

# *Design Codes Overview*



## **Design Codes Workshop**

September 23, 2010

NTNU – Trondheim, Norway

Jason Jonkman, Ph.D.  
Senior Engineer, NREL

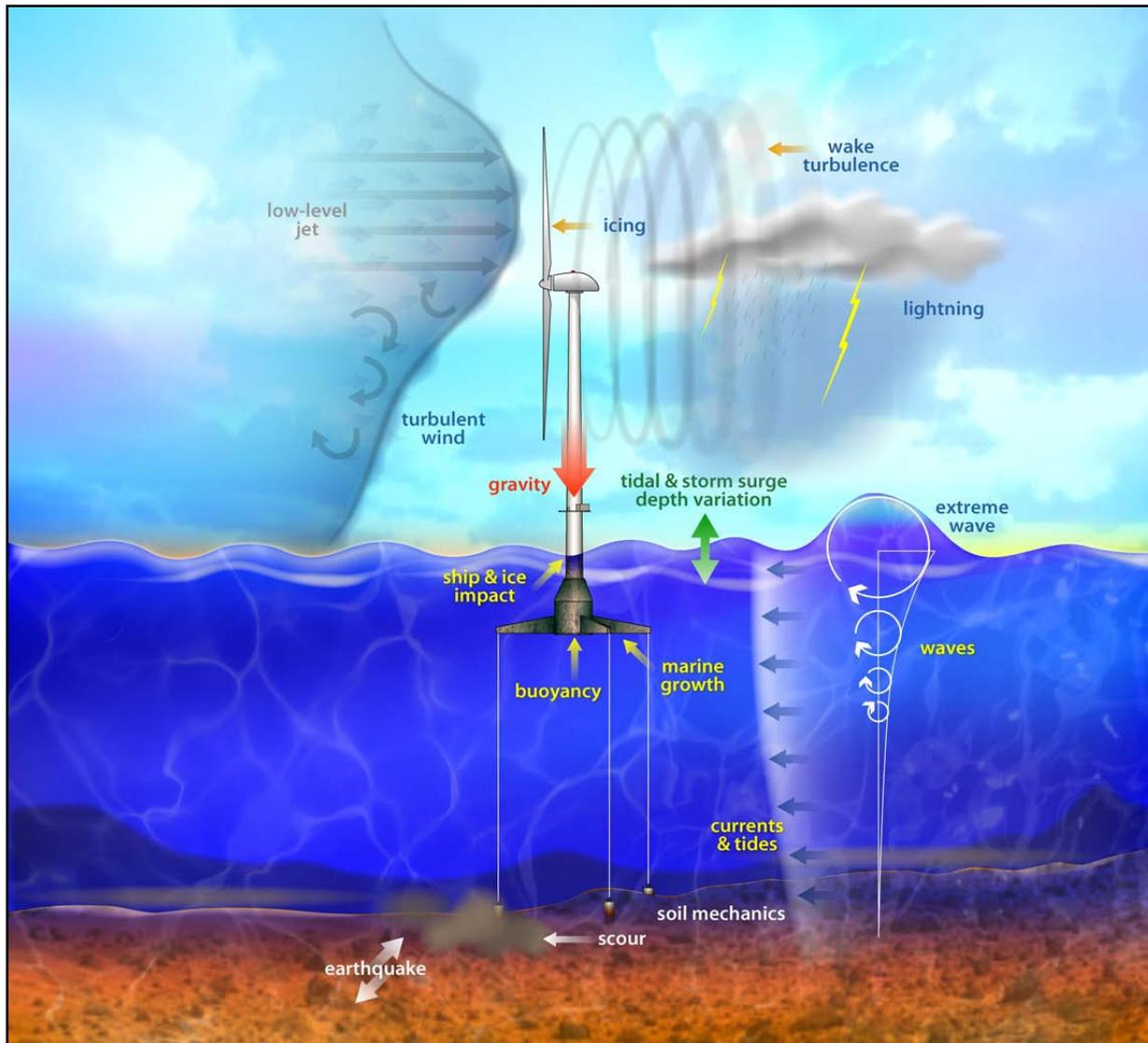
# Outline

---

- Introduction & Background:
  - Modeling Requirements
  - What Kind of Codes Are We Talking About?
  - Wind Turbine Design Process
- Design Codes:
  - Key NREL Codes in the Design Process
  - Main Focus: Modularization & Coupled Simulation
- Users & Support:
  - Users of NREL-Developed Codes
  - Successful Applications
  - Website & Forum

# Introduction & Background

## Modeling Requirements



- Fully coupled aero-hydro-servo-elastic interaction
- Wind-inflow:
  - Discrete events
  - Turbulence
- Waves:
  - Regular
  - Irregular
- Aerodynamics:
  - Induction
  - Rotational augmentation
  - Skewed wake
  - Dynamic stall
- Hydrodynamics:
  - Diffraction
  - Radiation
  - Hydrostatics
- Structural dynamics:
  - Gravity / inertia
  - Elasticity
  - Foundations / moorings
- Control system:
  - Yaw, torque, pitch

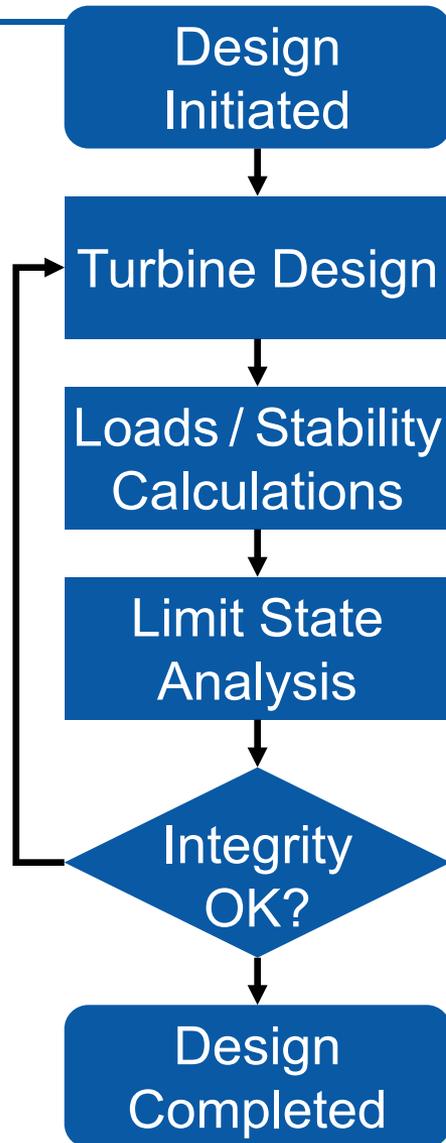
# Introduction & Background

## What Kind of Codes Are We Talking About?

- Codes developed for direct application in the design process
- Preprocessors, simulators, & post-processors
- Primary (simulation) codes are:
  - Multi-physics models (aero-hydro-servo-elastic)
  - Full system models (foundation + substructure + tower + nacelle + drivetrain + rotor)
  - Developed uniquely to the wind turbine application (not general purpose)
- Codes developed to run on standard PCs (not supercomputers)
- Codes whose accuracy is only as good as their inputs:
  - Inputs must be tuned with test data to ensure accurate outputs

# Introduction & Background

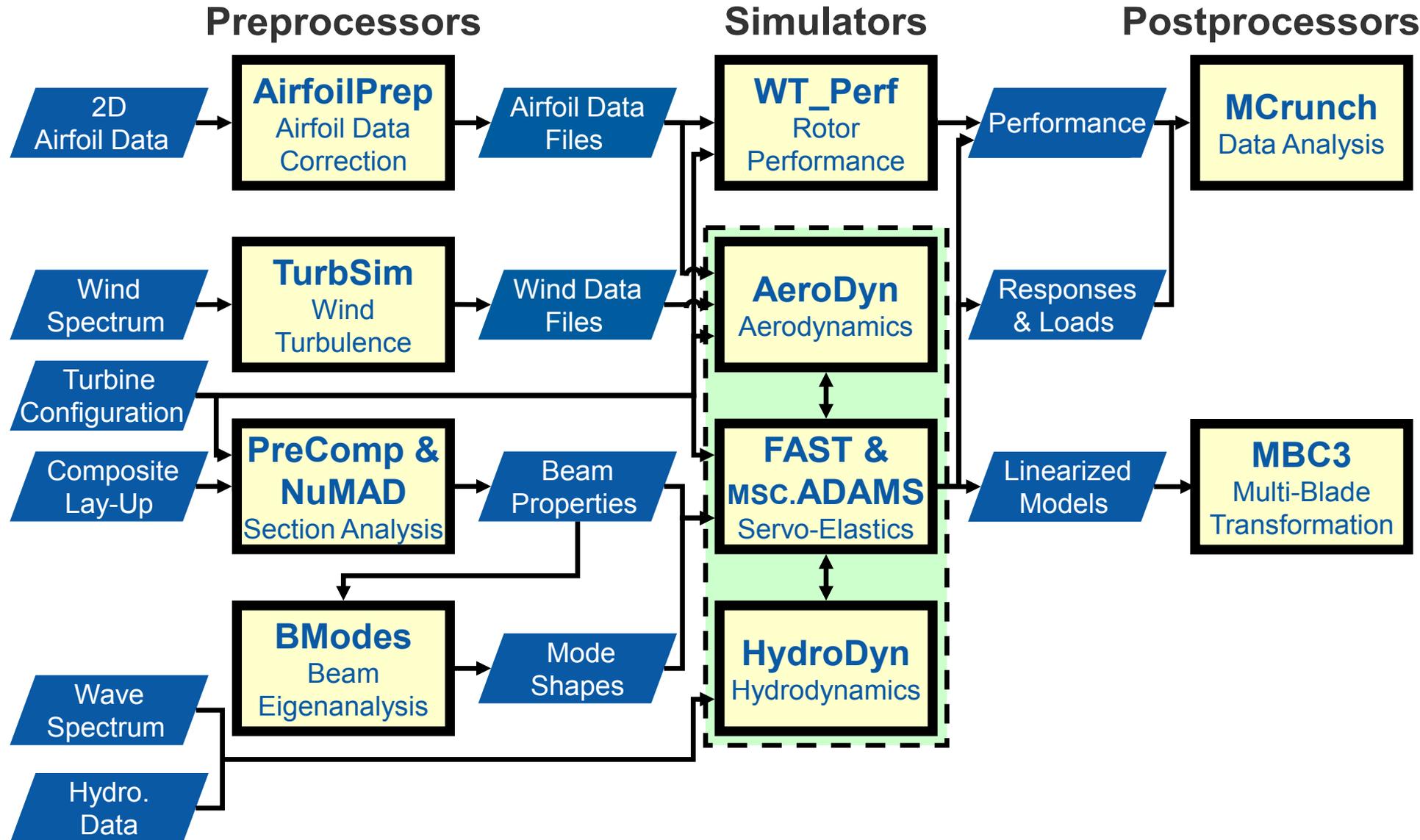
## Wind Turbine Design Process



- A design is derived from a design basis, consisting of:
  - Design objectives
  - Environmental conditions
  - Analysis methods
  - Design standards
- Coupled aero-hydro-servo-elastic models of the full system are used to calculate loads / stability
- The loads are used within component models (e.g., FEA) to perform limit state analysis
- The design is iterated until structural integrity is achieved
- Structural integrity achieved when:  
 $\text{Design Load} \leq \text{Design Resistance}$

# Design Codes

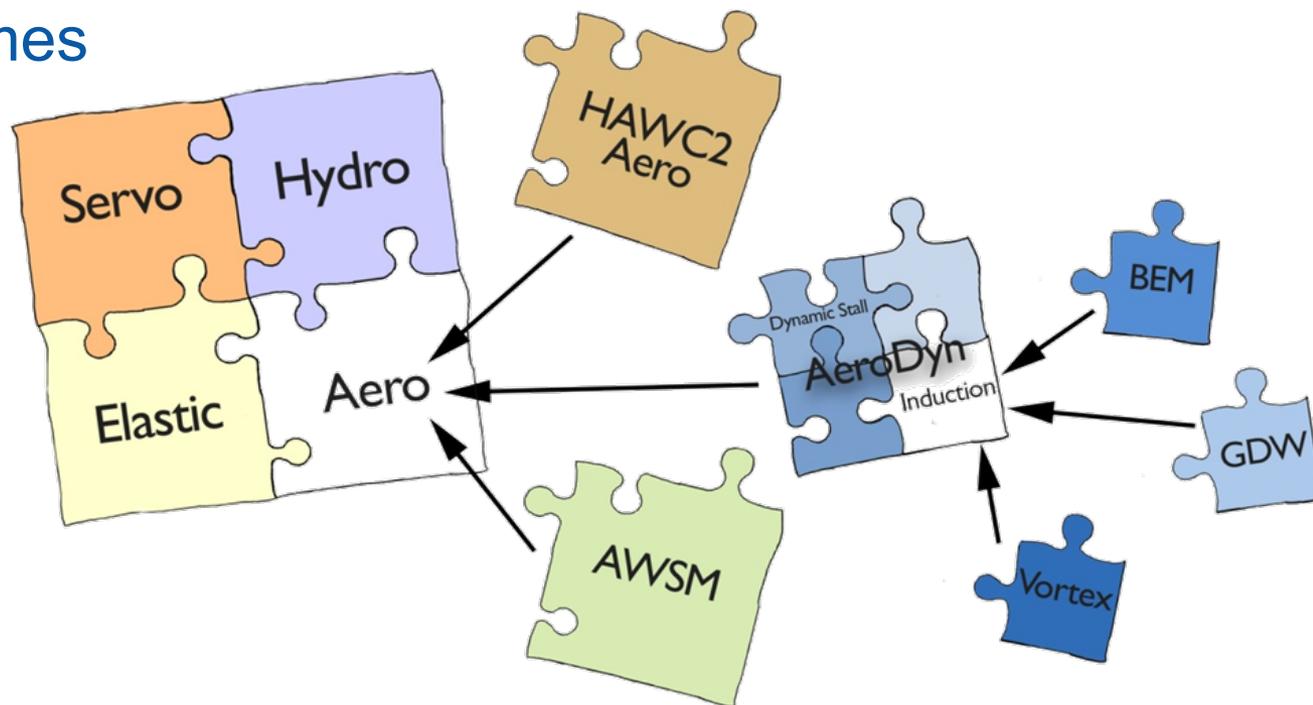
## Key NREL Codes in the Design Process



# Design Codes

## Main Focus: Modularization & Coupled Simulation

- Motivation – Increasing system complexity requires coupled analysis
- Benefits – Enables shared code development, improves maintainability, & eases integration of science advances
- Challenges – Establishing standardized interfaces & coupling schemes



# Users & Support

## Users of NREL-Developed Codes

- Used by all of the major U.S.-based (& many foreign) organizations

### Manufacturers

### Consultants

### R&D Institutes

### Universities



THE UNIVERSITY OF TEXAS AT AUSTIN



University of Massachusetts



defy.convention



# Users & Support

## Successful Applications (Only Subset Shown)



*Southwest  
Windpower  
Skystream*



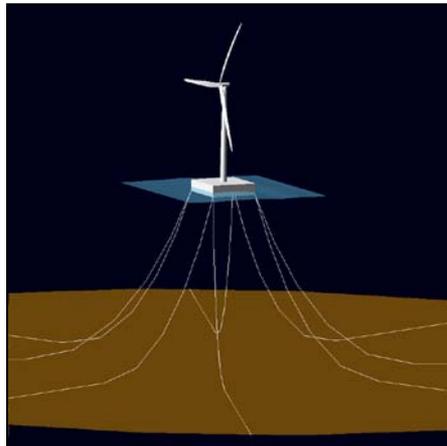
*CART2*



*Clipper 2.5-MW  
Liberty*



*NorthWind 100*



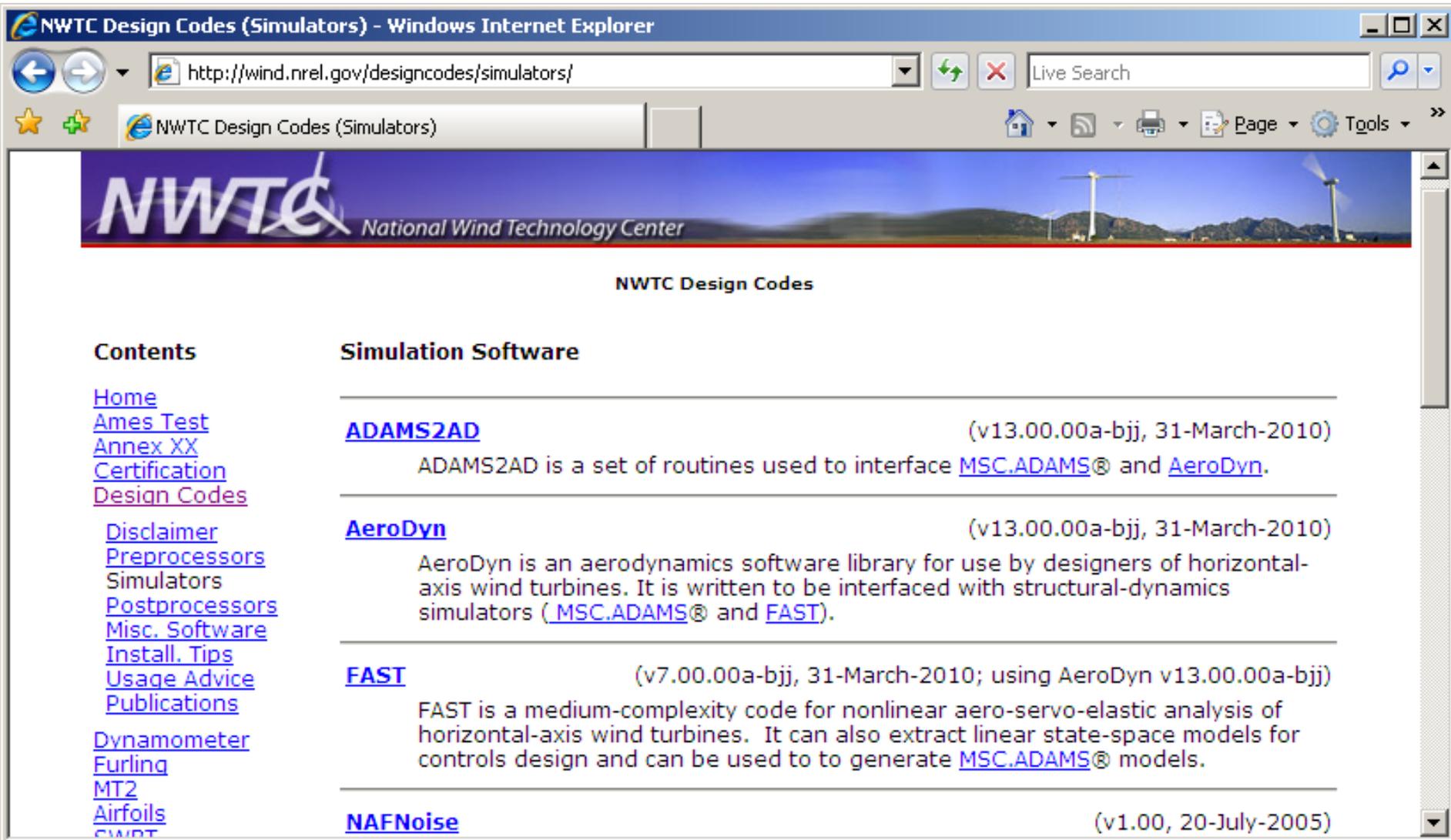
*NREL 5-MW Turbine on ITI Energy Barge*



*GE 1.5 MW*

# Users & Support

## NWTC Design Codes Website



The screenshot shows a Windows Internet Explorer browser window displaying the NWTC Design Codes website. The browser's address bar shows the URL <http://wind.nrel.gov/designcodes/simulators/>. The website header features the NWTC logo and the text "National Wind Technology Center" above a banner image of wind turbines. The main content area is titled "NWTC Design Codes" and is divided into two columns. The left column, titled "Contents", lists various links: Home, Ames Test, Annex XX, Certification, Design Codes, Disclaimer, Preprocessors, Simulators, Postprocessors, Misc. Software, Install. Tips, Usage Advice, Publications, Dynamometer, Furling, MT2, Airfoils, and CWBT. The right column, titled "Simulation Software", lists three software packages: ADAMS2AD (v13.00.00a-bjj, 31-March-2010), AeroDyn (v13.00.00a-bjj, 31-March-2010), and FAST (v7.00.00a-bjj, 31-March-2010; using AeroDyn v13.00.00a-bjj). A fourth package, NAFNoise (v1.00, 20-July-2005), is listed at the bottom of the right column. Each software entry includes a brief description of its purpose and the software it interfaces with.

**Contents**

- [Home](#)
- [Ames Test](#)
- [Annex XX](#)
- [Certification](#)
- [Design Codes](#)
- [Disclaimer](#)
- [Preprocessors](#)
- [Simulators](#)
- [Postprocessors](#)
- [Misc. Software](#)
- [Install. Tips](#)
- [Usage Advice](#)
- [Publications](#)
- [Dynamometer](#)
- [Furling](#)
- [MT2](#)
- [Airfoils](#)
- [CWBT](#)

**Simulation Software**

---

**ADAMS2AD** (v13.00.00a-bjj, 31-March-2010)  
ADAMS2AD is a set of routines used to interface [MSC.ADAMS®](#) and [AeroDyn](#).

---

**AeroDyn** (v13.00.00a-bjj, 31-March-2010)  
AeroDyn is an aerodynamics software library for use by designers of horizontal-axis wind turbines. It is written to be interfaced with structural-dynamics simulators ([MSC.ADAMS®](#) and [FAST](#)).

---

**FAST** (v7.00.00a-bjj, 31-March-2010; using AeroDyn v13.00.00a-bjj)  
FAST is a medium-complexity code for nonlinear aero-servo-elastic analysis of horizontal-axis wind turbines. It can also extract linear state-space models for controls design and can be used to generate [MSC.ADAMS®](#) models.

---

**NAFNoise** (v1.00, 20-July-2005)

# Users & Support

## NWTC Forum

NWTC • Index page - Windows Internet Explorer

https://wind.nrel.gov/forum/wind/

NWTC  
NREL's National Wind Technology Center

Search... Search  
Advanced search

Board index

FAQ Register Login

It is currently Wed May 05, 2010 5:07 am

View unanswered posts • View active topics

WIND EXTERNAL	TOPICS	POSTS	LAST POST
 <b>Access Requests (READ THIS FIRST BEFORE CREATING AN ACCOUNT)</b> Information on accessing our forums.	1	1	by Marshall.Buhl  Mon Feb 25, 2008 11:58 am
 <b>General</b> Topics of general, but wind-related interest.	7	23	by Andreas.Ferber  Mon Mar 01, 2010 1:12 pm
 <b>Airfoils</b> Discuss acquisition, use, and manipulation of airfoil data.	8	33	by Yinping.Yang  Thu Sep 03, 2009 2:44 am
 <b>Design Codes</b> Provide feedback, request enhancements, and get help with wind-turbine design codes.	133	587	by Javier.Gil  Tue May 04, 2010 1:03 am
 <b>AeroDyn Development</b> This forum is dedicated to discussions of the redevelopment of AeroDyn. Moderator: Jason.Jonkman	7	18	by Marshall.Buhl  Mon Nov 16, 2009 9:51 am
 <b>Furling</b> Discuss furling in small wind turbines.	0	0	No posts
 <b>Inflow Turbulence</b> Discuss the effects of turbulence on wind turbines and its simulation.	23	58	by Jason.Jonkman  Mon Apr 12, 2010 12:57 am

# *Questions?*



Jason Jonkman, Ph.D.  
+1 (303) 384 – 7026  
[jason.jonkman@nrel.gov](mailto:jason.jonkman@nrel.gov)