

# Presenter



- Lead Application Engineer
- 18+ years Adams experience
- Former US Army Blackhawk test pilot
- Austin, TX



# MSC Solutions for Wind Energy

Presenter: Jennifer L. Peeples

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# MSC Software Company at a Glance

## Company Overview

- ▶ Leading provider of computer aided engineering ("CAE") software solutions
  - ✓ Mission critical simulation & analysis ("S&A") products enabling engineers and analysts to validate and optimize their designs
  - ✓ Complement and / or replace the traditional physical prototype-based "build-and-test" product design process
- ▶ **Value proposition:** Improve quality, accelerate time-to-market and save costs associated with design and test of manufactured products
- ▶ **Innovation:** 50+ PhDs hired & ~30 acquired since 2010
- ▶ **Governance** – BOD includes Richard Riff – Henry Ford Technical Fellow, Frank Cappuccio – SVP - Lockheed Martin

## Strong Core Business

- ▶ Virtually every auto, aero & heavy machinery OEM is a customer
- ▶ 25+ year relationship with the top 50 customers
- ▶ Broad core product portfolio (built over 40+ years) complemented by investments in new in-house extensions and complementary acquisitions
- ▶ Acquisitions – Best in class acoustics (FFT), multi-phase material modeling (e-Xstream engineering) and mechanical joining and welding (Simufact)

## Game Changing CAE Platform: "Apex"

- ▶ Game changing CAE platform
  - ✓ Complements and significantly extends the core simulation solutions
  - ✓ 19 patents filed so far, 5 awarded to date
  - ✓ Award winning



## Key Highlights

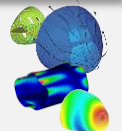
- **Founded:** 1963
- **Employees:** ~1,100
- **HQ:** Newport Beach, CA
- **R&D:** 375+ employees
- **Total Offices:** 27



## MSC's Value Proposition



**Airbus Leverages MSC to Reduce Aircraft Noise**  
Noise Reduction



**Key Results:** Understand the effects of various parameters such as the excitation type, the presence of the floor, and the variable thickness on the interior noise levels



**MSC Helps Bugatti Build The World's Fastest Cars**  
Vehicle Dynamics



**Key Results:** Successfully develop chassis and driveline performance prior to building first prototype



**Nissan Uses MSC To Design Quieter Cars**

Noise Vibration and Harshness (NVH)



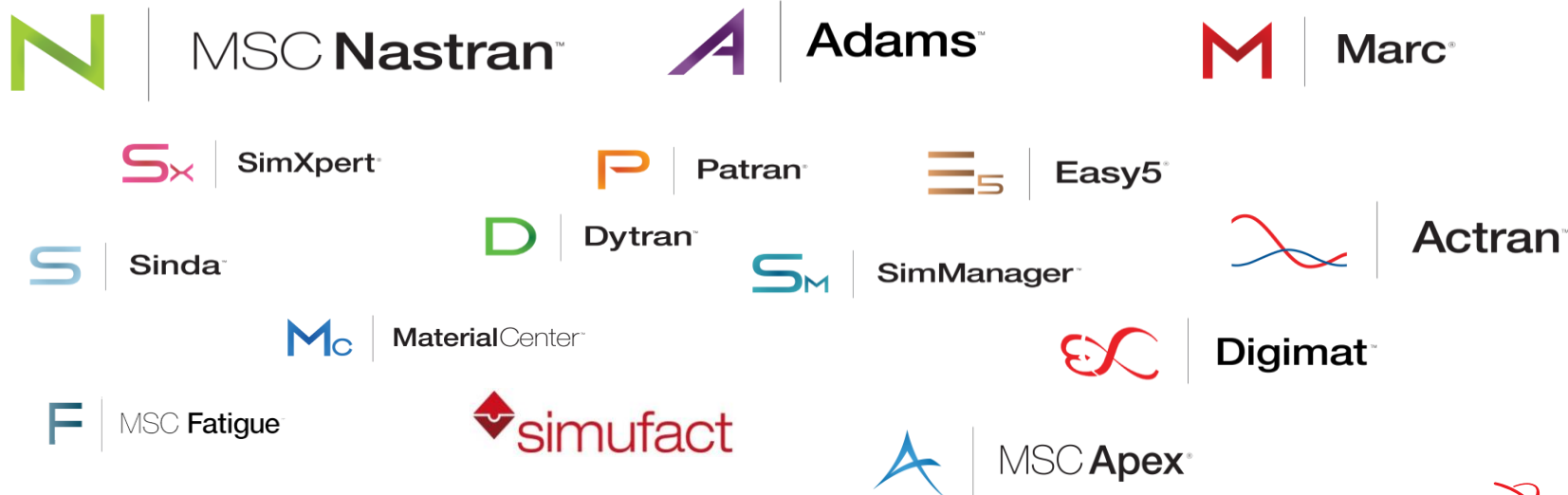
**Key Results:** Improvement of the fidelity of numerical models thanks to the accurate representation of trim components



What We Do

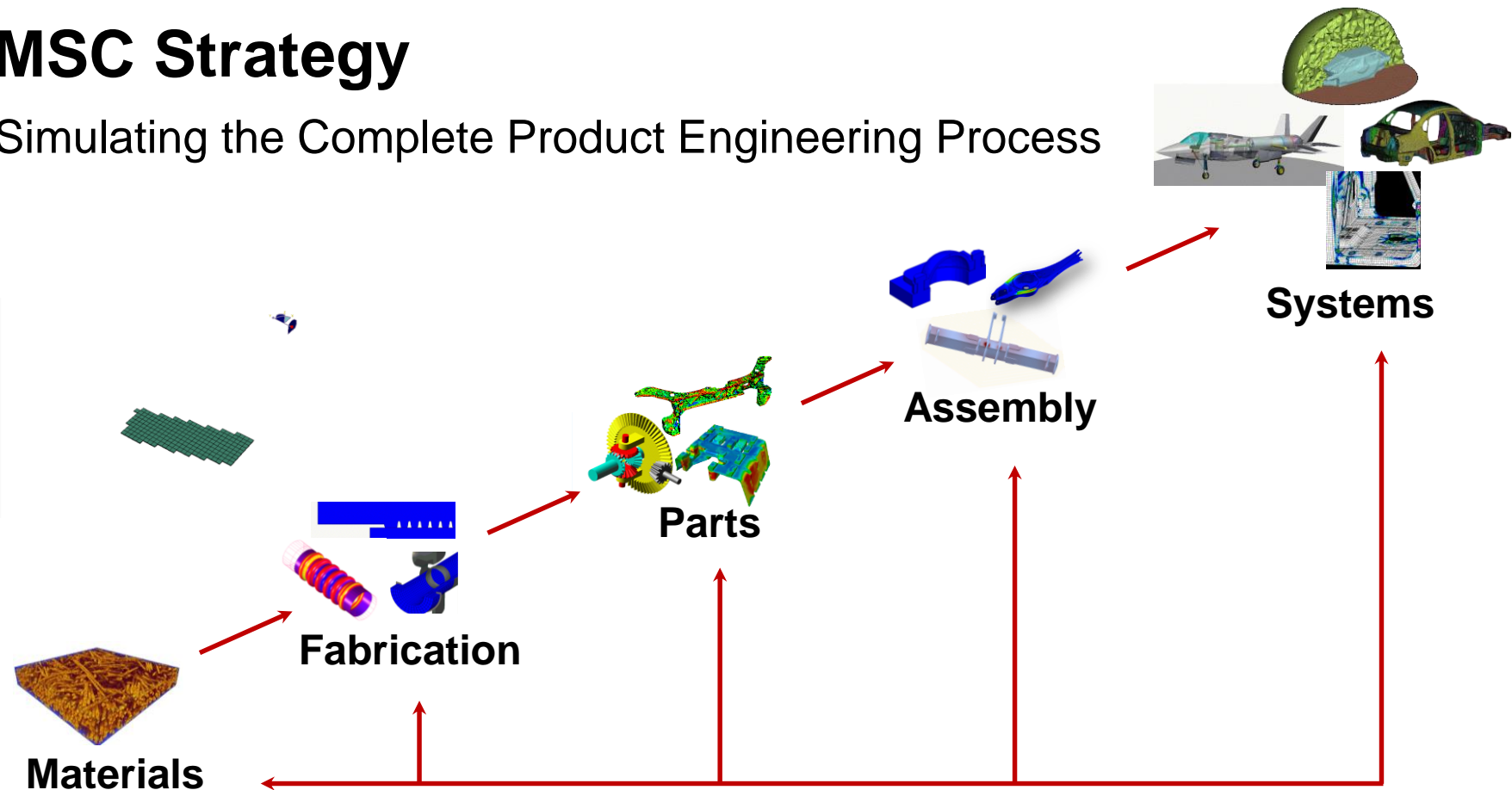
# Simulating Reality, Delivering Certainty

- A worldwide leader in Multidiscipline Simulation & Analysis
- Half a Century of Engineering Simulation Excellence & Innovation
- Portfolio of best-in-class technologies



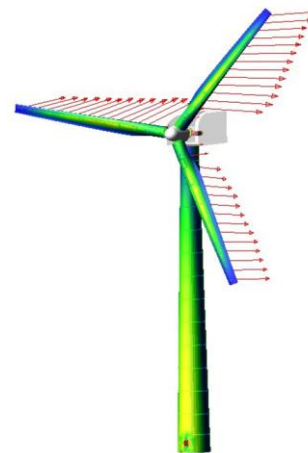
# MSC Strategy

Simulating the Complete Product Engineering Process



# Executive Summary

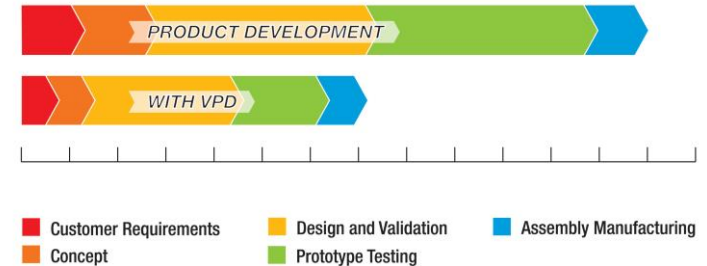
- **Wind Energy Trends**
  - More efficient, more reliable, larger turbines
- **Competing Engineering Requirements**
  - Increase energy generated per wind turbine while reducing costs and maintaining durability
- **Complex Challenges**
  - High degree of component coupling
  - Large number of simulations needed for certification



# Value of Simulation

- **Limitations of physical tests**
  - Size of equipment (rotor blades, tower, ...) limits number of available test facilities
  - Control over loads (weather / wind conditions)
  - Expensive, slow, late in development cycle
  - Limited understanding of durability issues
- **Simulation advantages (virtual tests)**
  - Accelerate time to market
  - Allows prediction of durability issues
    - Increasing system reliability
    - Decreasing warranty and maintenance expenses
  - Virtual tests against various weather (wind velocity and turbulence) conditions
  - System size not an issue
  - Best tools to find the optimum configuration

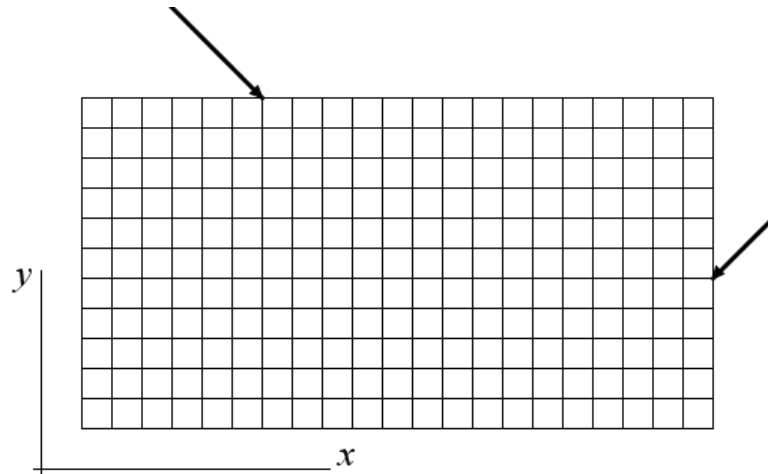
## Accelerating the Product Development Process



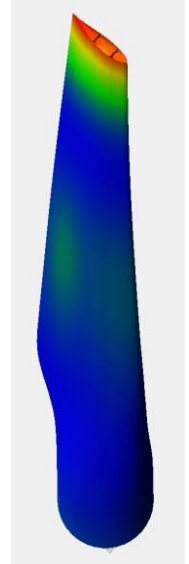
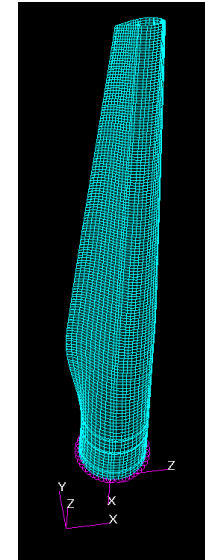


# Finite Element Modeling (FEM) in Wind Turbine Analysis

- In general, Finite Element Analysis is used for detailed linear, non-linear, dynamic analysis where every component is deformable.
- FEA is essential for modeling deformation in wind turbine components, as well as for recovering stresses in critical components.

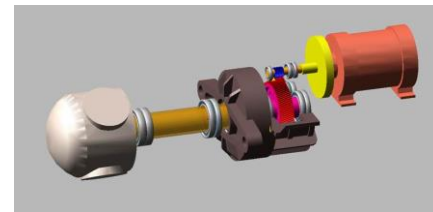
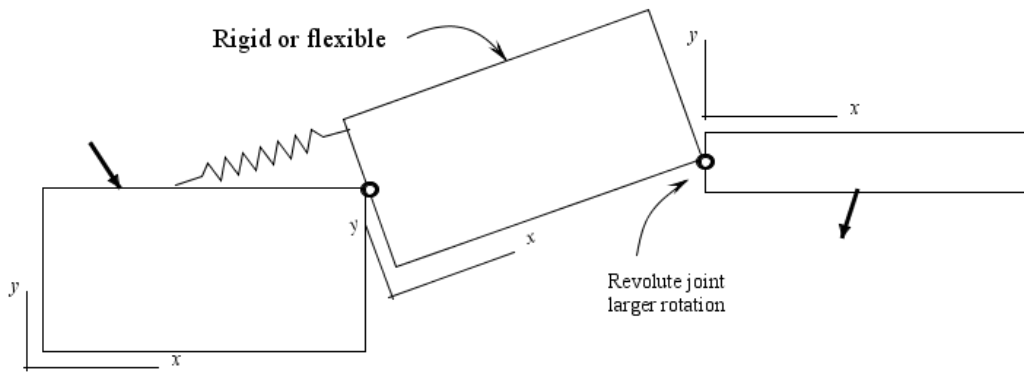


FEA arena



# Multi Body Dynamics (MBD) in Wind Turbine Analysis

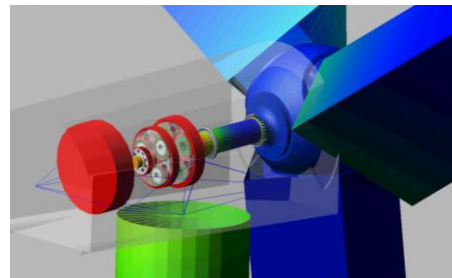
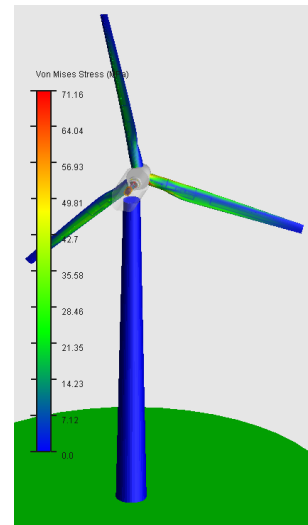
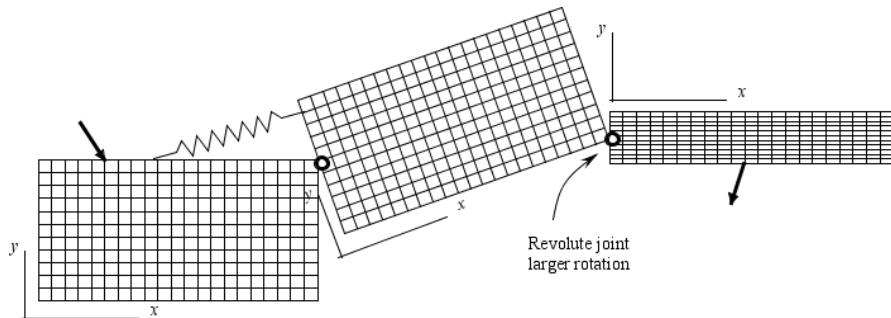
- Finite Element Analysis codes struggle to analyze multiple connected domains undergoing large rotations. Modeling distributed contacts and connections adds to the computational burden.
- Multibody dynamics can analyze multiple connected components undergoing large rotations by using a reduced representation of the components (rigid or flexible) and their connections.



Multibody Dynamics Arena

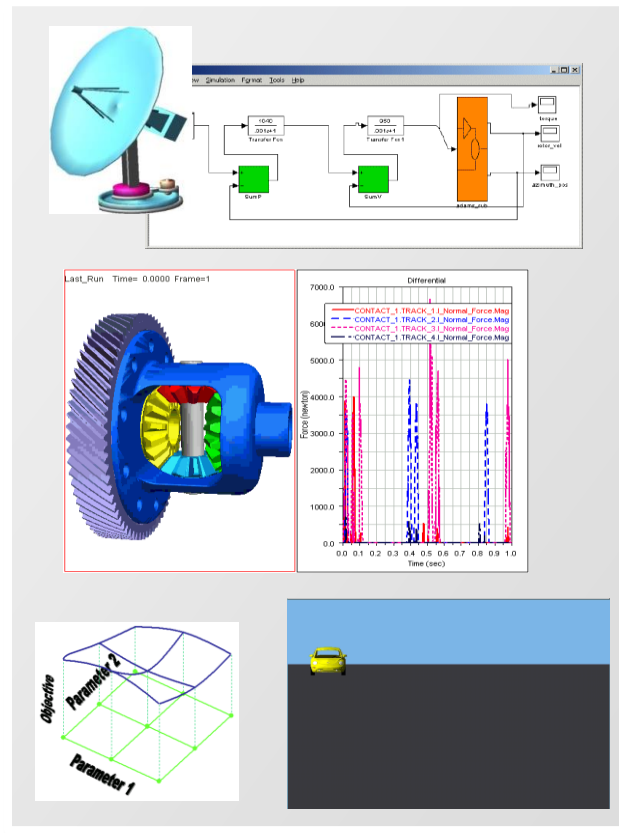
# Integrated MBD and FEA – The Best of Both Worlds

- In a more advanced scenario MBD and FEA can work together, each overcoming the limitations of the other.
- MBD provides the capacity to assemble and solve schematic components and their connections, while FEA can provide the correct internal stiffness and deformation of the parts.



# Integrate Technologies With Adams

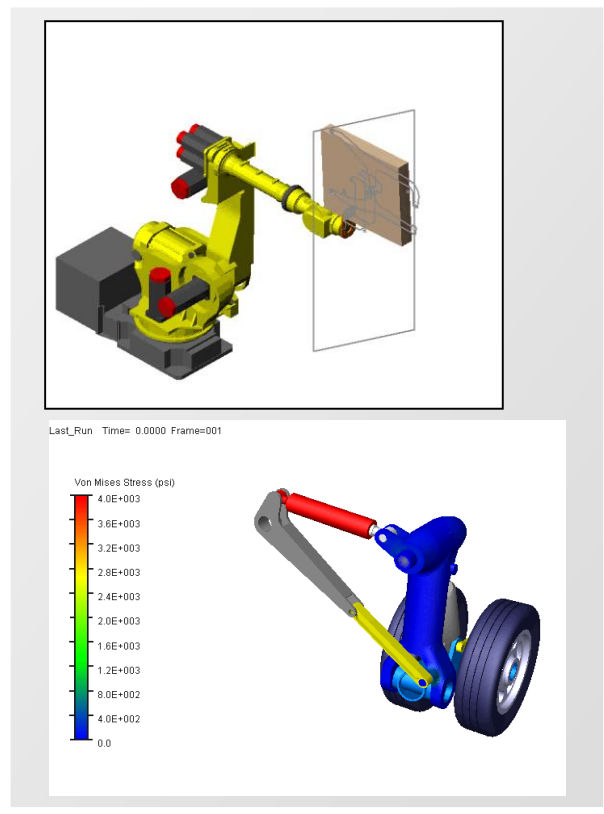
- **Design confidently with accurate Mechanical Model for Controls System Modeling**
  - Difficult with several moving parts, complex interactions, and dynamic phenomena
  - Understand the mechanical system being controlled
- **Efficient Solution for Problems with Moving Parts**
  - MBD often more efficient than FEA for systems with many moving parts that can be represented as rigid bodies
  - Enables representing flexibility where required
- **Accelerate innovation by exploring multiple design concepts**
  - Design Study, DOE and Optimization
  - Quickly assess multiple design variants
  - Understand interaction between factors
  - Determine objective-parameter response surface



# Adams Enables System-Level Analysis

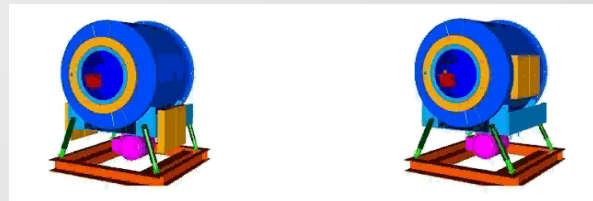
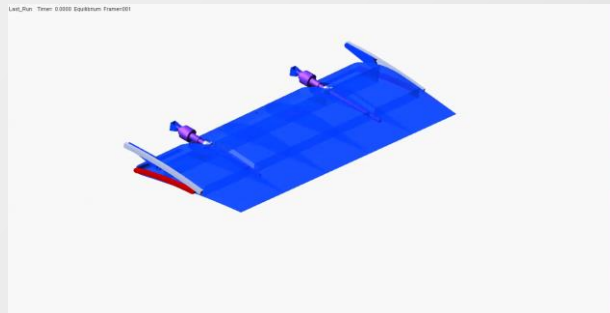
- **What's in an Adams model?**
  - Parts (rigid or flexible)
  - Constraints (ideal or complex)
  - Forces
- **Studies interaction between multiple components in an assembly**
- **Kinematics vs Dynamics**

Kinematics	Dynamics
0 degrees of freedom	> 0 degrees of freedom
Simple, motion-driven analysis	Complex, nonlinear systems



# Tackle Multiple Design Challenges With Adams

- **Leverage System-Level Analysis to *identify issues* early in design cycle**
  - Many problems stem from component interactions
  - Require sub-system or system-level viewpoint
- **Accurately *Predict Loads* for FEA**
  - Dynamic loads far more difficult to predict and understand compared to static loads
  - Use MBD loads as inputs to component FEA
- ***Understand Vibration Performance***
  - Frequency-domain analysis
  - NVH analysis for comfort prediction



# Wind Turbine Simulation = System Simulation

- **Main Mechanical system**

- Blades
- Hub
- Shafts
- Gears
- Generator
- Rolling bearings
- Engine frame
- Tower
- Foundation
- Mooring lines (floating)

- **Aerodynamics**

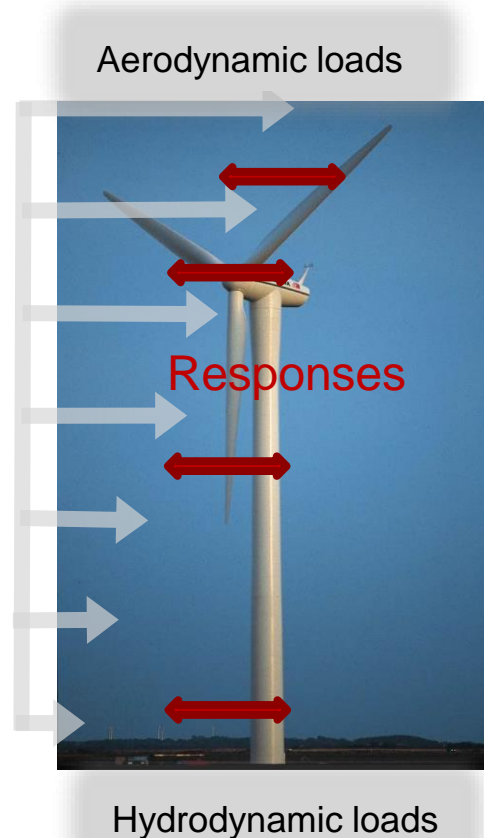
- Blade, tower, nacelle

- **Controls**

- Pitch, yaw, brakes, engine...

- **Hydrodynamics**

- Waves, currents, buoyancy



Rotor Blade Modeling

Noise Predictions

Power-Train Modeling

Fatigue Predictions

System Performance

Structural Integrity

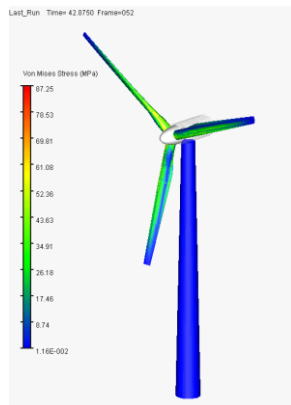
Certification

# Advanced Windturbine Modelling

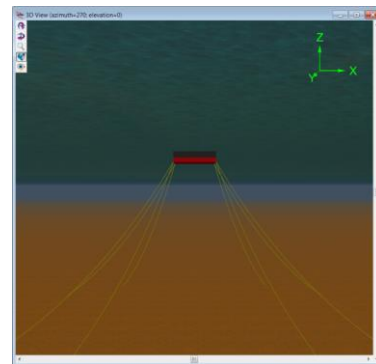
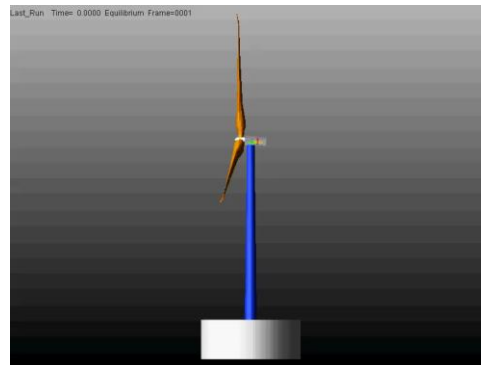
- **AdWiMo is a plug-in for Adams that puts powerful computational tools – Adams and Nastran – in the hands of domain experts.**
- **It is no longer necessary to be an expert in multiple computational tools to analyze windturbine designs and get accurate results.**
- **AdWiMo is built on the template-based technology used in MSC's industry-standard automotive product, Adams/Car.**
- **All functions of Adams remain available to the user, including flexible bodies, integration of control systems, and application of aero and wave loads.**
- **AdWiMo supports single design studies up to the full certification of a windturbine.**



# AdWiMo Addresses Multiple Configurations

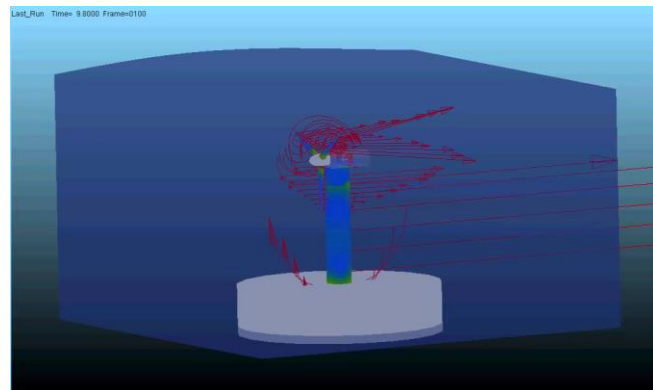
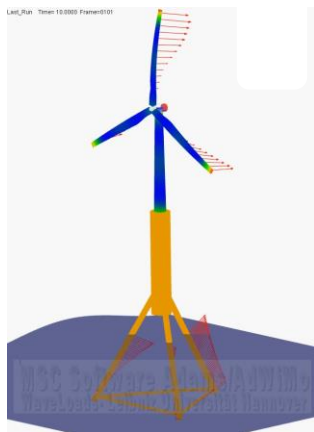


Onshore



Floating (Ex Adams coupling with Orcaflex™)

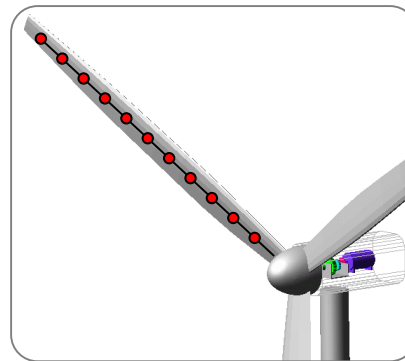
Offshore



# Flexible Body Simulation

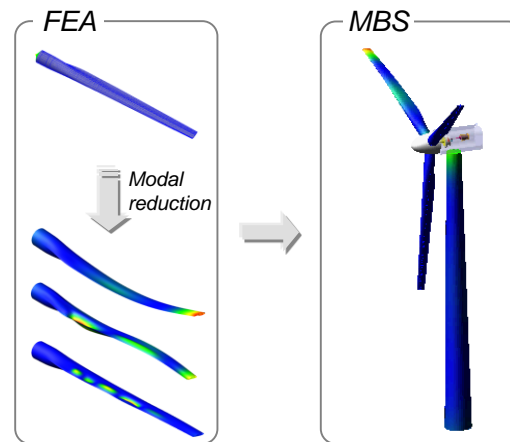
- **Discrete flexibility**

- Masses connected with beam elements
- Will capture stiffening effects due to rotation, gyroscopic effects, etc
- Typically used for wind turbine blades

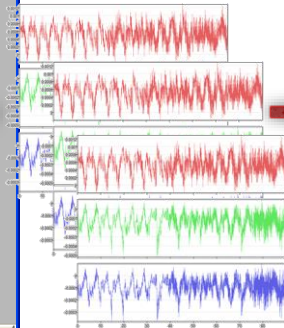
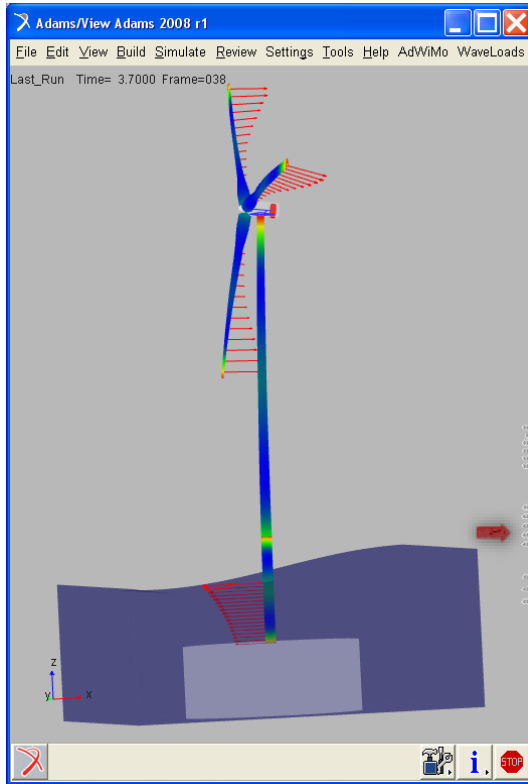


- **Modal flexibility**

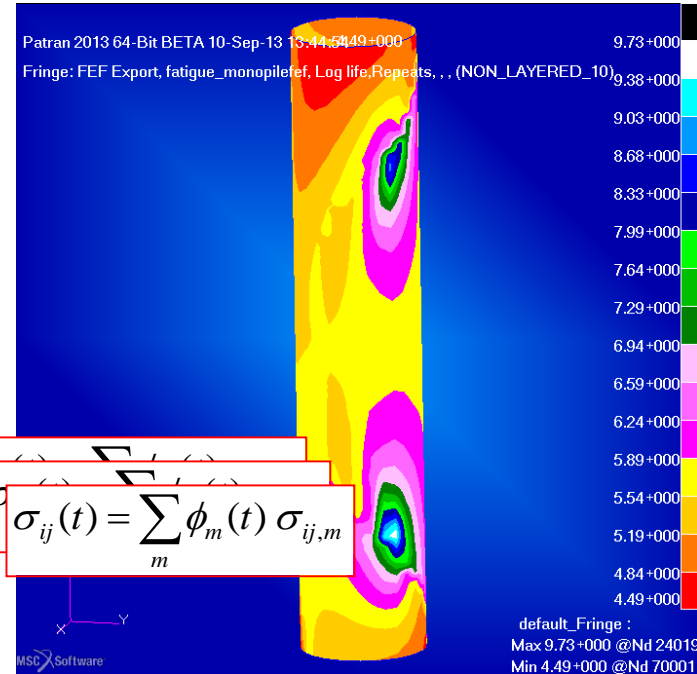
- Import flexible body from FEA
- Craig-Bampton modes exported to Adams
- Represents linear elastic flexible body
- Modal stress recovery



# AdWiMo Supports Fatigue Analysis

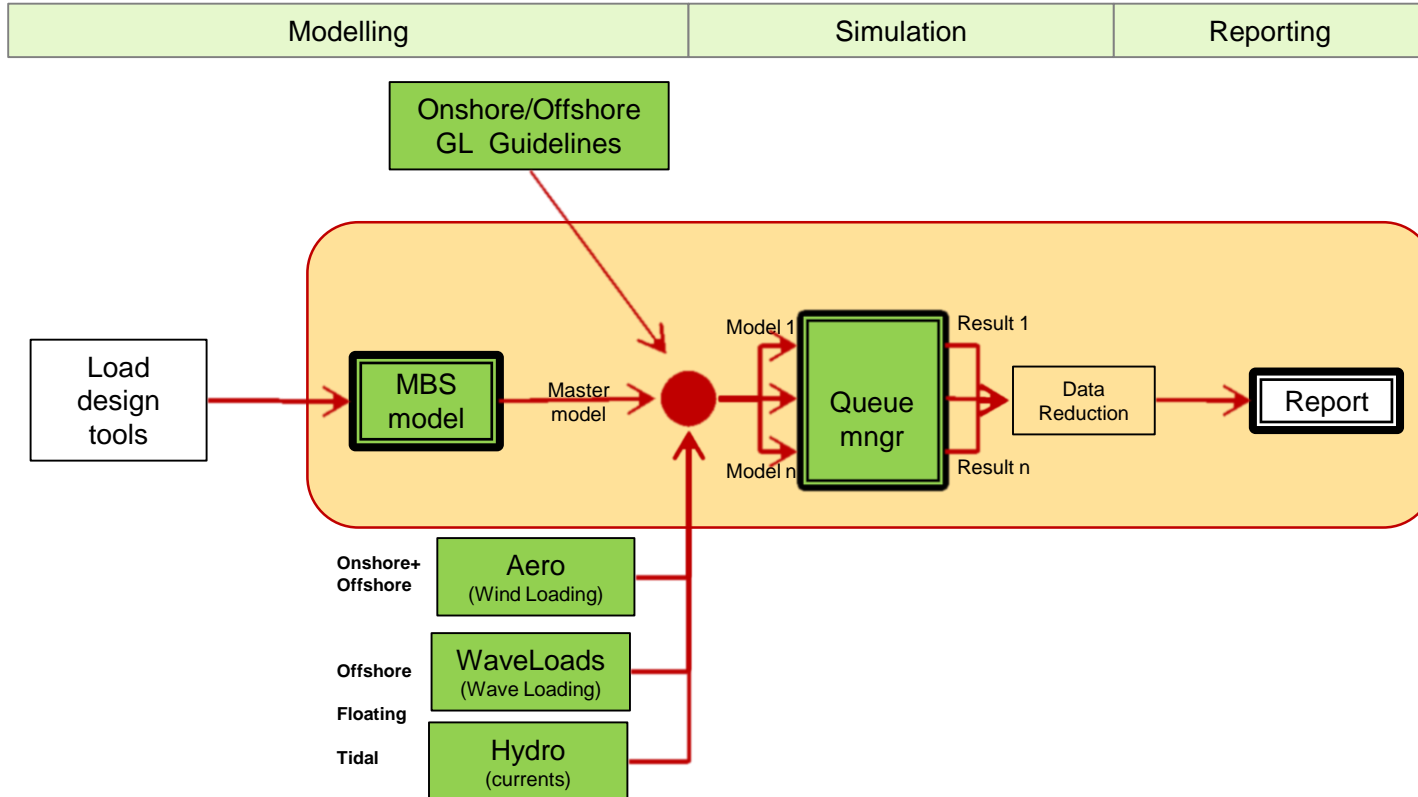


$$\sigma_{ij}(t) = \sum_m \phi_m(t) \sigma_{ij,m}$$

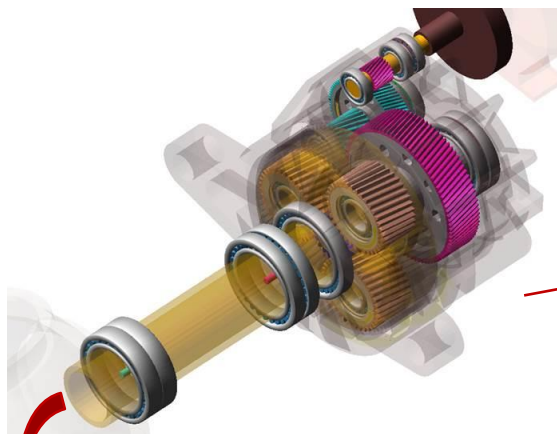


Stress Recovery and Duty Cycle Fatigue Analysis

# Automated Certification Engine Process

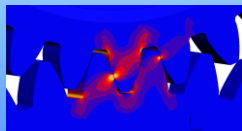


# Adams is a Core Part of a Larger Process



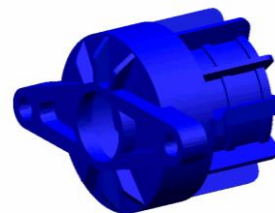
## Durability

Geometry / Mesh / Loads



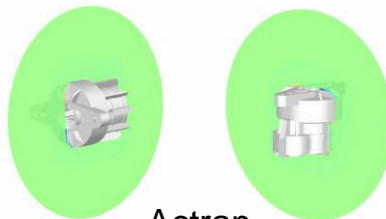
## Vibration

Geometry / Mesh / Loads



## Noise

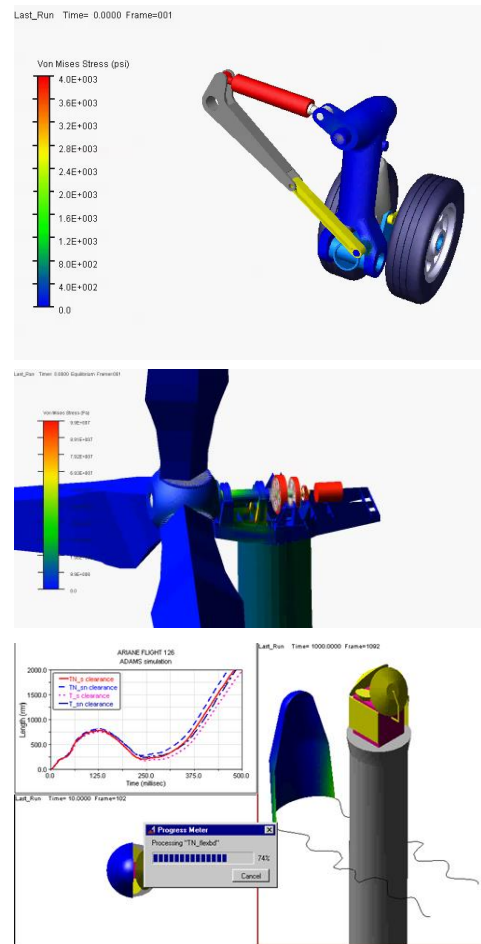
Radiate in Near and far field



Actran

# The Art of the Possible With Adams

- **Verify Motion Performance**
  - “Will it work?”
  - Example: will landing gear fully deploy/retract in these conditions?
- **Compute Detailed Loads in a Mechanism**
  - “Will it break?”
  - Example: what are the cyclic loads on a wind turbine driveshaft?
- **Examine Clearances in a Complex Mechanism**
  - “Will it fit?”
  - Example: will launch vehicle fairing deploy without hitting the payload?





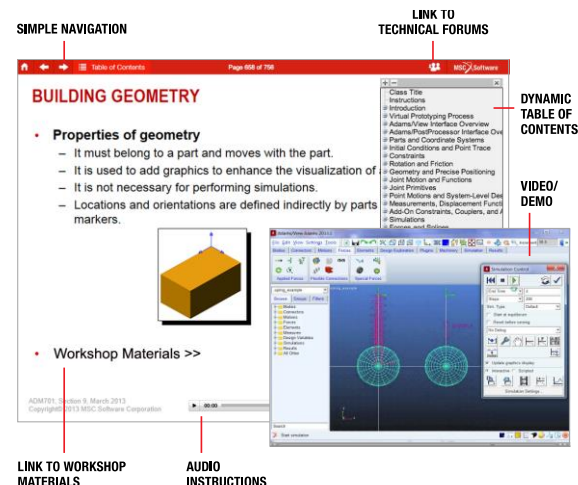
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- The Demos are the same ones an instructor would do in a live classroom setting
- Workshops that range from simple examples to real-world problems delivered with model files, step by step instructions and quizzes
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<http://www.mscsoftware.com/msc-learning-center>

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- Technical Support
  - Hotline:
  - SimCompanion: Technical Articles, Forums





Thank You

