U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Small Business Vouchers – Sentient Project ID #T20

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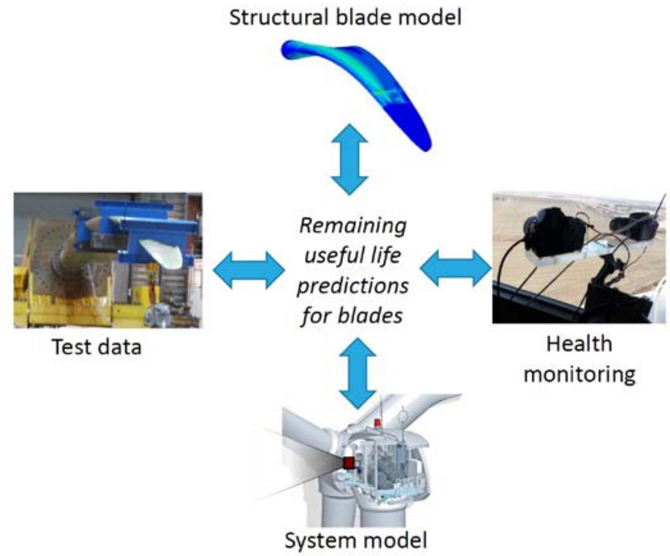


FY17-FY18 Wind Office Project Organization

"Enabling Wind Energy Options Nationwide"

Technology Development	Market Acceleration & Deployment
Atmosphere to Electrons	Stakeholder Engagement, Workforce Development, and Human Use Considerations
Offshore Wind	Environmental Research
Distributed Wind	Grid Integration
Testing Infrastructure	Regulatory and Siting
Standards Support and International Engagement	
Advanced Components, Reliability, and Manufacturing	

Analysis and Modeling (cross-cutting)

Project Overview

T20: Small Business Vouchers – Sentient

Project Summary

- This project will provide operational fatigue data of a realistic wind turbine blade for testing and improving damage detection models to Sentient Science.
- The project will include three main components; (1) test article development, (2) blade fatigue testing, and (3) damage model generation and validation.

Project Objective & Impact

- The overarching goals of the SBV Pilot Program are to (1) enable and accelerate commercialization of promising clean energy technologies, (2) strengthen relationships with the small business innovation community, and (3) to improve technology transfer.
- Sentient will leverage the experimental campaign and damage modeling to develop and assess predictive tools suited for turbine OEMs and wind plant owner operators.

Project Attributes

Project Principal Investigator(s)

Brandon Ennis – SNL
Scott Hughes – NREL

DOE Lead

Mike Derby

Project Partners/Subs

Elon Terrell – Sentient Science

Project Duration

October 2017 – June 2019

Technical Merit and Relevance

- The repair and maintenance of wind turbine blades represents a significant portion of the operations and maintenance (O&M) costs of a wind plant
- Blade repair and replacement operations tend to be highly reactive, resulting in aggregated downtime revenue losses
- Wind plant operators require a proactive operation strategy to maximize the operational lives of wind turbine blades

Approach and Methodology

- Test article development of a 13-meter National Rotor Testbed (NRT) blade
- Blade Fatigue Testing with instrumentation necessary to validate and calibration damage detection modeling approaches
- Damage Modeling of the test subject calibrated to experimental data from the fatigue test campaign

Approach and Methodology

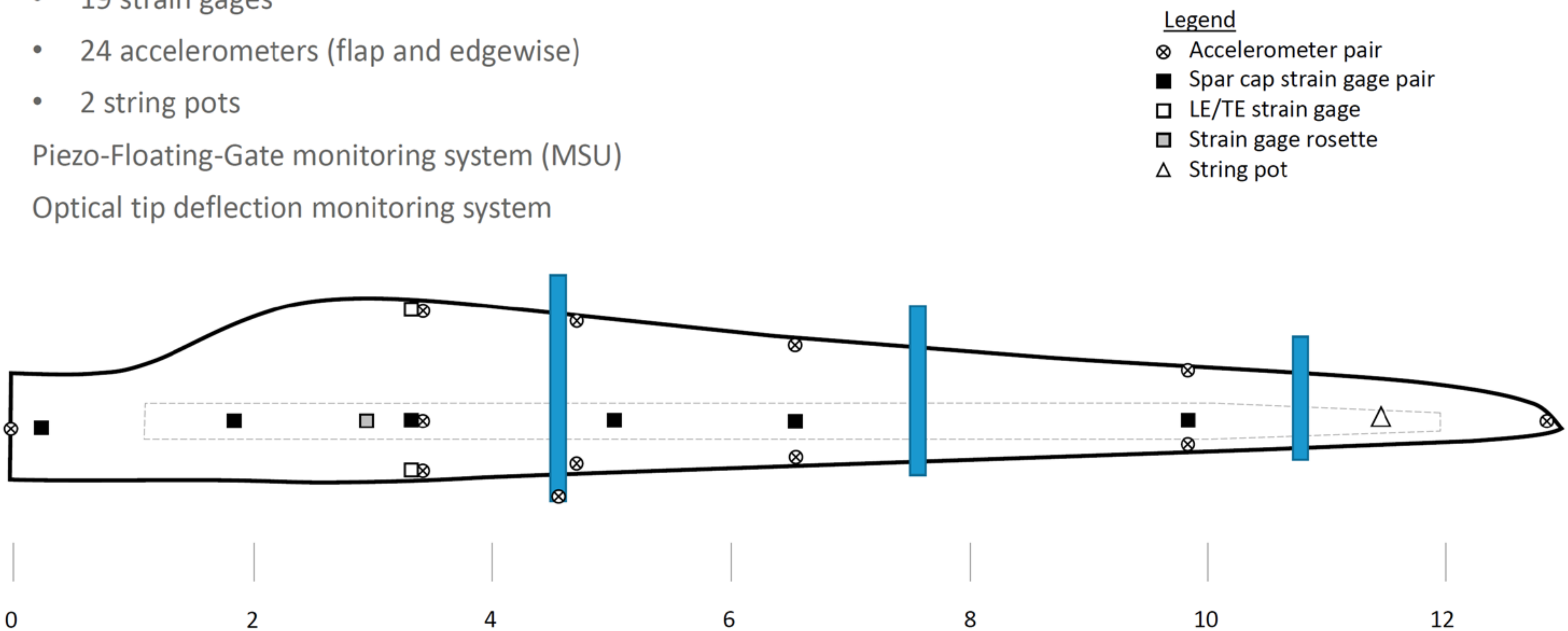
Instrumentation

Traditional local sensors (continuous data)

- 19 strain gages
- 24 accelerometers (flap and edgewise)
- 2 string pots

Piezo-Floating-Gate monitoring system (MSU)

Optical tip deflection monitoring system



Accomplishments and Progress

- **Successful coordination between lab partners and Sentient Science**
- **Test article fabrication and instrumentation**
- **Blade tested to failure (required introducing damage) and successful data acquisition**
- **Blade lumped parameter generated which will be calibrated to experimental data, revealing sensitivity to damage of:**
  - Blade stiffness and deflection
  - Blade modal properties
  - Blade structural damping

Accomplishments and Progress

- Blade fatigue test required over 4 million cycles at up to 140% one-million cycle fatigue equivalent load

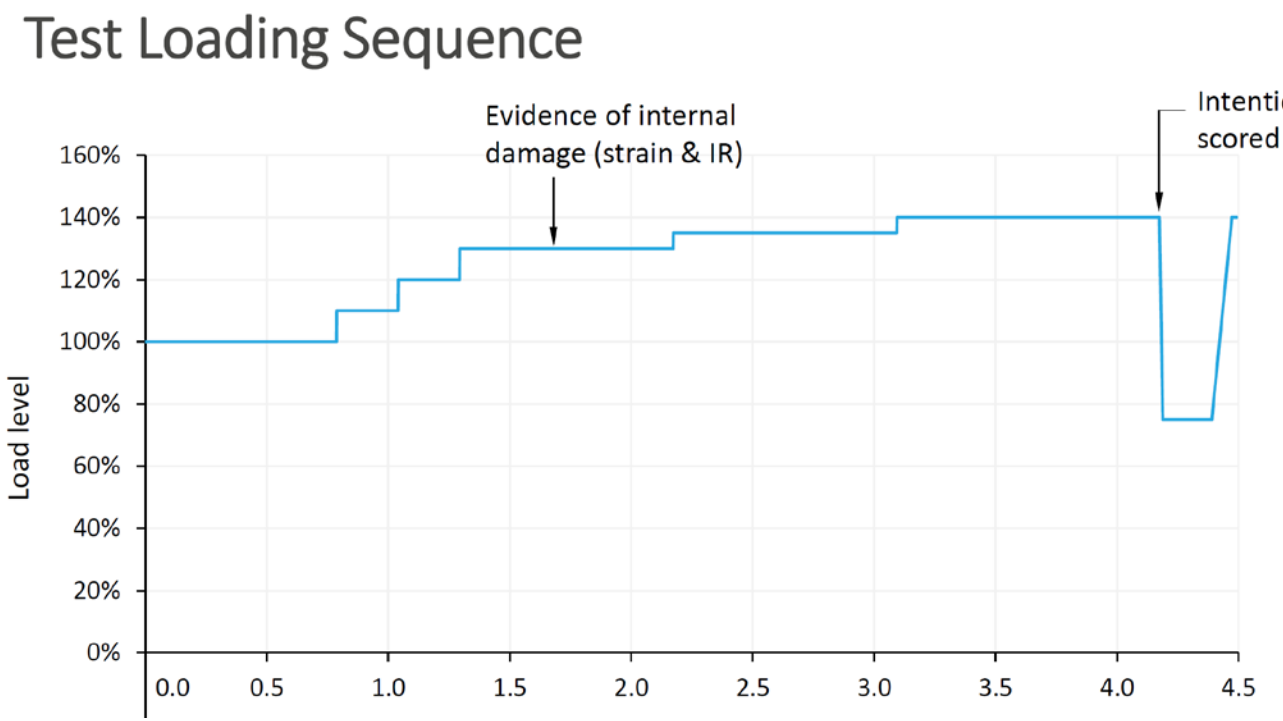
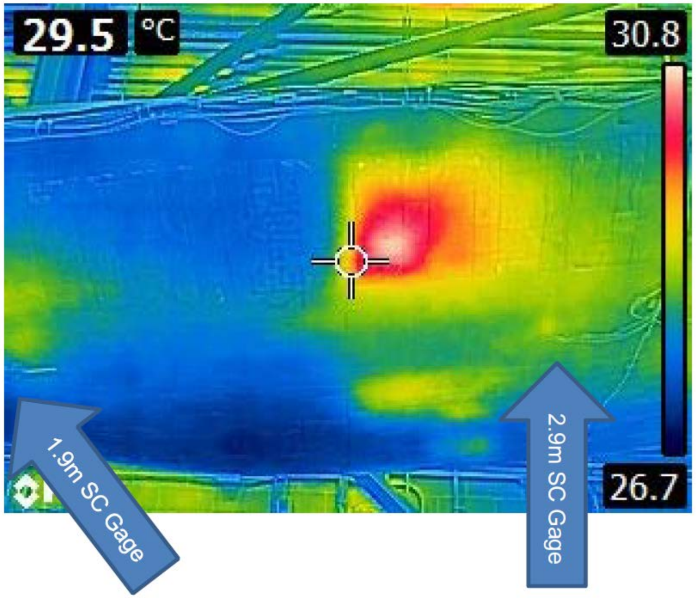
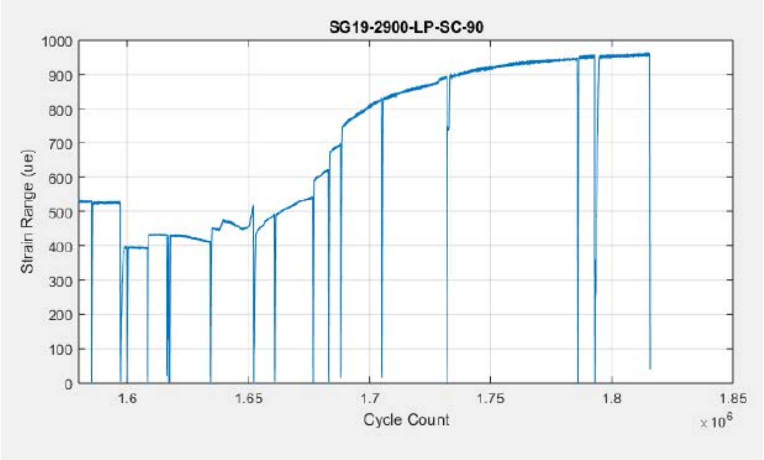


Figure 10.3. Damage introduced to the 2.8 m LP spar cap

Accomplishments and Progress

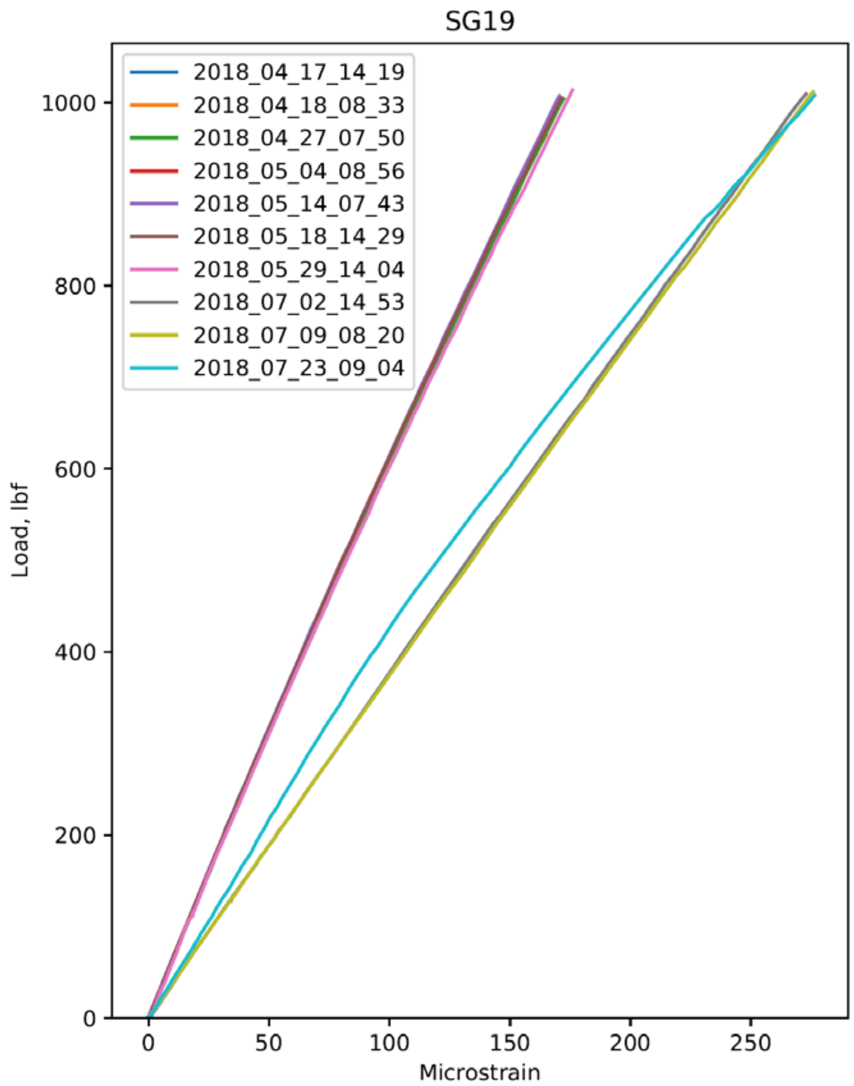
- Due to the NRT not being a fatigue-driven design, the blade required damage to be introduced for reaching blade failure
- Prior to introducing damage, stress concentrations were noticed in the blade where strain levels increased and thermal images revealed localized stress increases





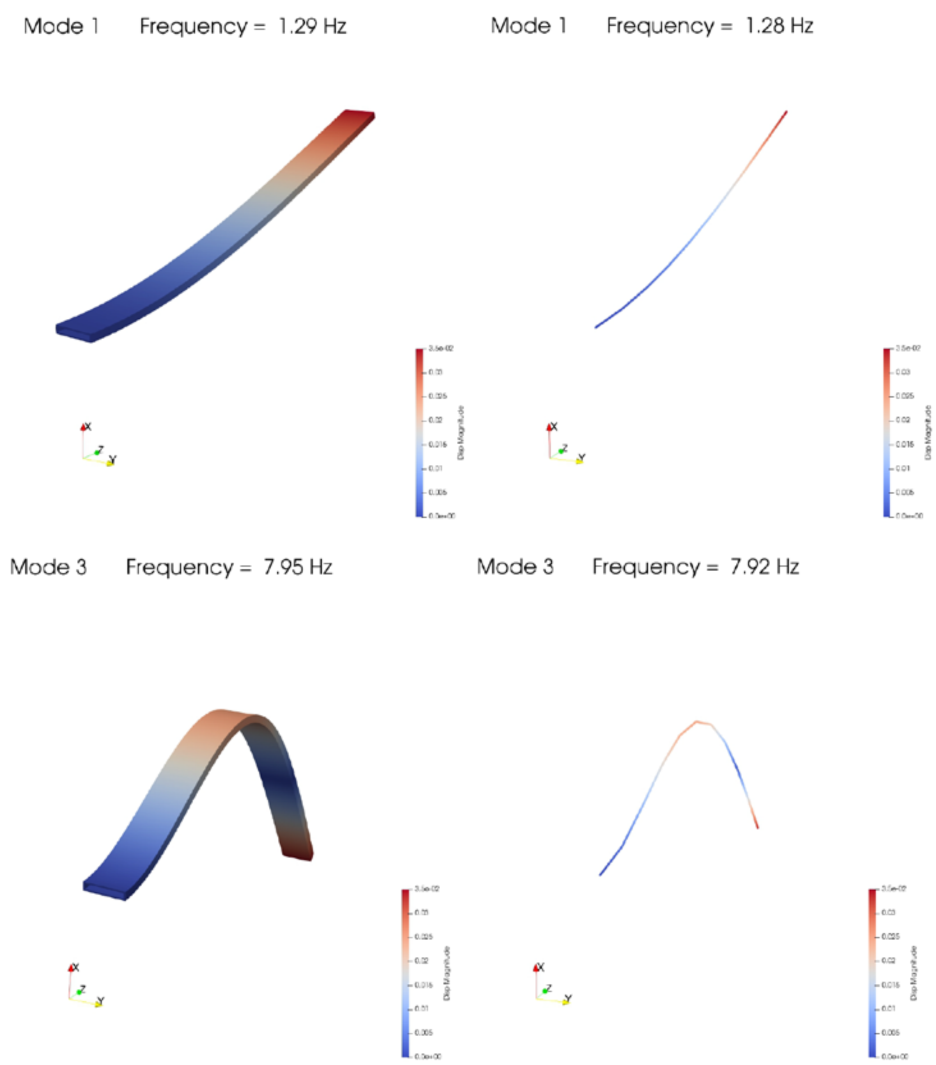
Accomplishments and Progress

- Strain levels were observed to naturally progress and reveal damage, but this did not result in blade failure
- The blade spar cap was cut partially through the depth to lead to failure
- Data acquisition was successful to track changes in blade state throughout the entire experimental campaign



Accomplishments and Progress

- A lumped parameter model has been developed to calibrate to experimental data for damage identification
- The model has been validated against idealized solid models
- The model will reveal sensitivity to blade deflection, modal properties, and structural damping from the damage states



Accomplishments and Progress

- The project is behind its original schedule due to staff transition at SNL and a prolonged experimental campaign lasting over four times longer than the 20-year design life of the blade

Communication, Coordination, and Commercialization

- The data from the experimental campaign have been transferred to Sentient Science
- A high-fidelity, finite element model has been given to Sentient Science for data comparison
- A testing report has been delivered to Sentient Science that summarizes the data campaign
- A damage model validation report will be produced that compares the different methods of detecting damage in blades and key sensitivities to damage for the different approaches