

Design Codes Overview



CREW/NREL Wind Turbine Design Codes Workshop

March 4, 2011

CU Campus – Boulder, CO

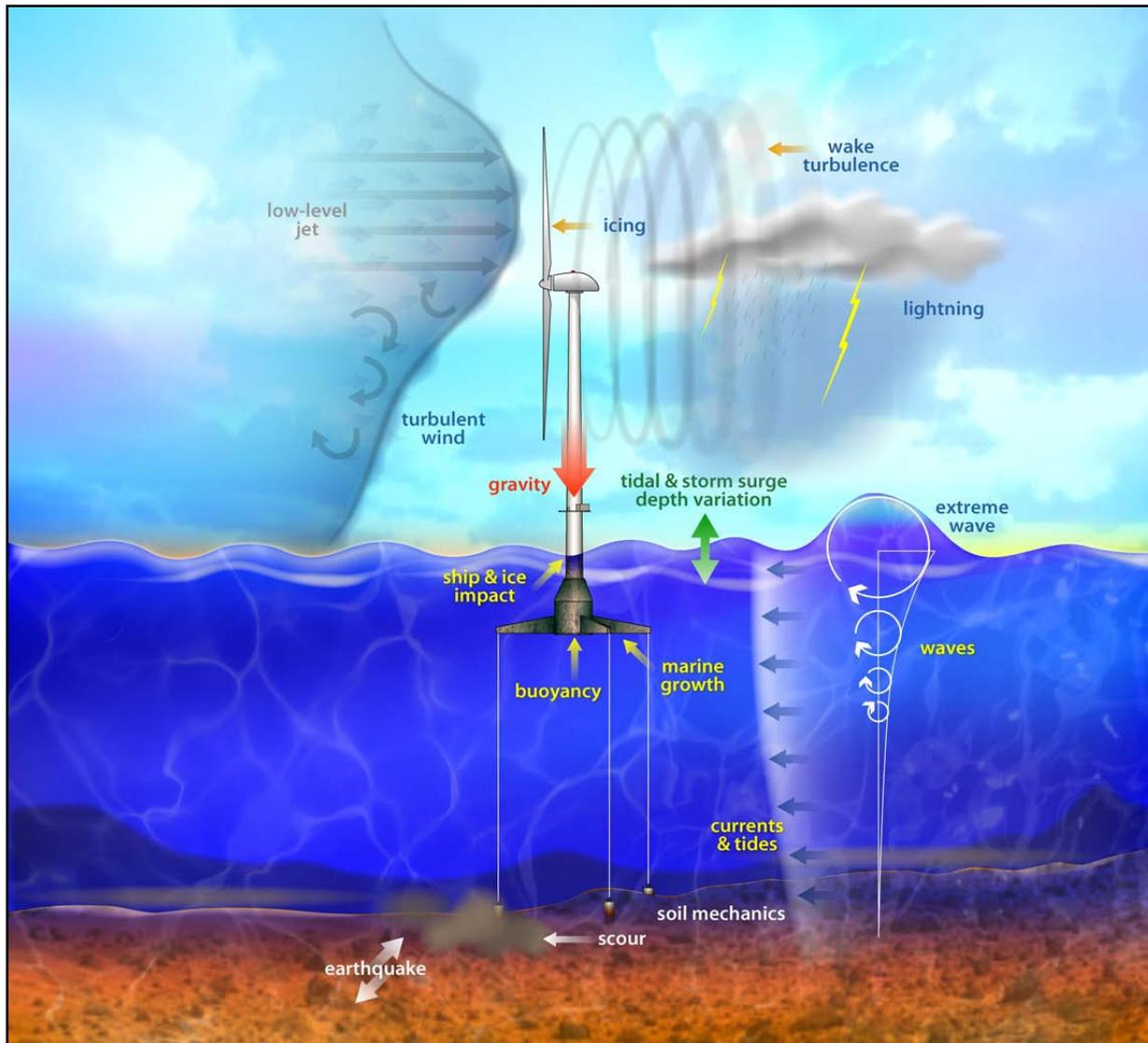
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Outline

- 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
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 - Successful Applications
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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

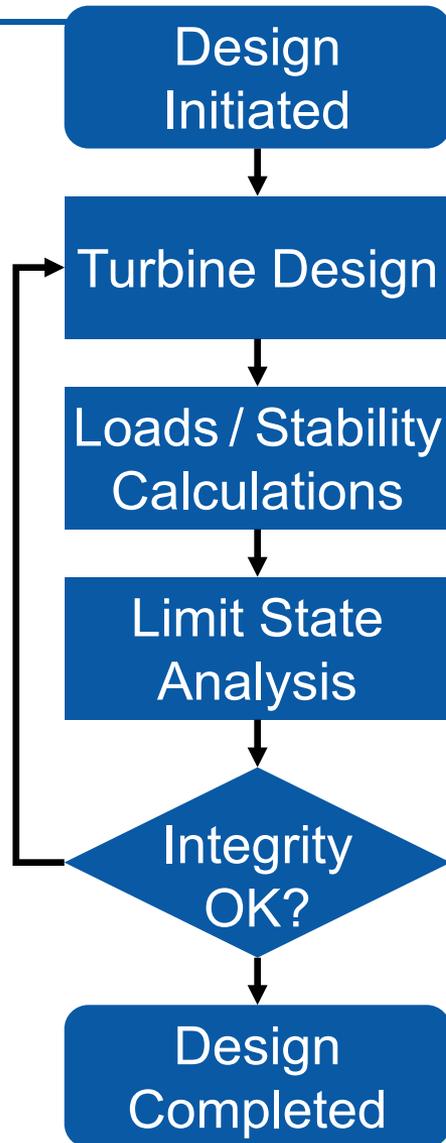
Introduction & Background

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

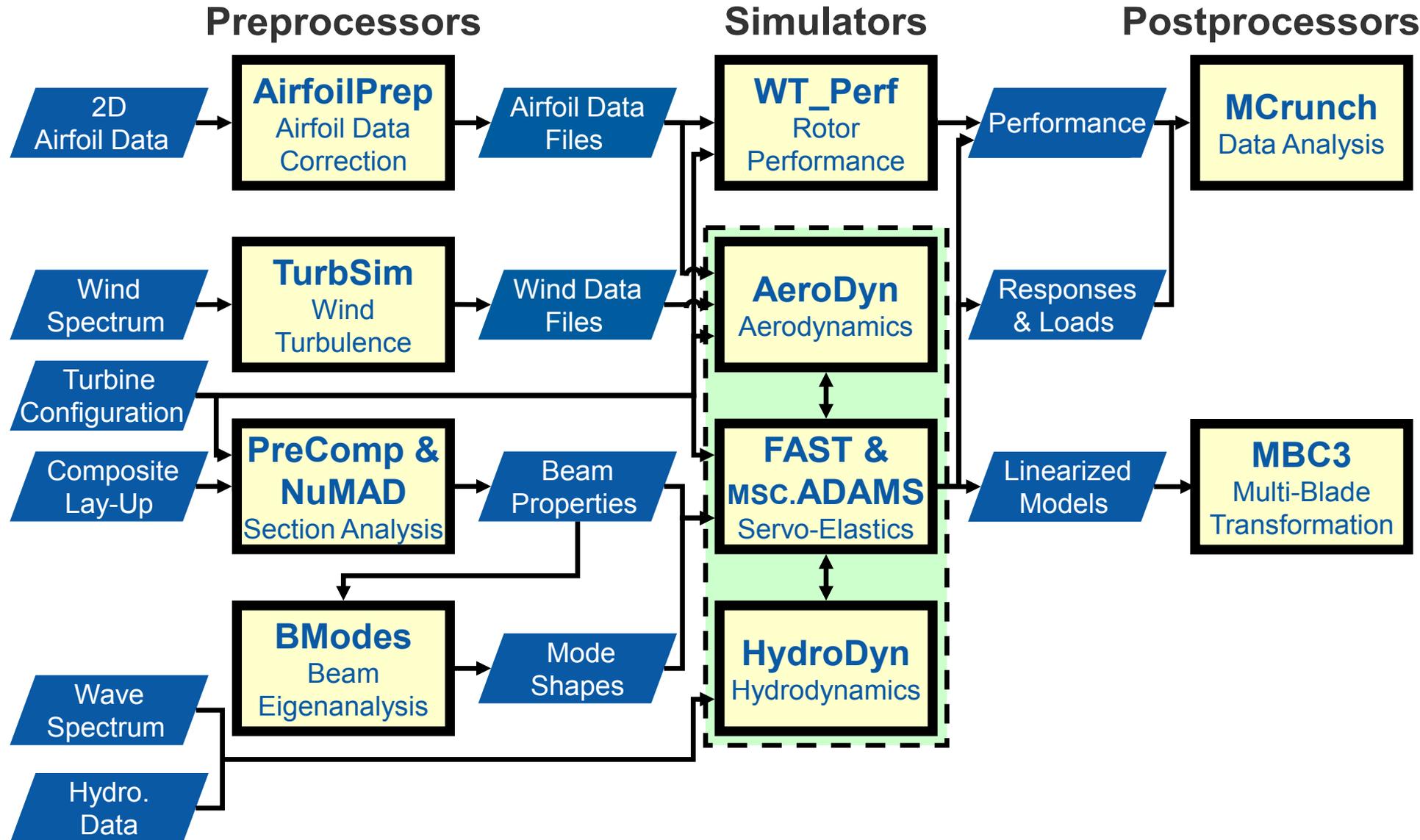
Wind Turbine Design Process



- 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

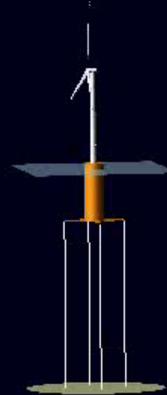
Key NREL Codes in the Design Process



Design Codes

Sample MIT/NREL TLP Response

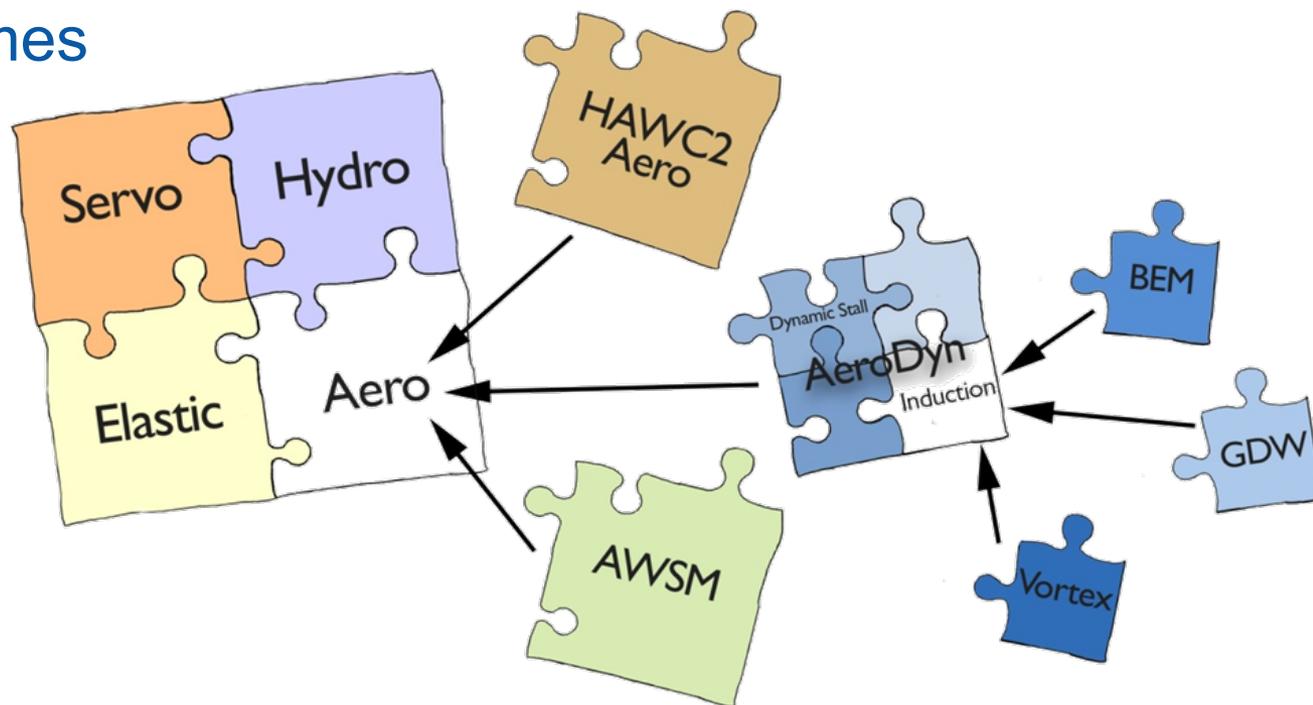
NRELOffshrBslne5MW_Floating_TLP_ADAMS Time= 0.0000 Frame=0001



Design Codes

Main Focus: Modularization & Coupled Simulation

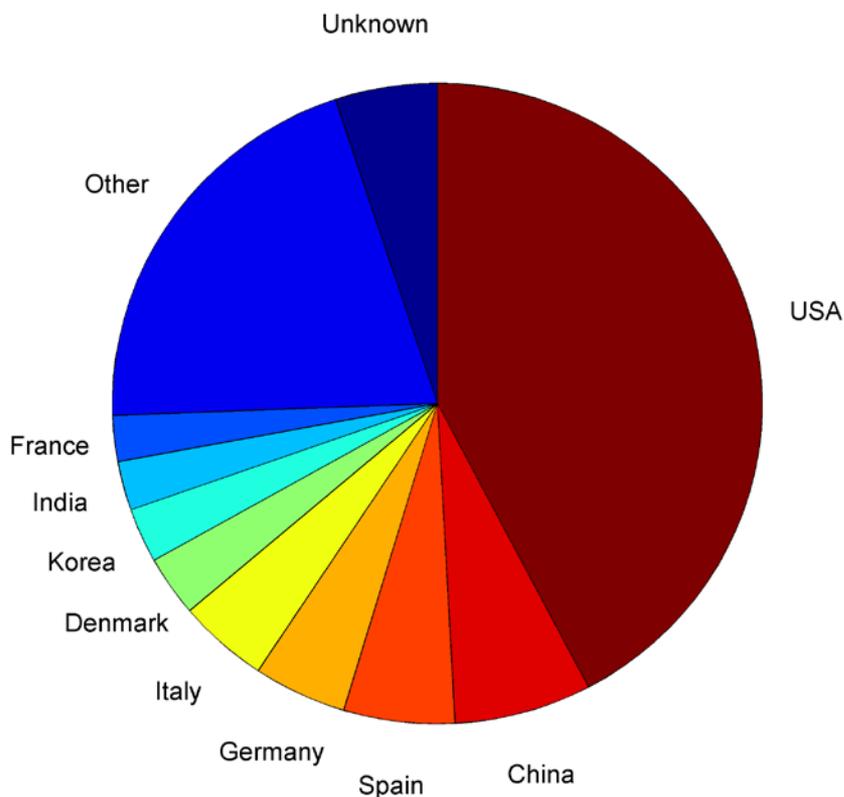
- Motivation – Increasing system complexity requires coupled analysis
- Benefits – Enables shared code development, improves maintainability, & eases integration of science advances
- Challenges – Establishing standardized interfaces & coupling schemes



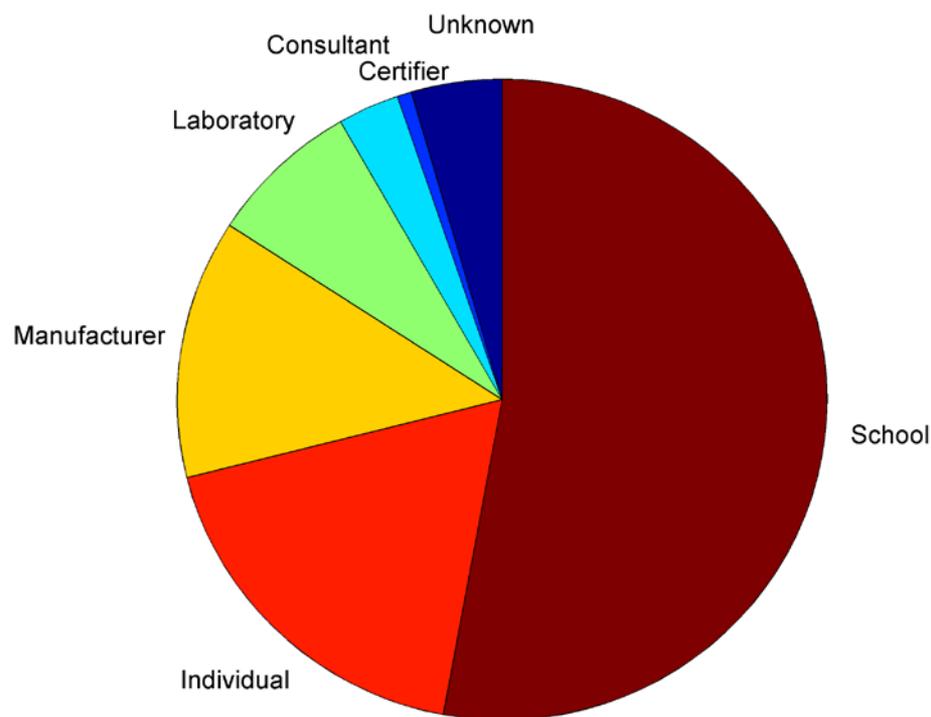
Users & Support

Users of NREL-Developed Codes

- Used by all of the major U.S.-based (& many foreign) wind energy organizations
- Since 2/1/2011, there have been 688 unique downloads



Downloads by Country (45 Total)



Downloads by Organization (227 Total)

Users & Support

Successful Applications (Only Subset Shown)



*Southwest
Windpower
Skystream*



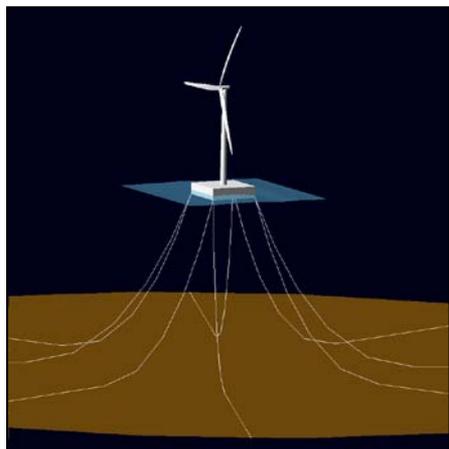
CART2



*Clipper 2.5-MW
Liberty*



NorthWind 100



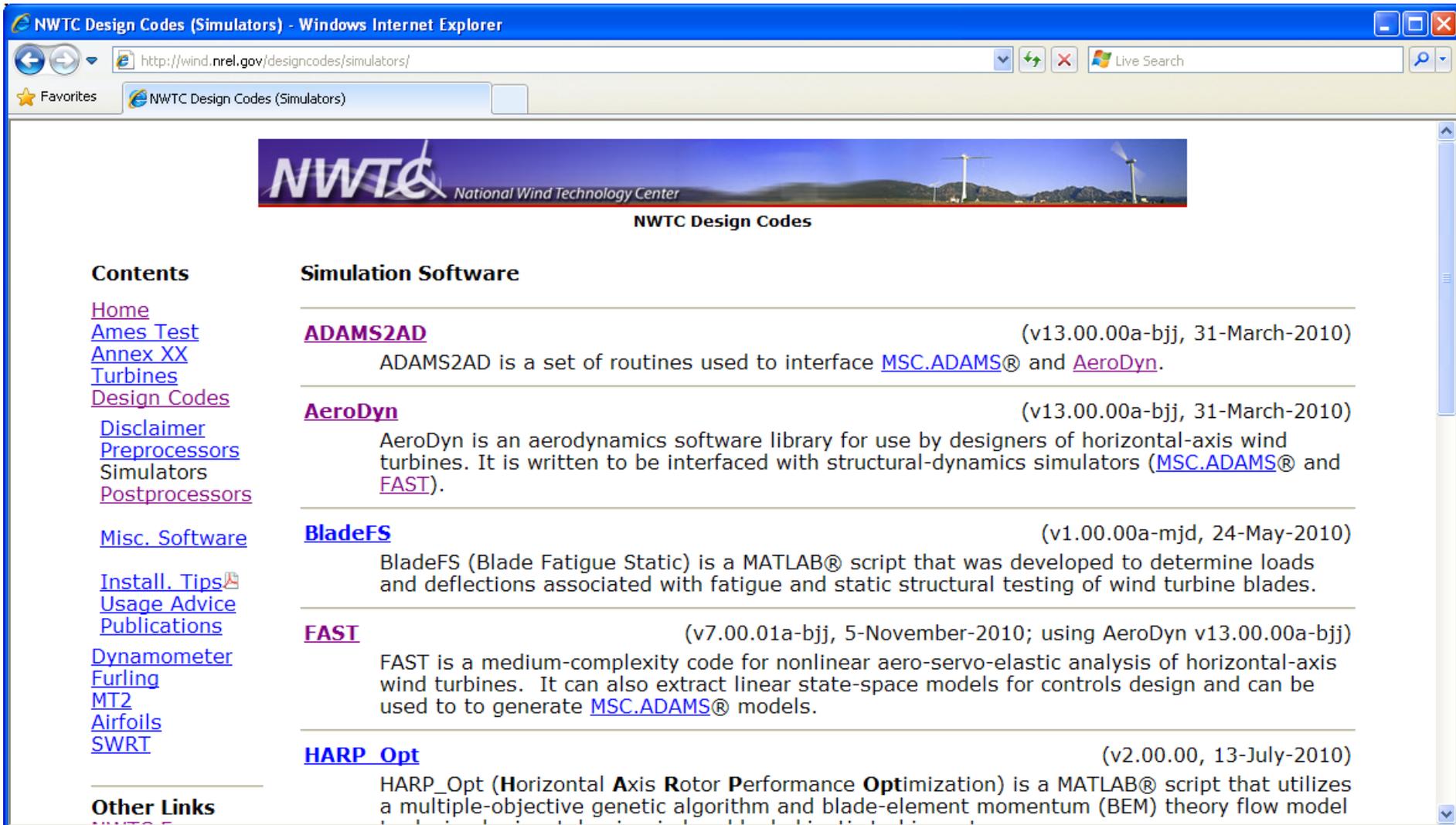
NREL 5-MW Turbine on ITI Energy Barge



GE 1.5 MW

Users & Support

NWTC Design Codes Website



The screenshot shows a Windows Internet Explorer browser window titled "NWTC Design Codes (Simulators) - Windows Internet Explorer". The address bar displays "http://wind.nrel.gov/designcodes/simulators/". The page content includes a banner for the National Wind Technology Center (NWTC) with the text "NWTC National Wind Technology Center" and "NWTC Design Codes". Below the banner, there are two main sections: "Contents" and "Simulation Software".

Contents

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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](#)).

BladeFS (v1.00.00a-mjd, 24-May-2010)
BladeFS (Blade Fatigue Static) is a MATLAB® script that was developed to determine loads and deflections associated with fatigue and static structural testing of wind turbine blades.

FAST (v7.00.01a-bjj, 5-November-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.

HARP_Opt (v2.00.00, 13-July-2010)
HARP_Opt (**H**orizontal **A**xis **R**otor **P**erformance **O**ptimization) is a MATLAB® script that utilizes a multiple-objective genetic algorithm and blade-element momentum (BEM) theory flow model

Users & Support

NWTC Forum

NWTC • Index page - Windows Internet Explorer

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

NREL HOME

NWTC
NREL's National Wind Technology Center

Search... Search
Advanced search

Board index

User Control Panel • View your posts

FAQ Members Logout [Jason.Jonkman]

It is currently Tue Mar 01, 2011 11:23 am
[Moderator Control Panel]

Last visit was: Mon Feb 28, 2011 6:06 pm

View unanswered posts • View new posts • View active topics

Mark forums read

WIND EXTERNAL	TOPICS	POSTS	LAST POST
 Access Requests (READ THIS FIRST BEFORE CREATING AN ACCOUNT) Information on accessing our forums.	1	1	by Marshall.Buhl  Mon Feb 25, 2008 11:58 am
 General Topics of general, but wind-related interest.	11	32	by Ekaitz.Zulueta  Wed Oct 27, 2010 2:25 am
 Airfoils Discuss acquisition, use, and manipulation of airfoil data.	11	47	by Danny.Sale  Thu Dec 02, 2010 12:00 pm
 U.S. Standards AWEA Road-Mapping U.S. Standards to International Standards	4	76	by Arielle.Wolfe  Wed Oct 20, 2010 1:33 pm
 Design Codes Provide feedback, request enhancements, and get help with wind-turbine design codes.	207	959	by Jason.Jonkman  Thu Feb 24, 2011 9:20 am
 AeroDyn Development This forum is dedicated to discussions of the redevelopment of AeroDyn.	7	23	by Jason.Jonkman  Tue Feb 08, 2011 12:02 pm

Questions?



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