



**National Laboratory
of the Rockies**

The “WETO Stack” DOE’s Wind Energy OSS

Rafael Mudafort

National Lab of the Rockies

IESO OSS Summit – August 4, 2026

US DOE & Lab-based Wind Research

*From a 2024 Presentation



WETO invests in wind energy **software** that enables and accelerates the innovations needed to advance wind energy.

NREL's active WETO projects

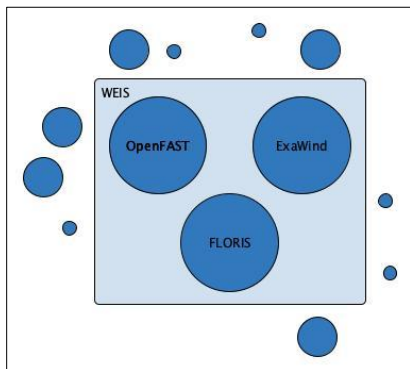
Study on the Potential Application of Additive Manufacturing in Wind Turbine Components and Tooling
Enabling Larger Rotors Through Modular, Customizable, Inflatable Blades
Eagle Topic Area 3 Funding Opportunity Announcement (FOA) Support
Co-Simulation Study and Control of a Wind Farm for Conversion Services
Continental-Scale Transmission Modeling Methods for Grid Integration Analysis
Atmosphere to Electrons to Grid (A2e2g)
Fusion Joining of Thermoplastic Composites Using Energy Efficient Processes (TCF)
Automating In-Situ Grinding and Repair for Thermoplastic Blades
Codesign and Intelligent Approaches for Cost-Effective Operation and Maintenance of Generators and Power Converters
Wind Power as Virtual Synchronous Generation (WindVSG)
Modeling and Validation for Offshore Wind
Technology Development and Innovation to Address Operational Challenges
Evaluating Deterrent Stimuli for Increasing Species-Specific Effectiveness of an Advanced Ultrasonic Acoustic Deterrent
North American Renewable Integration Study
High-Fidelity Modeling
Wind Turbine Drivetrain Reliability Assessment and Remaining Useful Life Prediction (TCF)
Enabling Autonomous Wind Plants through Consensus Control (TCF)
Big Adaptive Rotor
North American Energy Resiliency Model (NAERM)
Floating Downwind Turbines: A Conceptual System-Level Design and Feasibility Study for U.S. Waters
Energy Sector Modeling and Impacts Analysis
Wind Standards Development
Multiscale Integration of Control Systems (EMS/DMS/BMS)
Advanced Modeling, Dynamic Stability Analysis, and Mitigation of Control Interactions in Wind Power Plants
Wind Grid Integration Stakeholder Engagement
Atmosphere to Electrons (A2e) Performance Risk, Uncertainty and Finance (PRUF) Analysis Support
Working Together to Resolve Environmental Effects of Wind Energy (WREN)
High-Fidelity Modeling Toolkit for Wind Farm Development



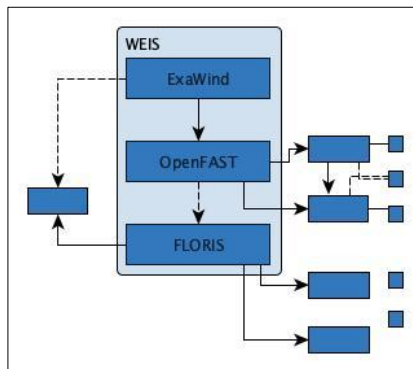
Holistic Modeling Project

Objective

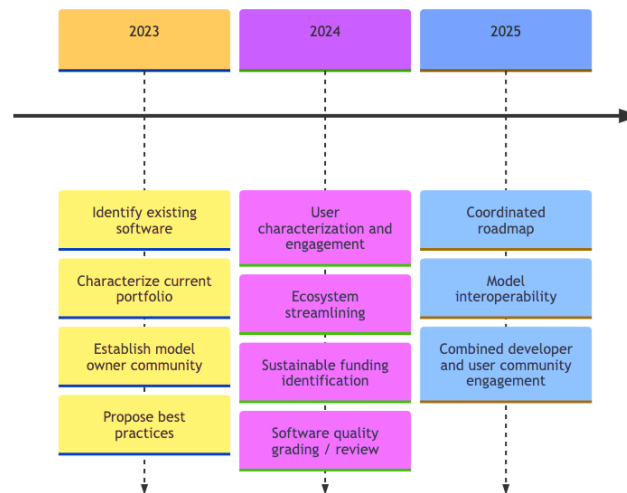
Past: Loose collection of software



Future: Cohesive software stack



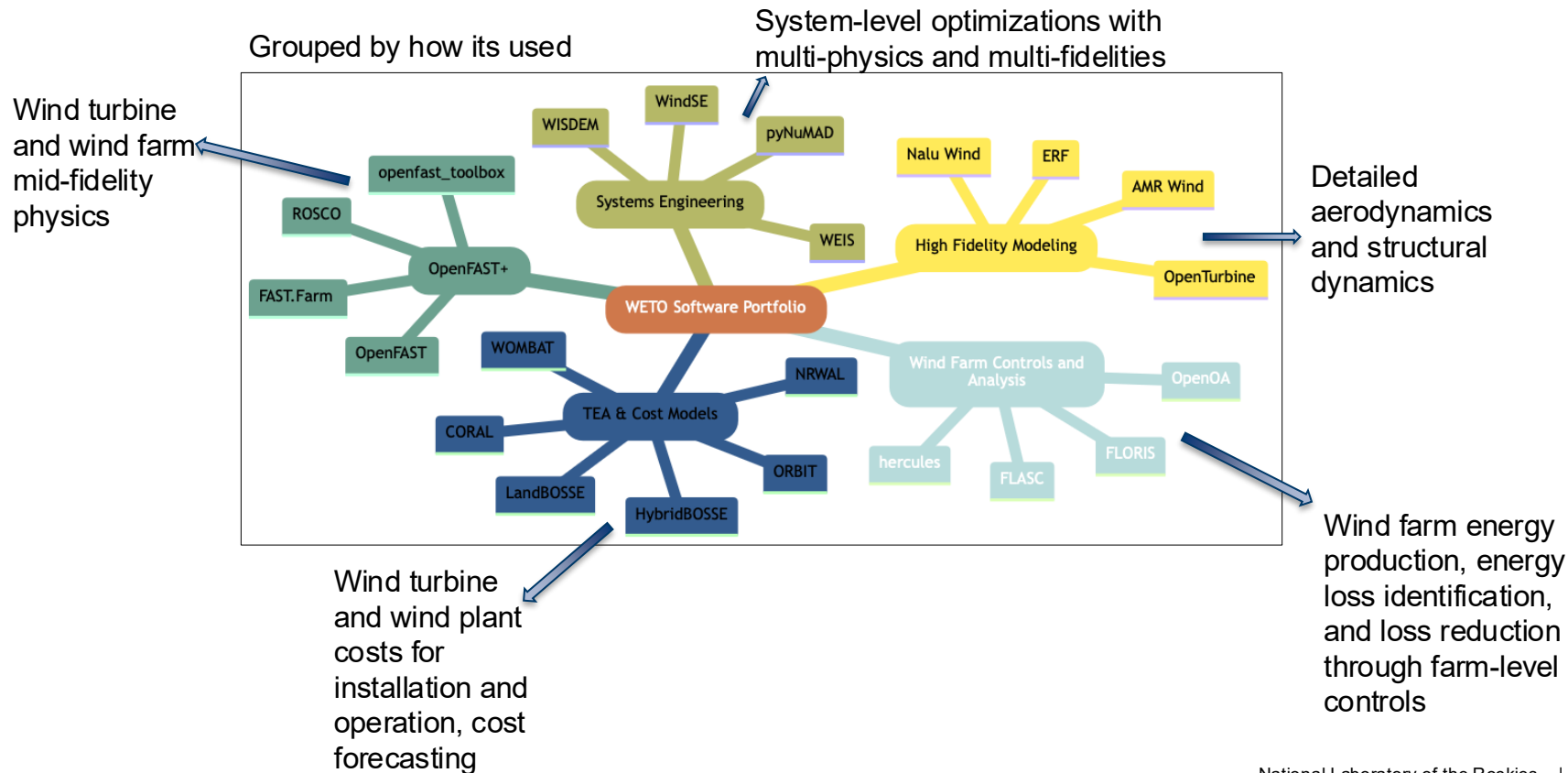
Project Timeline



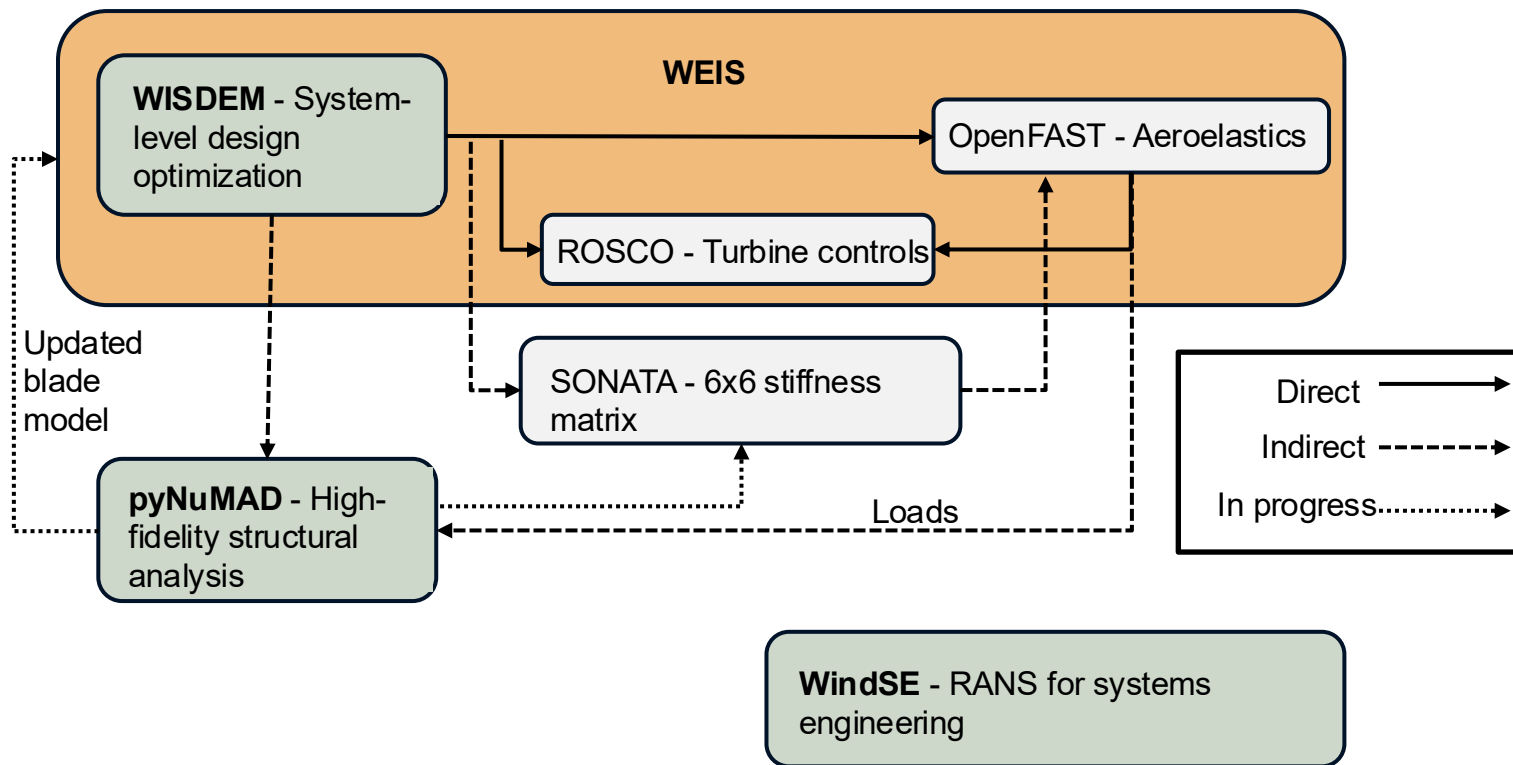
WETO Software Stack

A very brief overview

WETO Software Stack



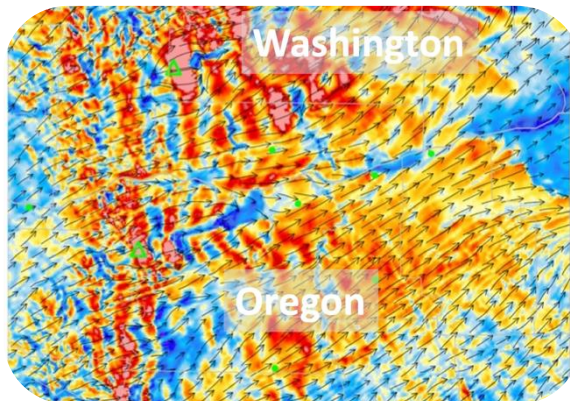
Systems Engineering



Adapted from Big Adaptive Rotor (BAR) project

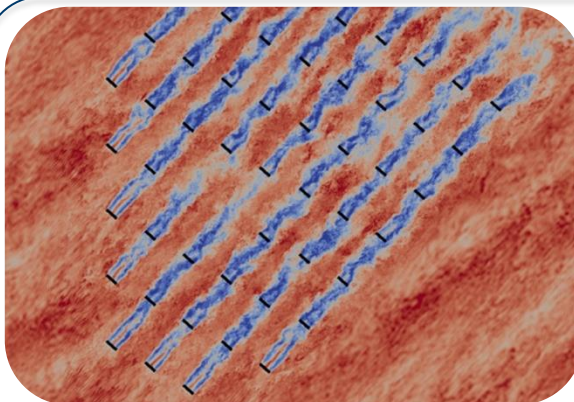
High Fidelity Models

ExaWind



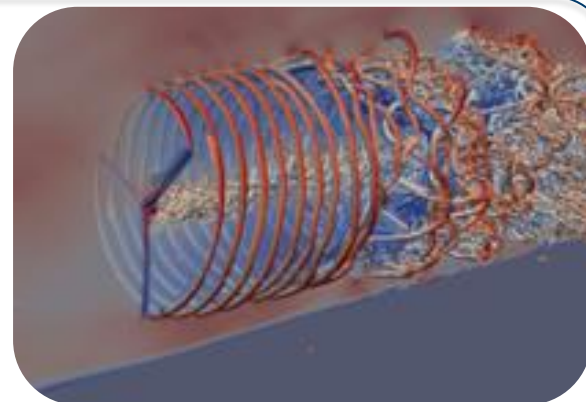
Mesoscale: ERF

- Regional scale weather
- **Scales 10 km to 1000 km**
- WRF numerics & models, built on AMReX
- GPU compatible
- Compressible



Microscale: AMR-Wind

- Atmospheric boundary layer
- **Scales less than 10 km**
- Large Eddy Simulation built on AMReX
- GPU compatible
- Structured grid with refinement zones
- Incompressible

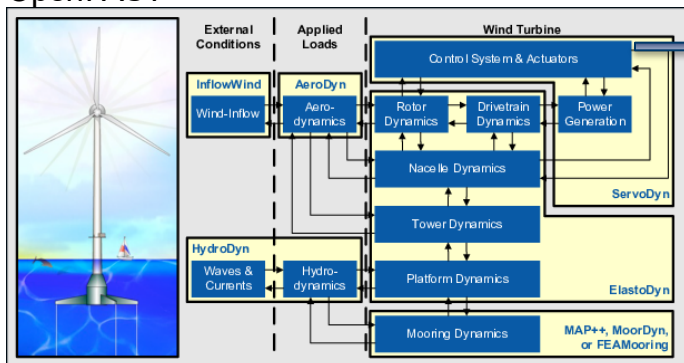


Turbine scale: NALU-Wind

- Turbine, rotor, tower, nacelle
- **Scales less than 1 km**
- Unsteady Reynolds Averaged Navier Stokes
- GPU compatible
- Unstructured grid, geometry resolving
- Incompressible

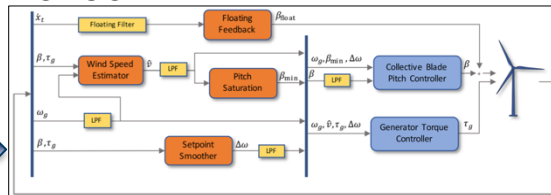
OpenFAST+

OpenFAST



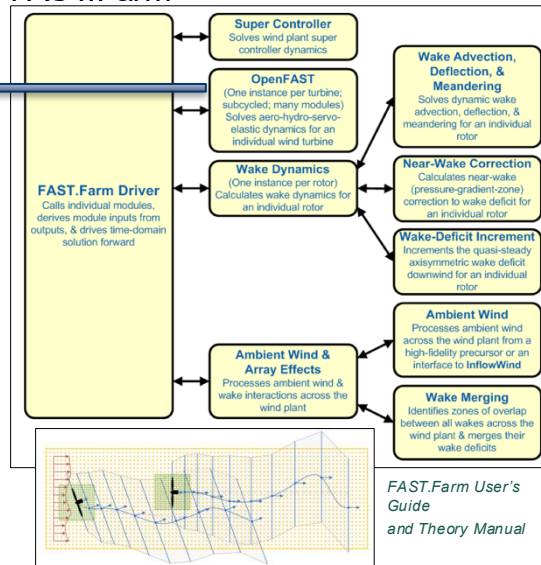
OpenFAST v3.5.3
documentation

ROSCO



N. J. Abbas et al.: A reference controller for wind turbines

FAST.Farm

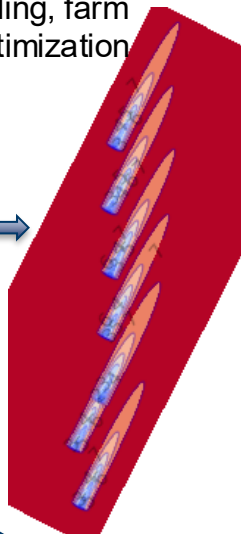


FAST.Farm User's
Guide
and Theory Manual

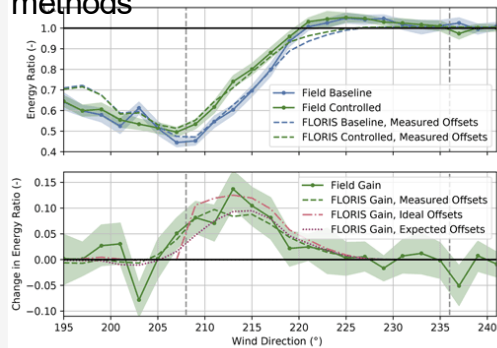
openfast_toolbox

Wind Farm Controls and Analysis

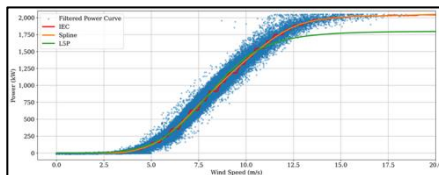
FLORIS: Steady-state modeling, farm controls optimization



FLASC: Validate FLORIS model with SCADA, compare control methods



Hercules: Realtime high-fidelity simulator for hybrid power plants with a specific focus on wind farm controls.



OpenOA: Characterize plant performance and quantify sources of operational loss

Technoeconomic Analysis / Cost Modeling

Energy Yield

Wind farm AEP estimate
FLORIS

CapEx

Balance-of-System
LandBOSSE
HybridBOSSE
ORBIT

Shared BOS Infrastructure
CORAL

OpEx

Operation & Maintenance
WOMBAT

NRWAL: Offshore wind
system cost and scaling
model

Wind Asset Value Estimate
WAVES

Pivot

Leveraging the past to meet the future's needs

Topics of Interest

- External (beyond DOE) support perspectives
 - For example, pvlb is part of NumFocus
 - Insights, lessons learned, etc
- Relationship with industry vs research / academia
 - Impact assessment?
 - Stakeholder prioritization?
- Modern software development (read: LLMs)
 - Adaptations to product, project, and team planning

Thank you!

<https://natlabrockies.github.io/WETOSStack/>



**National Laboratory
of the Rockies**