Installation Case Study
Wind Turbine Monitoring

Denver, Colorado, USA

SBlade Project – Overview

- Project Scope
  - To assess the performance of the sensing systems throughout the life of the 9m long, conventional fiberglass, carbon spar, wind turbine blade.
- Participants
  - Project Sponsor - Sandia National Laboratories through the US DOE
  - Wind Turbine Blade Manufacturer -TPI Composites, Inc.
  - Testing at: National Renewable Energy Labs / National Wind Technology Center, CO and SNL Wind Energy Technology, TX
- Sensing Project Participants
  - Micron Optics Inc.
  - Aither Engineering Inc.
  - Purdue University
  - Sandia National Laboratories

SBlade Project – Motivation

- Blades and towers are failing at high rate in the US.
- Shut down protects in high winds but reduces generation opportunities
- Lightning and EMI interferes with electronic gages.
- Large strains in composite materials
- Monitoring will help reduce operating costs & increase pr

SBlade Project - Instrumentation

- Luna Equipment
  - sm125 Optical Sensing Interrogator
  - sm130-500 Optical Sensing Interrogator
  - sp130 Optical Sensing Processor Module
- Application Software
  - LabVIEW based.
- Luna FBG Sensors
  - Blade Low-Pressure Skin
    - (9) os3200, Non-metallic Optical Strain Gage
    - (4) os4350, Armored cable, Non-metallic Temperature Sensor
    - (1) os4100, Temperature Compensation Sensor
  - Blade Hi-Pressure Skin
    - (10) os3200, Non-metallic Optical Strain Gage
    - (3) os4350, Armored cable, Non-metallic Temperature Sensor
    - (1) os4100, Temperature Compensation Sensor

SBlade Project – FBG Benefit

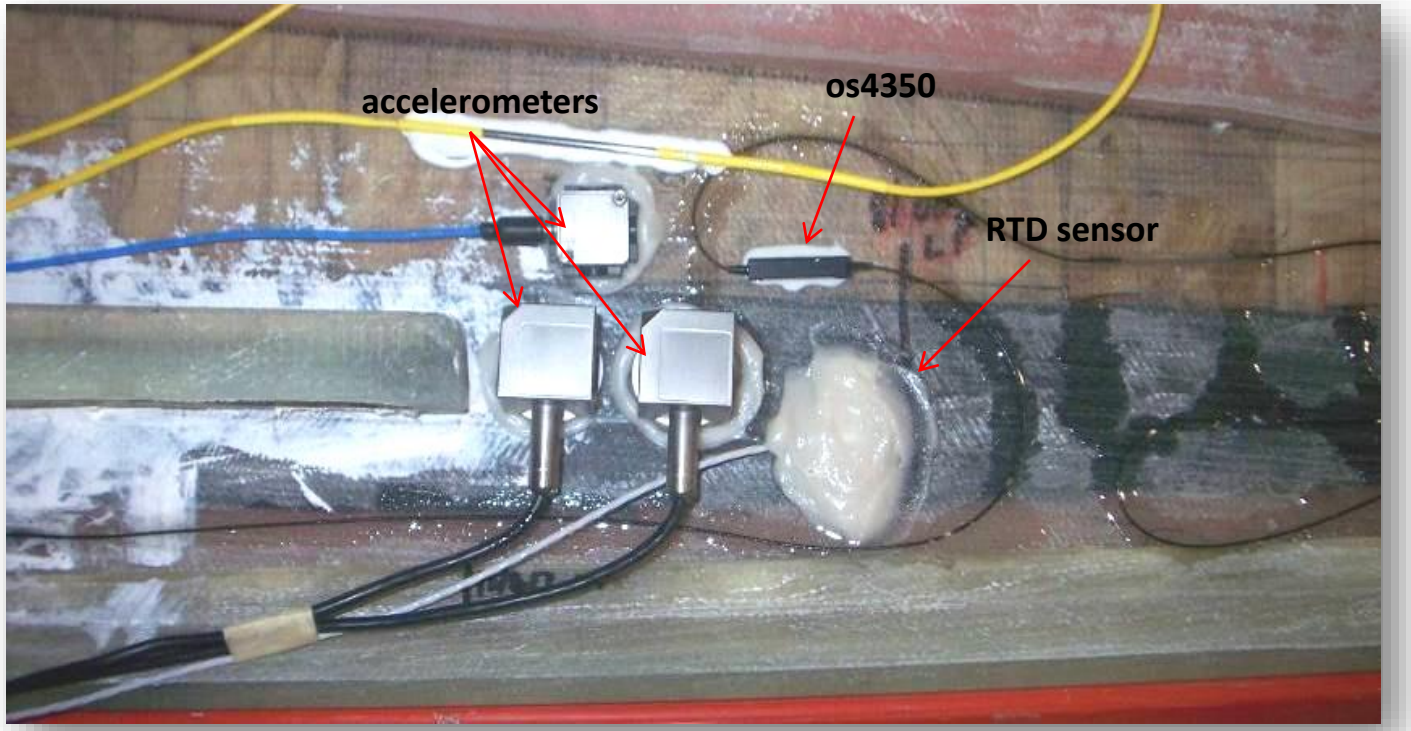
- Fiber Bragg Grating (FBG) Technology Benefits for Wind Blades
  - Lightweight and unobtrusive to the structure
  - Significant reduction in cable harness and associated handling
  - 28 sensors on two channels on two 3 mm reinforced fibers
  - Impervious to EMI and lightning-proof
  - Interrogator's small electronic footprint

SBlade Project – Sensor Installations at TPI Composites

- Installing the sensing systems onto the inside surfaces of the Sblade at the factory.

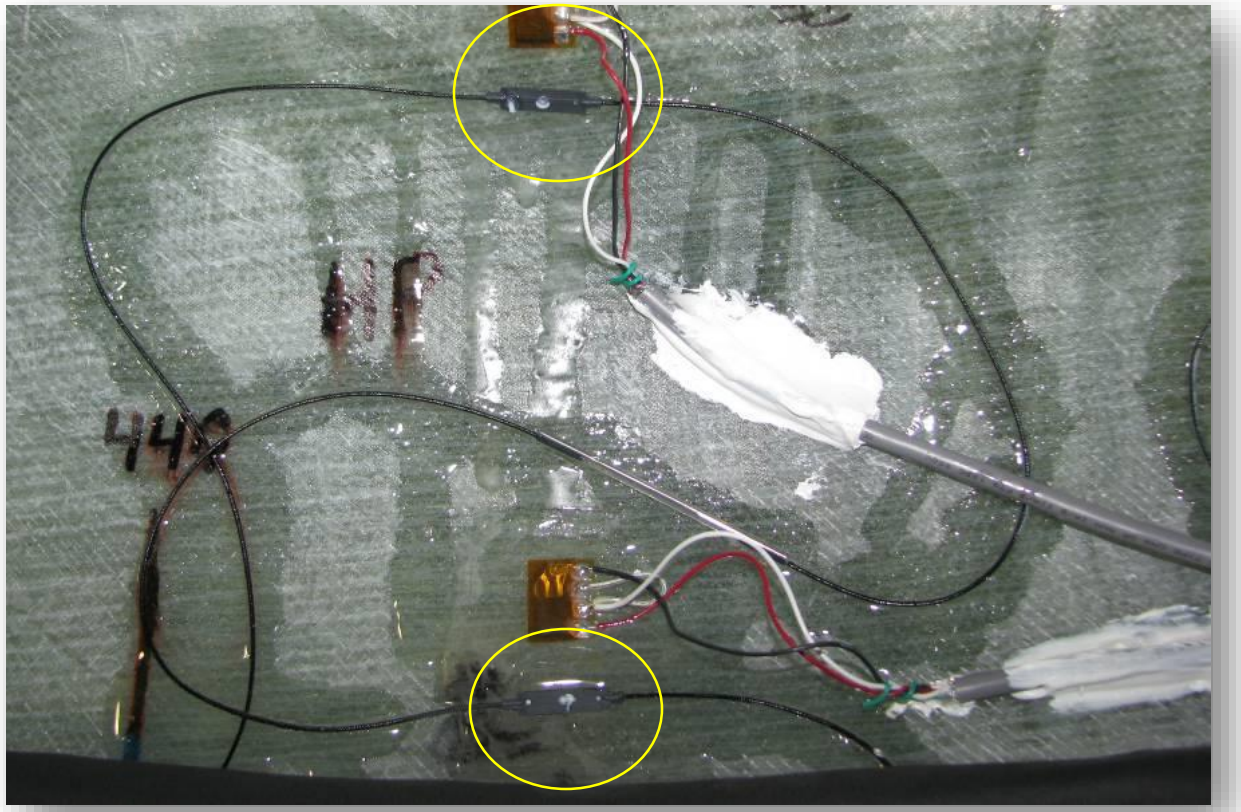
SBlade Project – Sensor Installations at TPI Composites

- SBlade Calibrated MOI os4350 double-ended temperature sensor, three (3) accelerometers, an RTD sensor, all mounted inside the SBlade and near the outboard end of the shear web.



SBlade Project – Sensor Installations at TPI Composites

- Two Micron Optics os3200 FBG strain gages mounted next to metal foil strain gages in the SBlade root.



SBlade Project – On-ground Calibrations at USDA-ARS - SNL field test facility

- SBlade in static edge deflection testing position. All sensing systems utilized, calibrated and the data correlated.

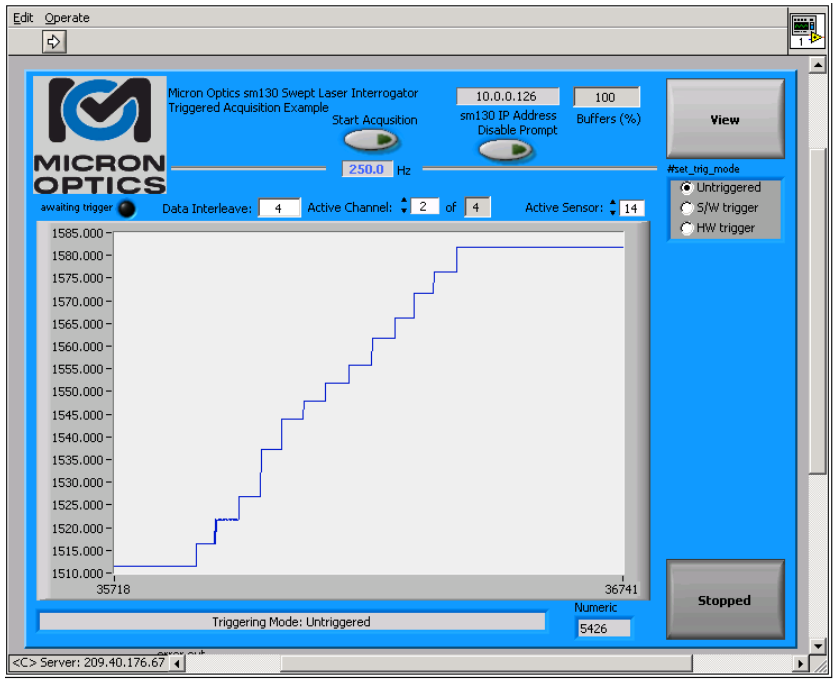
- Free-Free Modal Testing to understand SBlade structural dynamics.

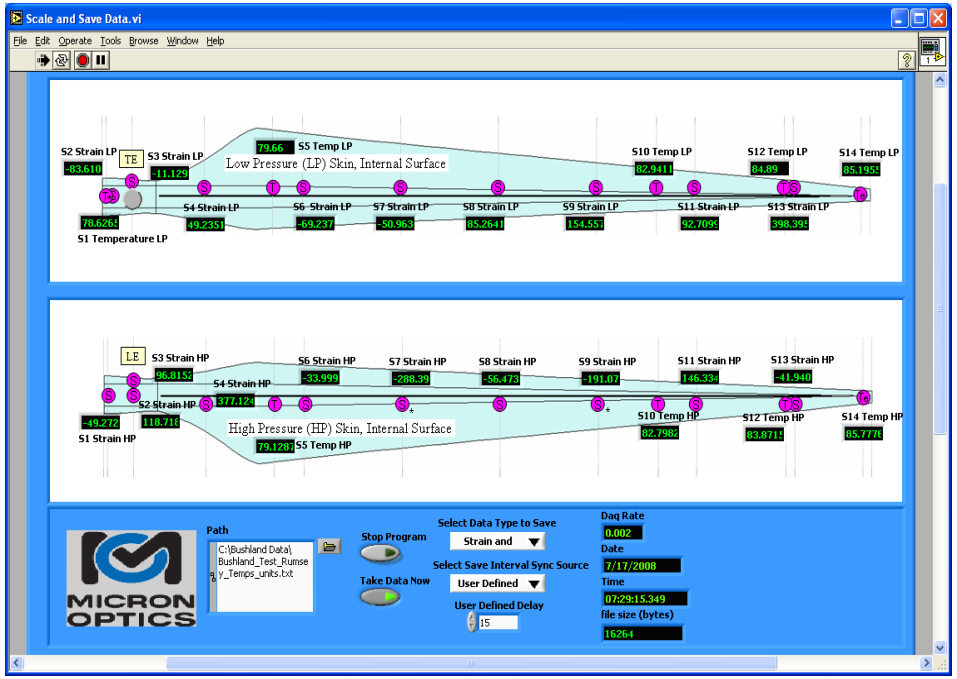
SBlade Project – In-air Calibrations at SNL/USDA field test facility

- Signals from the surface-mounted Luna's FBG sensors, embedded Aither FBG sensors and electrical accelerometers, resistance temperature detectors and metal foil strain gages mounted in the SBlade are acquired using the time-synchronized data acquisition system mounted on the hub of a MICON 65/13 wind turbine.

SBlade Project – Graphical User Interface

- Both Labview based User Interfaces can be accessed thru a web browser allowing for remote connections to the FBG blade monitoring system from any computer with access to the internet.





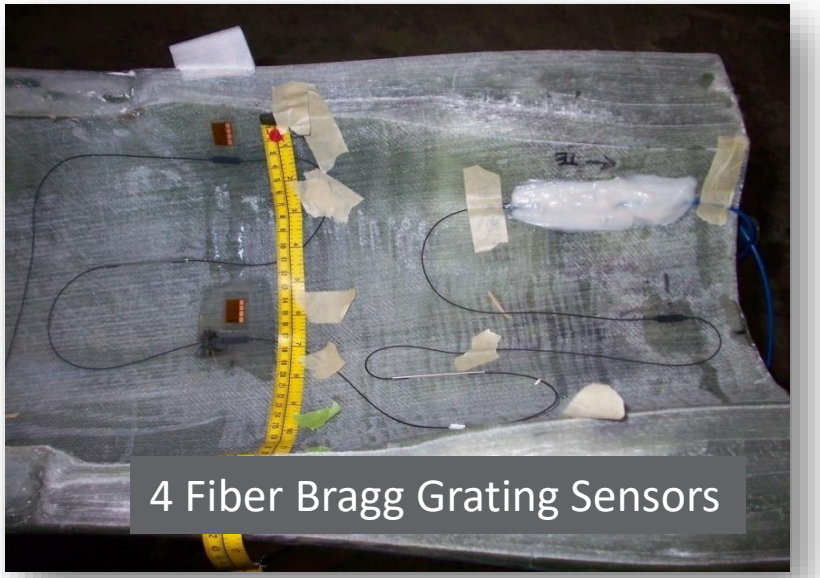
- This user interface provides for setting up the data acquisition parameters, selection of trigger source, and controlling the sm130.

- This graphical user interface provides for visualization of the FBG sensor layout, scaling data, setting up of data file storage, and remote real-time monitoring.

SBlade Project – Result Highlights

- Installation took 4 hours compared to 3 days.
- Fiber Optic cable weight is 6% of the electronic cables.
- No calibration required.
- 28 Fiber Bragg Grating sensors; capacity for 200 more.


Cables from Electrical Sensors


4 Fiber Bragg Grating Sensors


2 Fibers from 28 Fiber Bragg Grating Sensors

Results & Acknowledgements

- Results
  - The system is fully operational and the customer is collecting data in various time-windows throughout 2009 to account for variations in the weather conditions to which wind blades are exposed in the course of time. Results may be published in the future.

- Acknowledgements
  - Mark Rumsey Sensored Blade Project Lead , Wind Energy Technology Department, Sandia National Laboratories, Albuquerque, NM 87185
  - Steve Nolet, Blade Manufacturing and Research Manager, TPI Composites, Warren, RI 02885-0367
  - Byron Neal, Agriculture Engineer, USDA-Agricultural Research Service, Conservation & Production Research Laboratory, Bushland, TX 79012-0010
  - Jon White, PhD Research Fellow, Purdue University, Department of Mechanical Engineering, Ray W. Herrick Laboratories, West Lafayette, IN 47907-2031
  - Jason Kiddy, Principal Investigator and President, Aither Engineering: info@aitherengineering.com, web: www.aitherengineering.com
  - Luna Innovations, Inc. Tel: 404-325-0005, lunainc.com