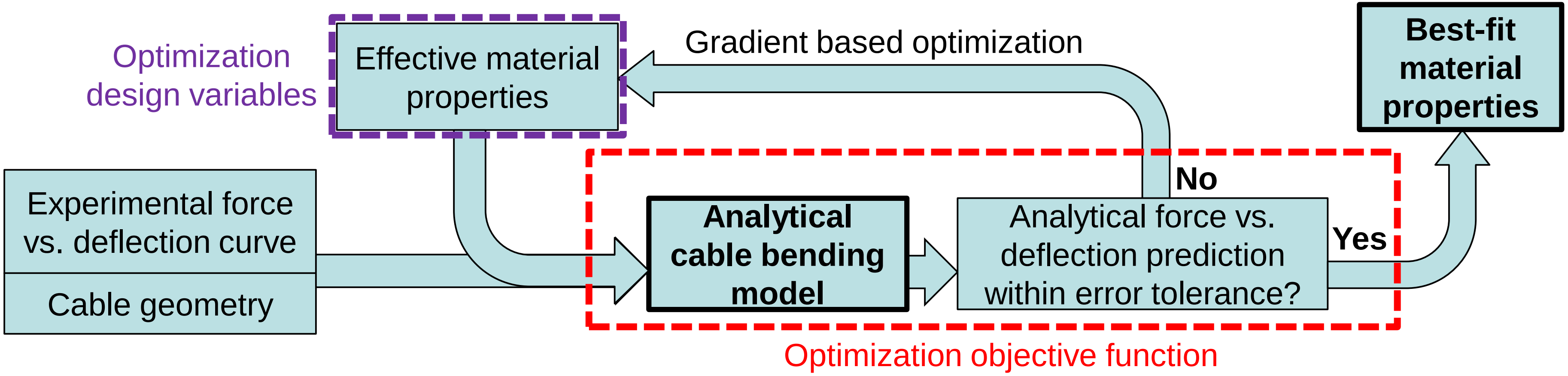


Analytical Cable Bending Model

➢ Analytical model alongside an optimization algorithm determined best-fit effective material properties



Analytical Cable Model Assumptions

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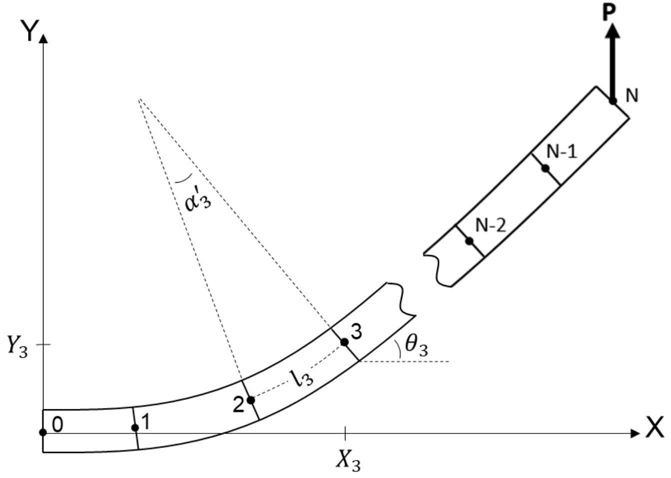
- Cantilevered cable is discretized into a set of elements
- Shear and axial deformations neglected



- Each element assumed to be in pure bending
- Analytical model produces results within 1% of FEA simulation

Cantilever Results

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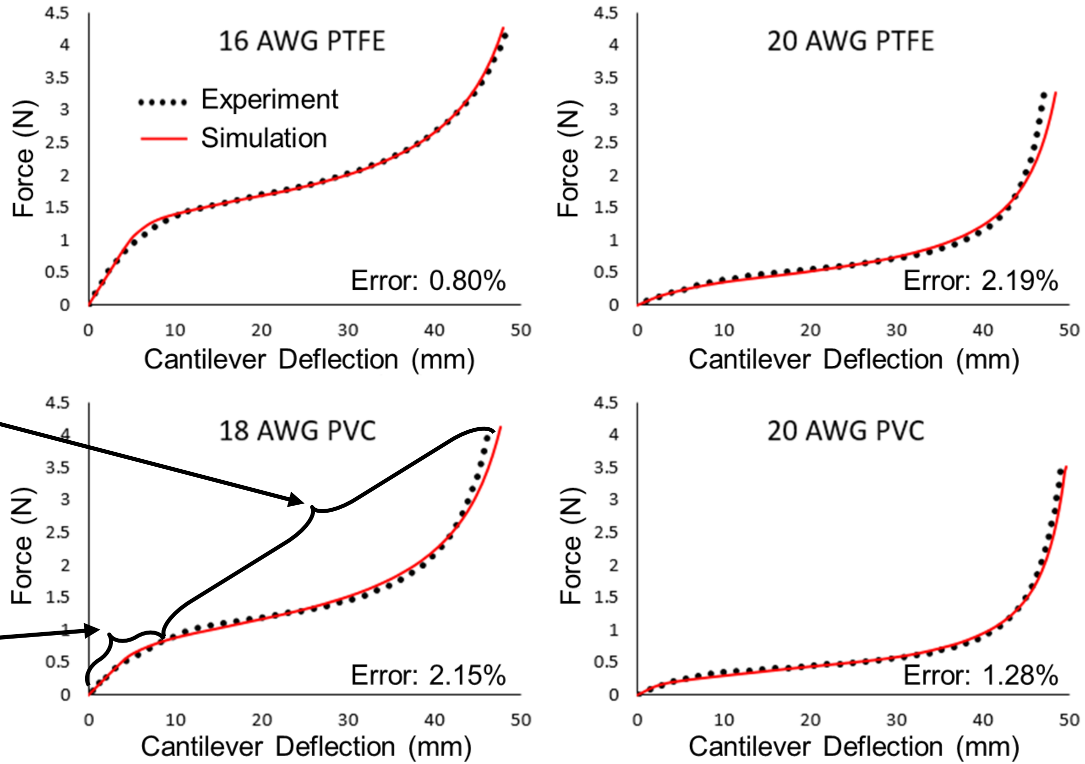
- Test specimens deflected to 15% strain

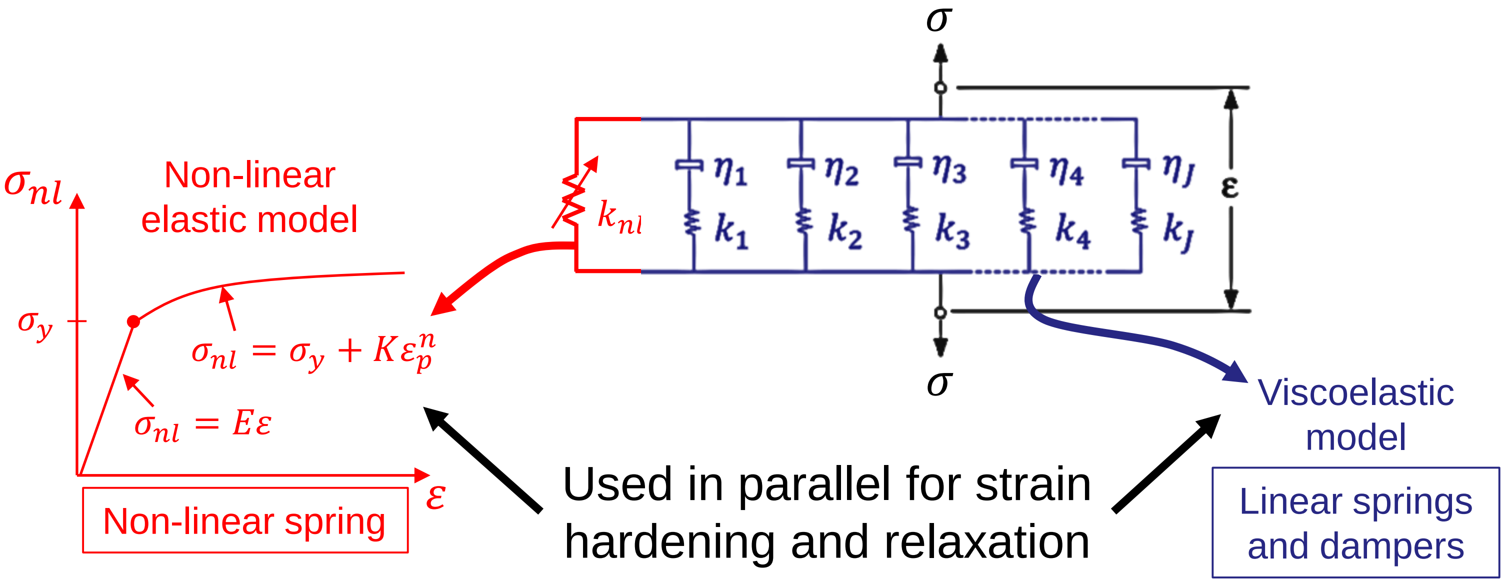
Plastic Response

Elastic Response



Constitutive Material Model

- Material model approximates how the cable deforms



Viscoelastic Cantilever Results

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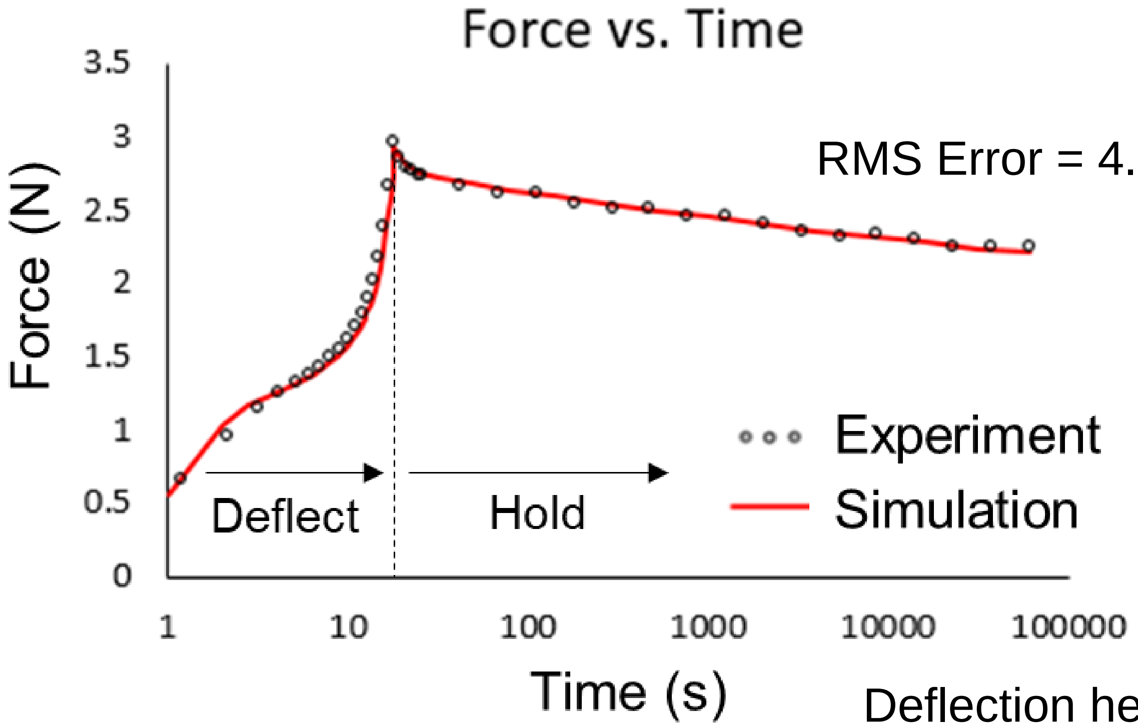

RMS Error = 4.0%

Deflection held for 40 hours

Two-Panel Representative Deployment Test

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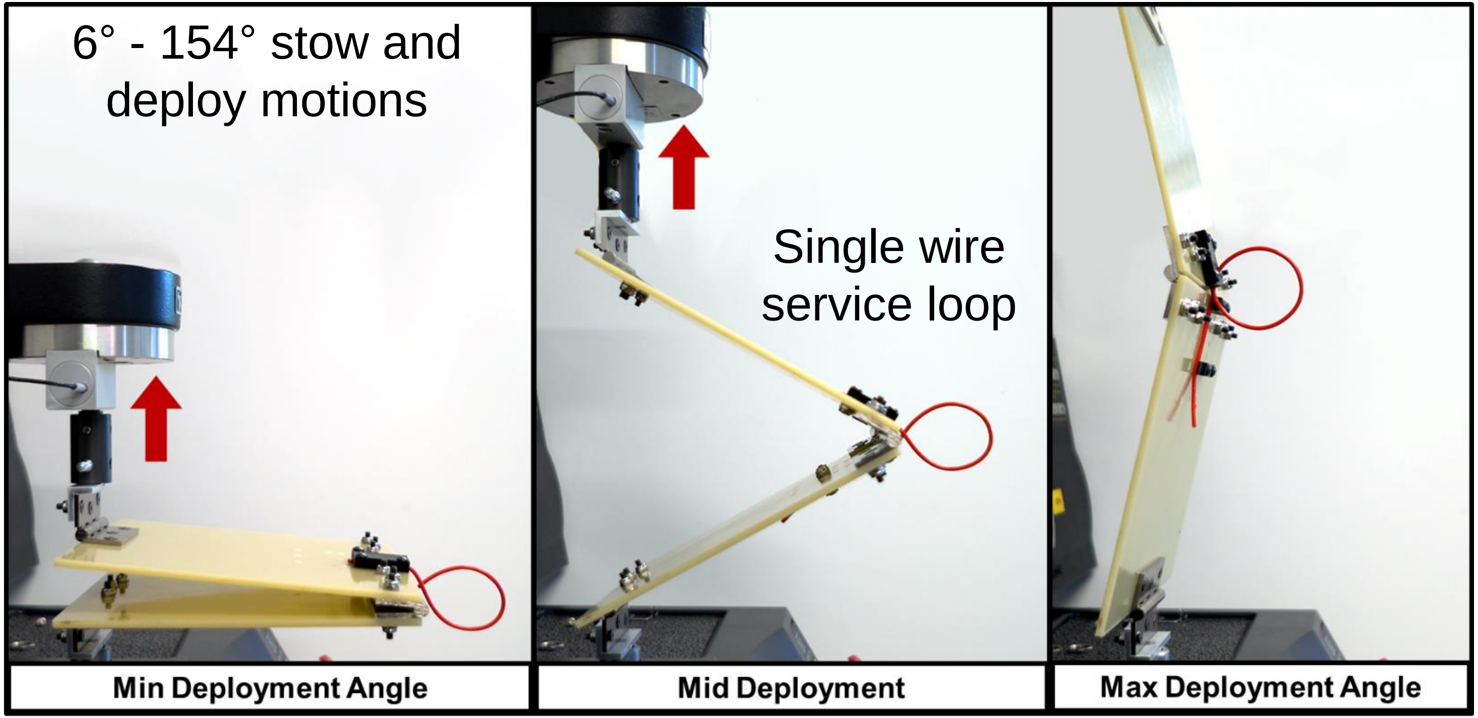

Two-Panel FEA Model

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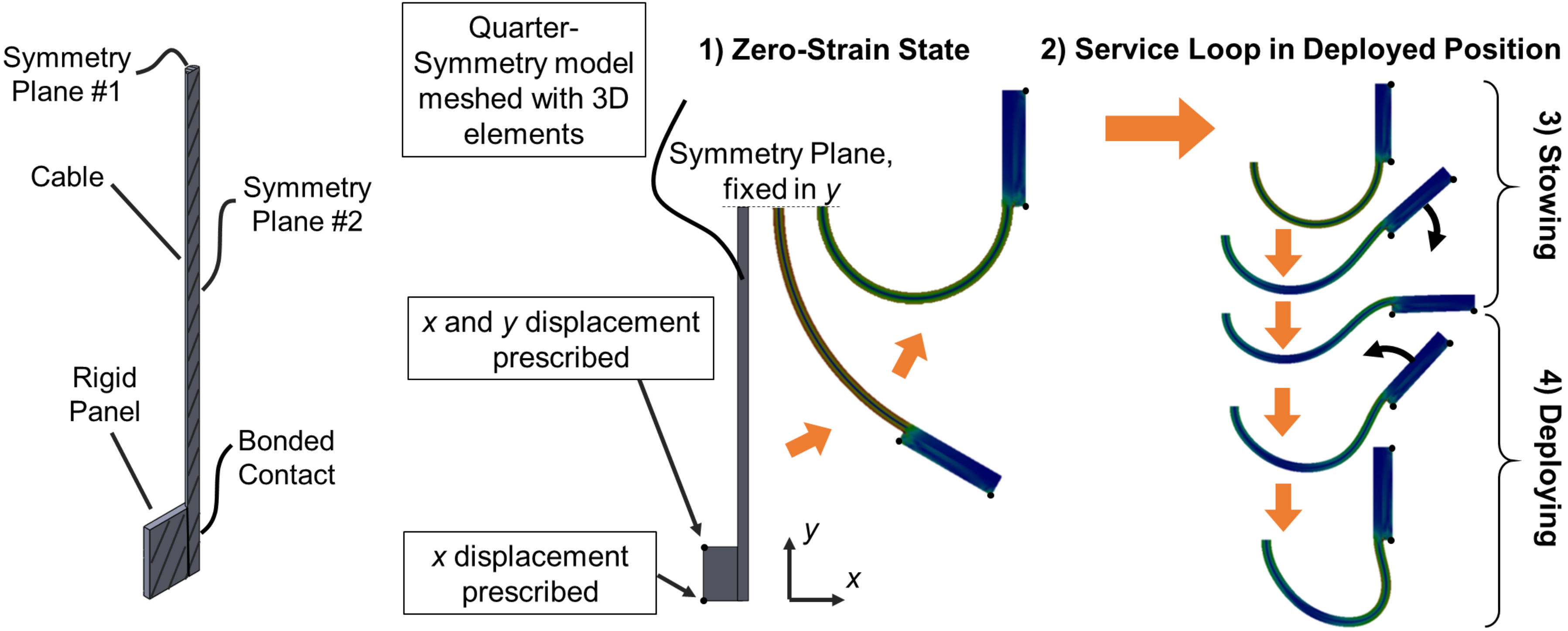

Two-Panel Results

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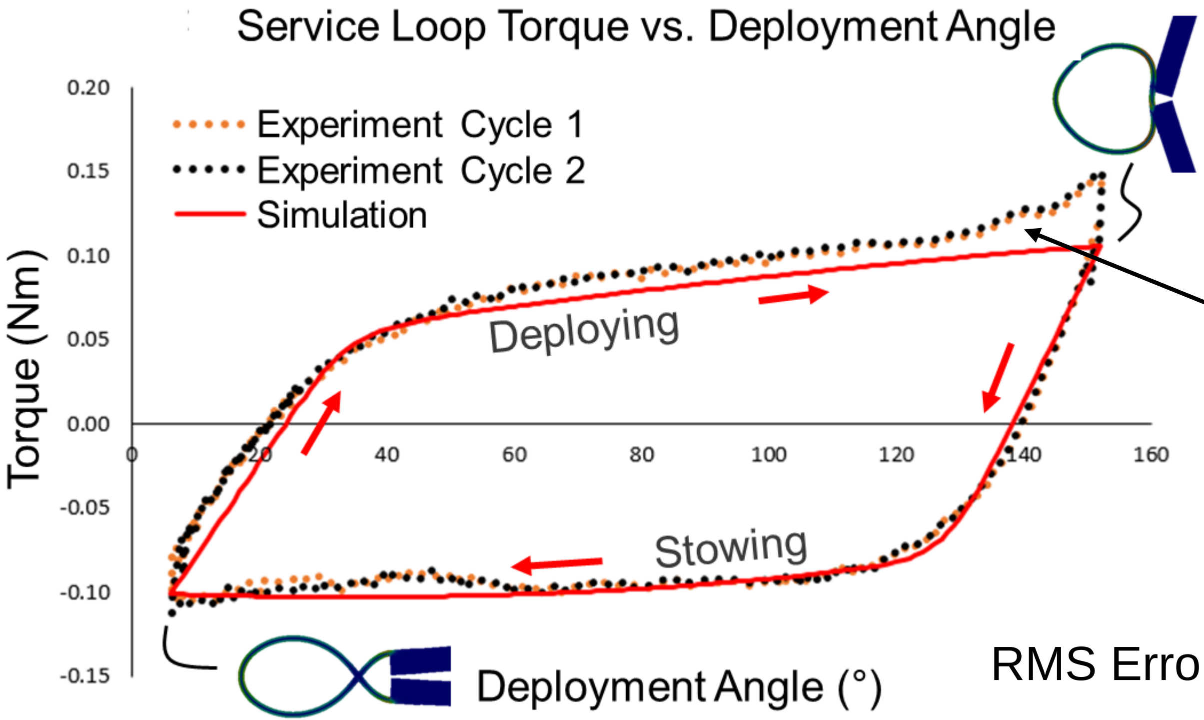

RMS Error = 10.0%

Comparison of Hybrid and Elastoplastic Model

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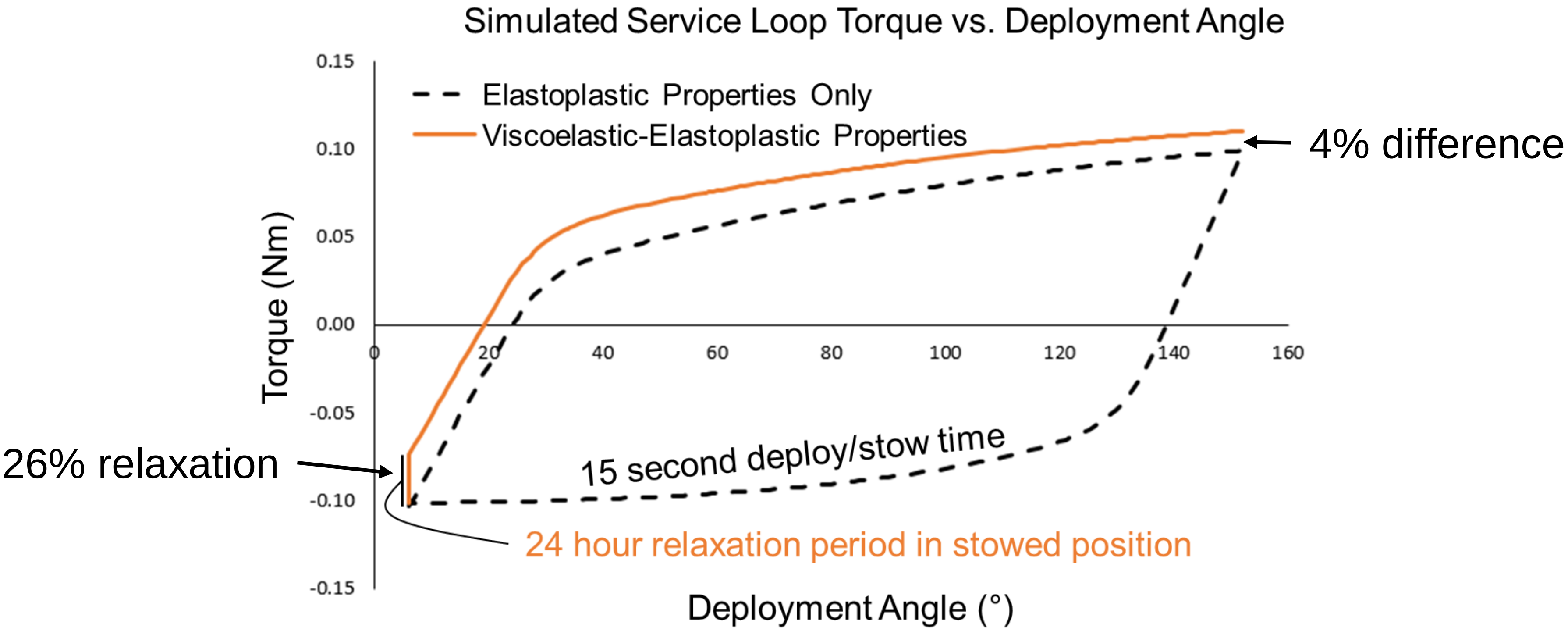

Conclusion

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- Methodology for predicting the force response of cables in a representative deployment system
- Captured a cables bending response
- Developed an analytical best-fit beam bending model
- Used the calibrated material properties with an FEA model to predict the response of a representative two-panel deployment system

Future Work

- Test complex and unique cables
- Expand FEA model to other deployment setups and more complex systems
- Improve accuracy with a more robust algorithm
- Account for the thermal environment of space and longer periods of creep

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