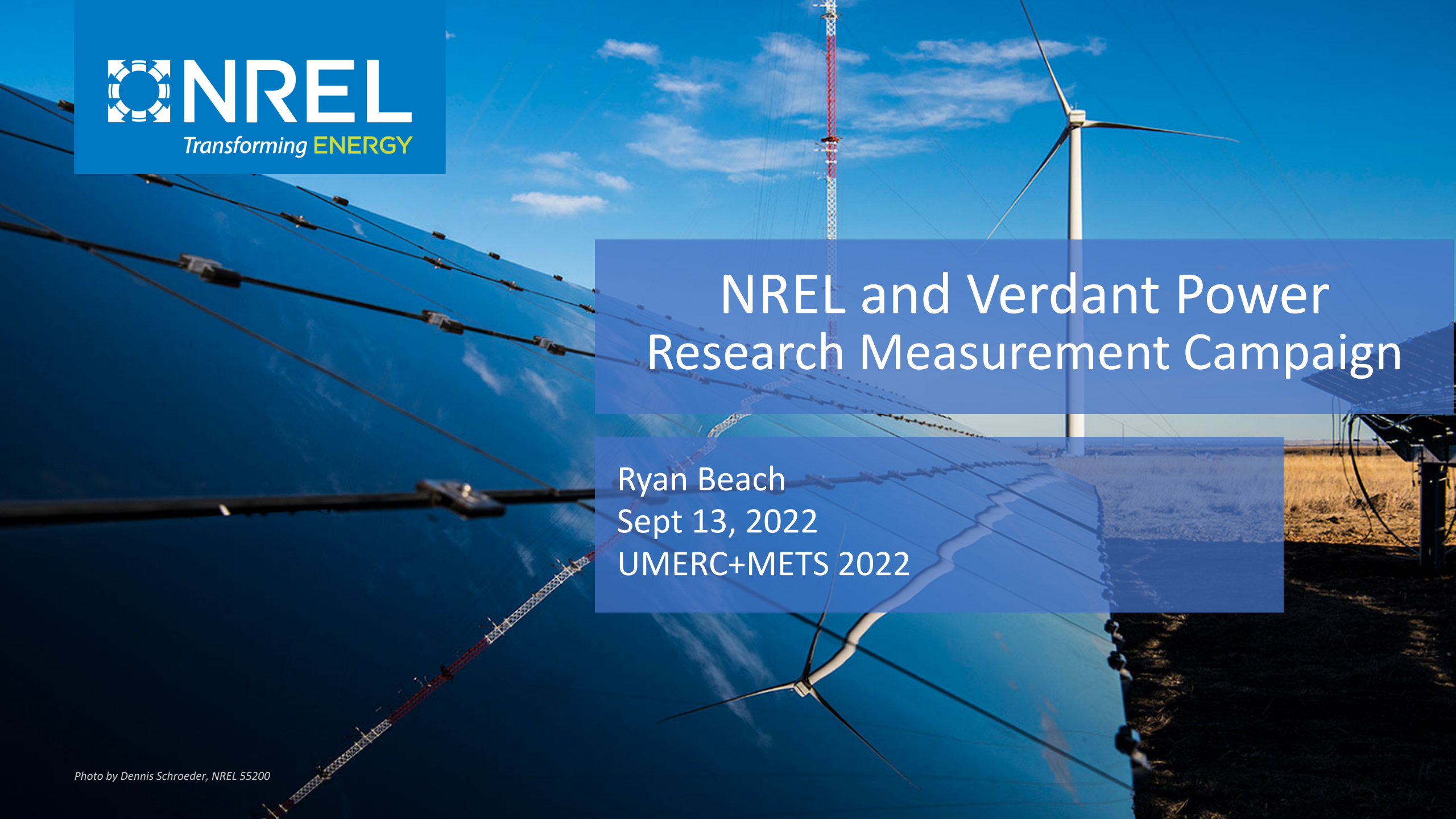


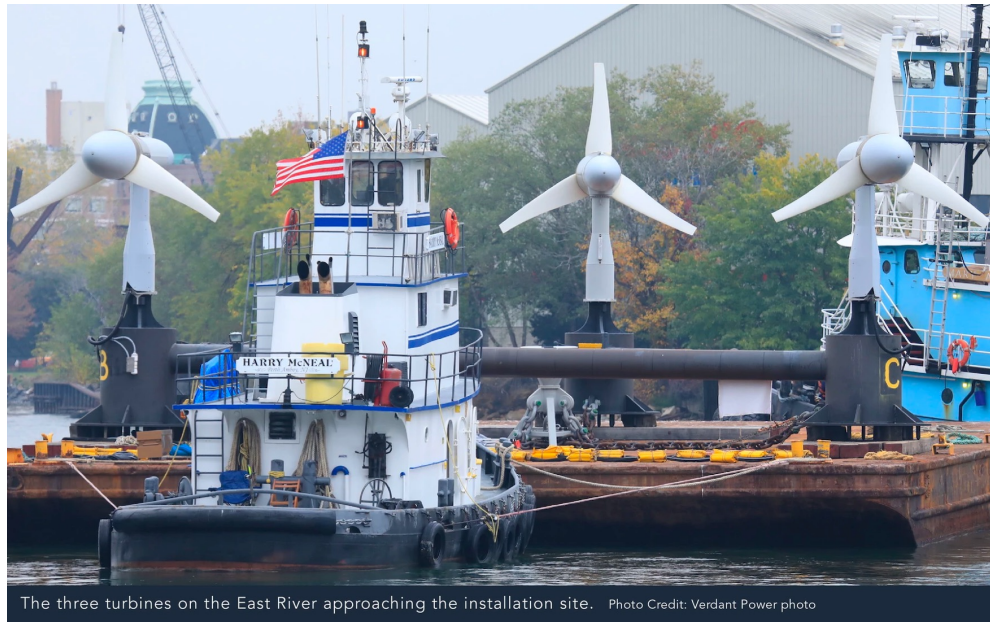
NREL and Verdant Power Research Measurement Campaign

Ryan Beach
Sept 13, 2022
UMERC+METS 2022

Photo by Dennis Schroeder, NREL 55200

Introduction

- Blade failures prevalent in tidal industry
  - Lack of loads data
  - Materials/designs not suited for environment



The three turbines on the East River approaching the installation site. Photo Credit: Verdant Power photo

https://www.waterpowermagazine.com/news/newsturbines-deployed-on-first-licensed-tidal-power-project-in-the-us-8345152

- Coupon-scale research shows thermoplastic composites have improved saturated performance over traditional materials
  - Glass/epoxy composite loses 58% of initial flexural strength after saturation, acrylic composite only loses 27% (Peter Davies, IFREMER)

NREL partners with Verdant Power to manufacture, characterize and deploy epoxy and thermoplastic blades on their Gen5d turbines at the RITE site in the East River in NY, enabling side-by-side comparison at scale

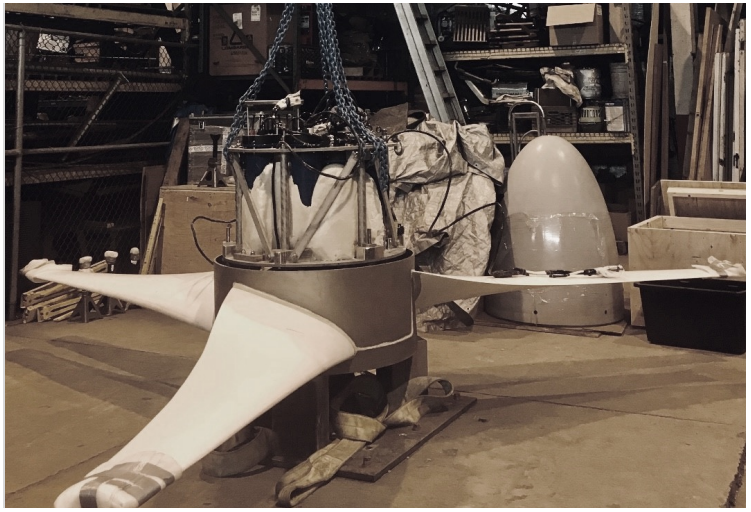
Epoxy & thermoplastic rotors were both deployed for 6 months. Lab testing is ongoing.

Scope

1. **Manufacture**
2. **Instrumentation**
3. **Deployment**
4. **Characterization**

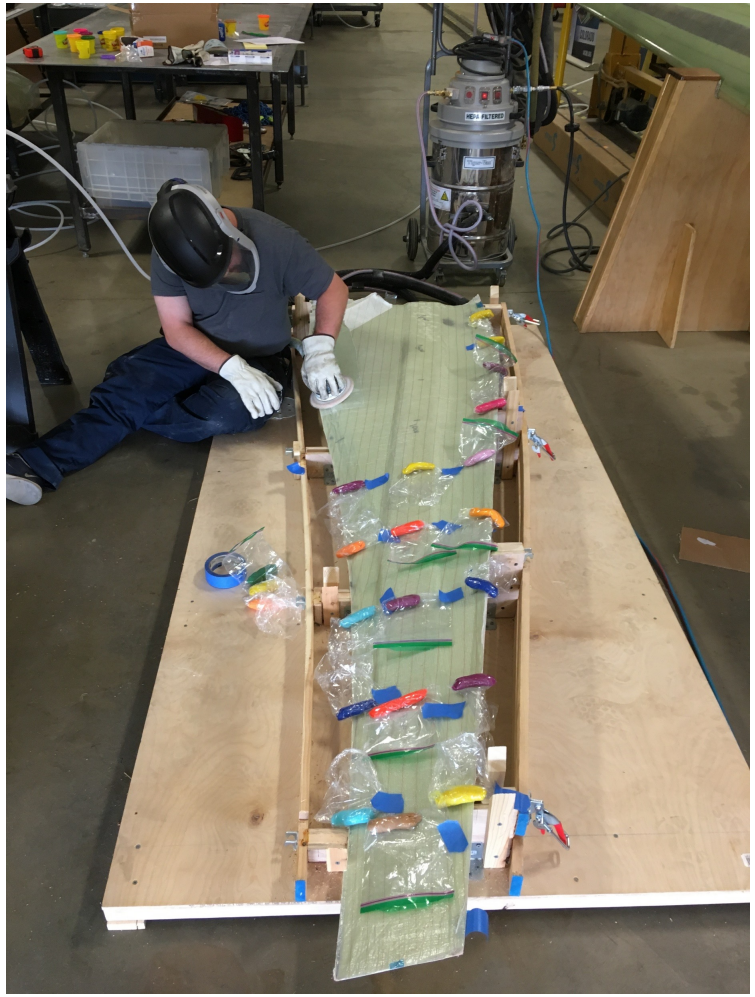
Blade Manufacturing

- Epoxy blades manufactured by Composite Builders (Holland, MI)
- Thermoplastic blades manufactured by NREL (Flatirons Campus, CoMET facility)



Rotor assembly at Verdant facility

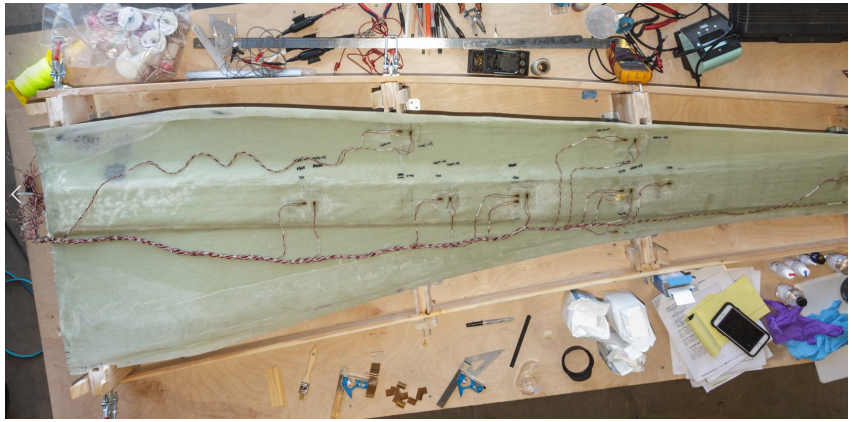
Blade move to trim station. Note instrumentation wire coming out of low pressure skin



Skin gap check and bond prep

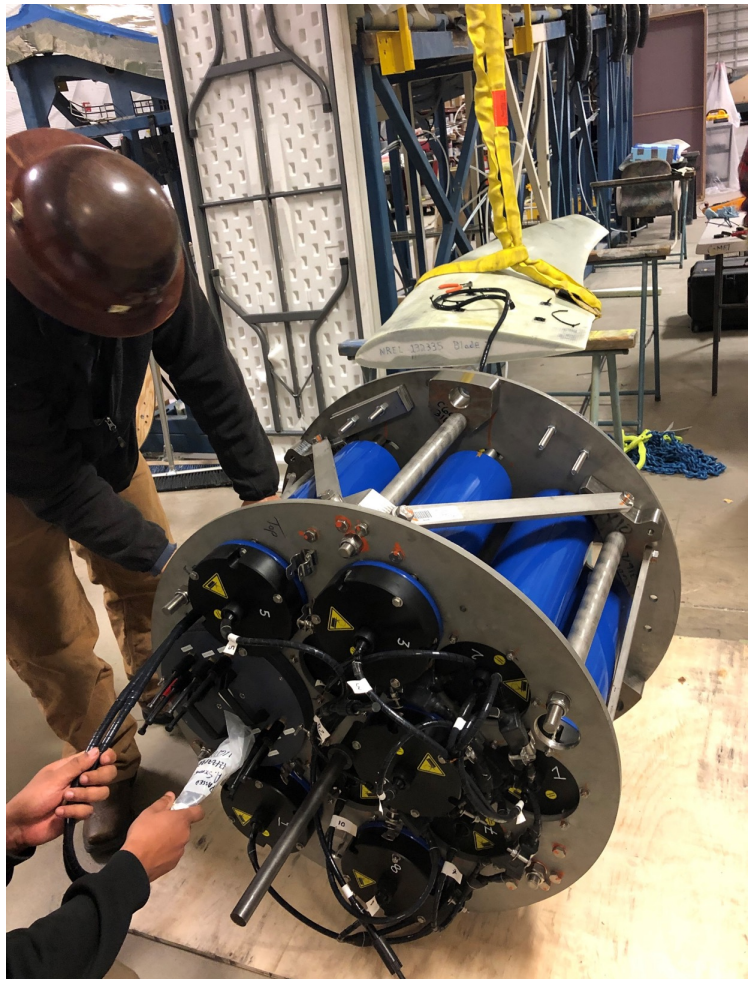
Instrumentation

- Data acquisition system (NDAQ) designed to measure and record strain and blade position with no communication or external power during the 6-month deployment
  - (10) Nortek 15V, 1800Whr batteries
  - (40) internal strain gages applied during manufacturing process



Strain gages and wires applied to internal skin surface prior to blade closing

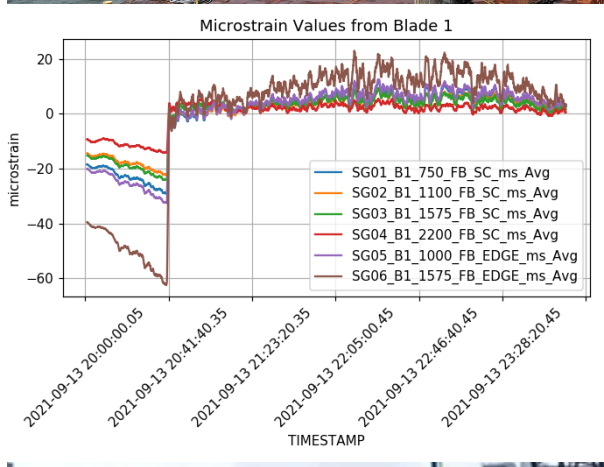
NDAQ on assembled rotor prior to deployment



NDAQ system check at NREL CoMET facility

Deployment

- Verdant turbine with TP blades deployed May, 2021
  - Produced 31.8 MWh of power into the NYC Grid
- NDAQ measured data for more than five months
- Data not recorded by the NDAQ system due to a software error.
  - Result: No blade loads data was recorded
  - NDAQ measured 3.7 billion data points; data was overwritten every 4 hours due to software failure.
  - After the code was tested and verified, a last minute code change was made and the change was not sufficiently tested and verified
- Blades and NDAQ structure appeared to have no damage upon retrieval, and all strain gages were still operational upon retrieval



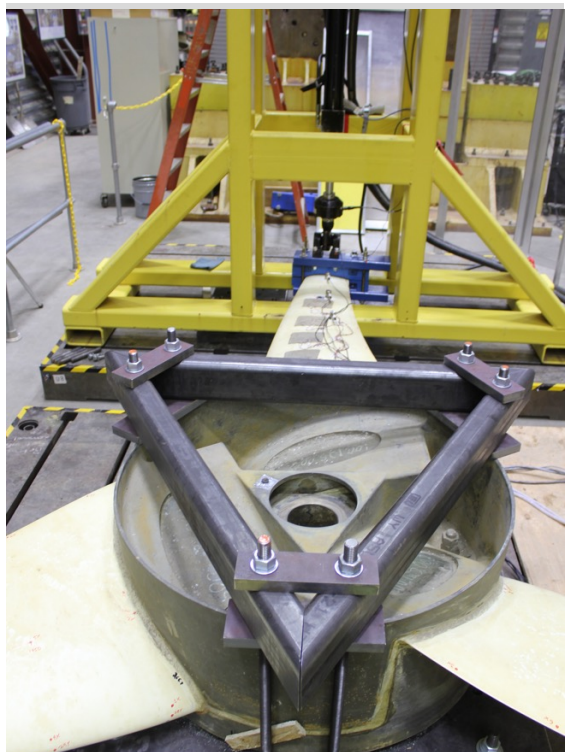
Top: TriFrame on Barge during Retrieve and Replace

Mid: Last 4 hours od recorded data

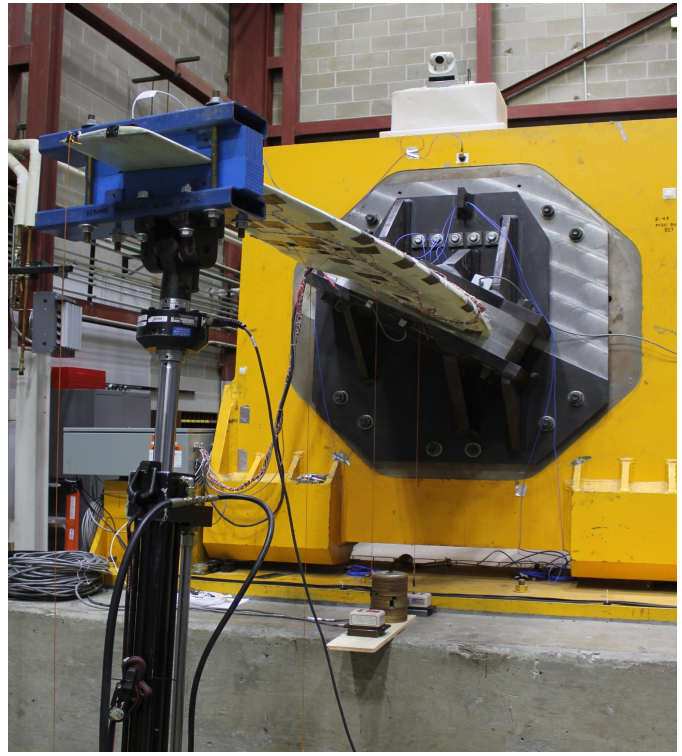
Bottom: TriFrame being lowered into East River

Structural Validation

- Static Loading
  - Blades loaded to 50% of maximum expected static load
  - Thermoplastic blades 6% stiffer than epoxy blades
- Fatigue Loading
  - 2M cycle, lifetime loading
- Modal Characterization
  - Mode shapes
  - Frequency
  - Damping

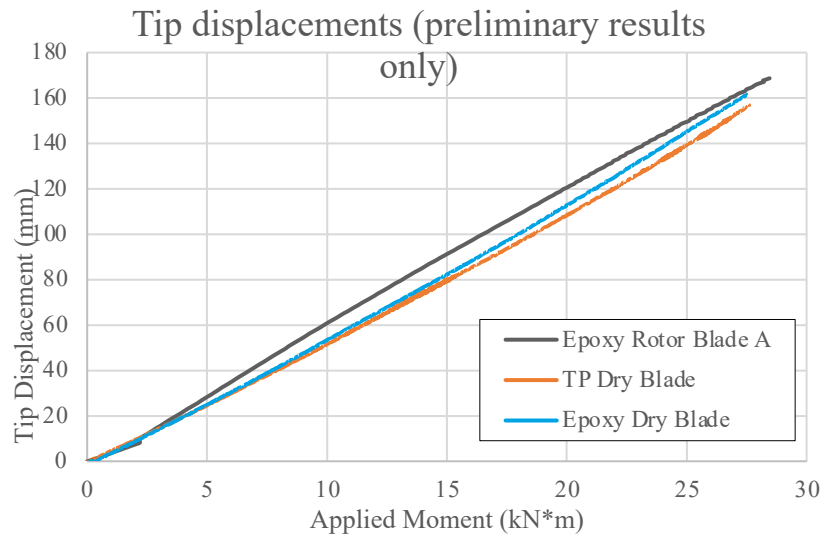


Post-deployed blade loading



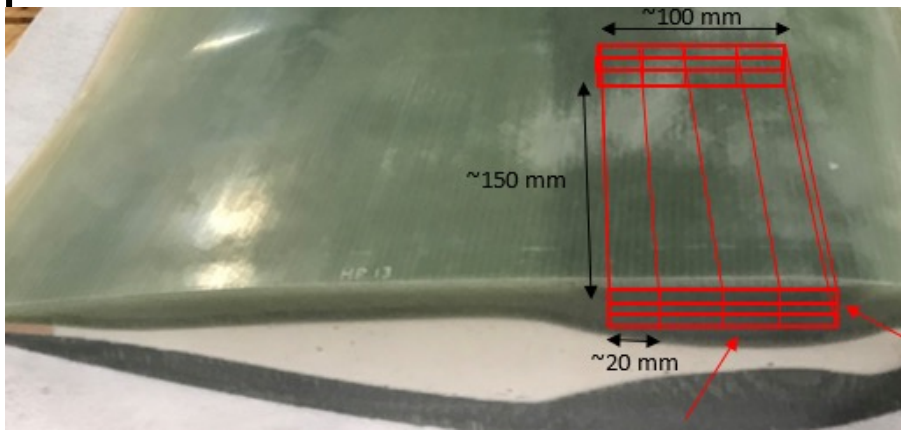
Pre-deployed blade loading

Rotor soaking in outdoor holding tank



Next Steps

- Post-deployment loading of thermoplastic rotor begins Jan, 2023
- Results comparison between:
  - Pre- and post-deployed blades
  - Thermoplastic and thermoset blades
- Dissection of deployed TP blades for instrumentation lessons-learned (Upcoming webinar!)
- Cut coupons from post-deployed blades to compare materials from as-built structure with coupon baseline
- Possible static loading to failure



Thank You

www.nrel.gov

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