OFFSHORE WIND TURBINE

04/17/2014

Team #12

Jason Davis

Stephen Davis

Kevin Foppe

Margaret Gidula

Mark Price

Matthew Robertson

Nicholas Smith

Sponsor: Dr. Jung

Advisors: Dr. Kumar

Dr. Frank

Instructors:

Dr. Amin

Dr. Shih

OUTLINE

- Abstract
- Problem Definition
- Design
- Prototyping and Testing
- Future Recommendations

OUTLINE

- Abstract
- Problem Definition
- Design
- Prototyping and Testing
- Future Recommendations

Jason Davis

ABSTRACT

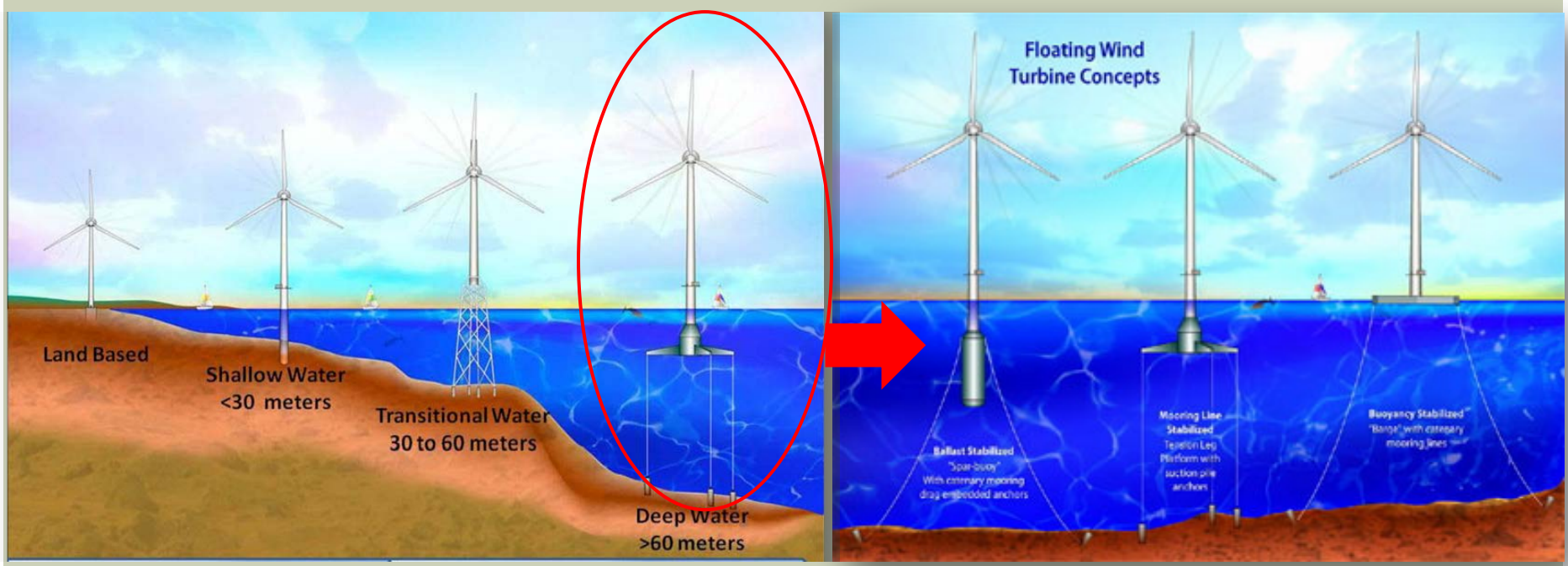
- Objectives
  - Reduce the cost
    - Autonomous navigation
    - Twin tower design
    - Catamaran base
    - Dry-dock construction
- Background
  - Potential energy production
  - Growing industry
  - Costs of offshore v. land-based

OUTLINE

- Abstract
- Problem Definition
- Design
- Prototyping and Testing
- Future Recommendations

PROBLEM DEFINITION

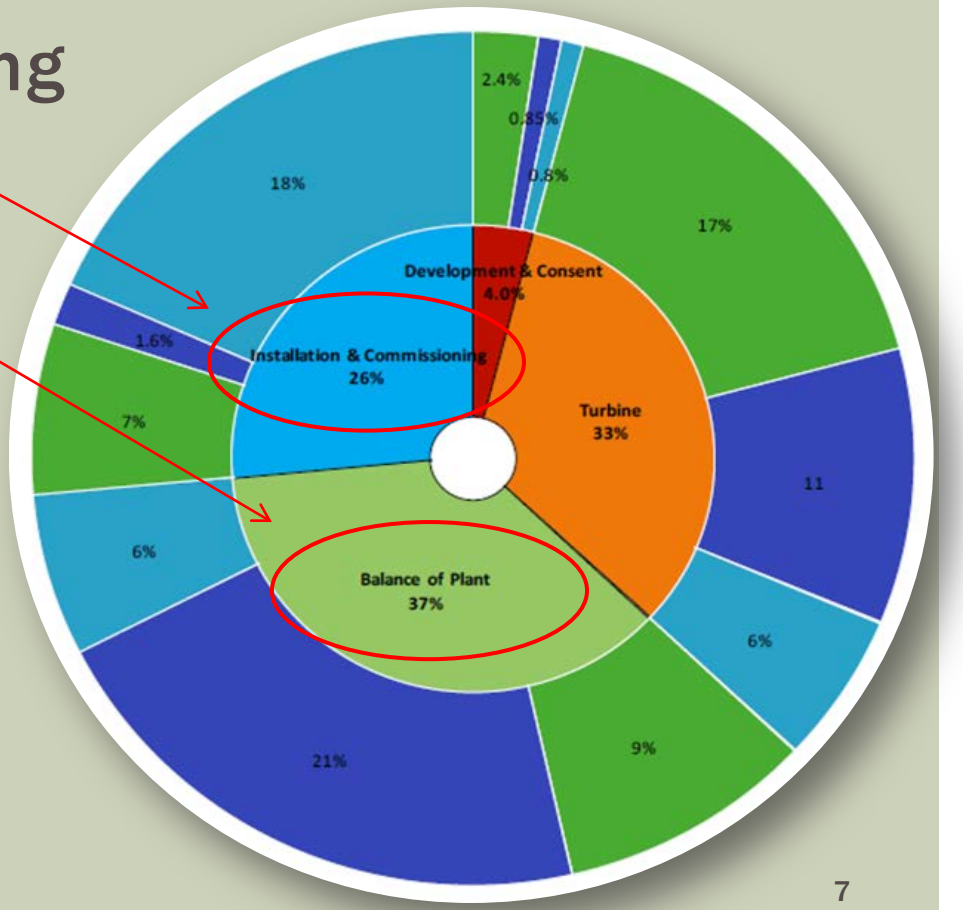
Matthew Robertson



- Existing Technologies are gradually moving due to better stronger winds offshore

NEEDS ASSESSMENT

- Determination of largest costs
  - Foundations/anchoring
  - Construction
- Design Innovations
  - Twin tower design
  - Autonomy
  - Swath base design



OUTLINE

- Abstract
- Problem Definition
- Design
- Prototyping and Testing
- Future Recommendations

Margaret Gidula

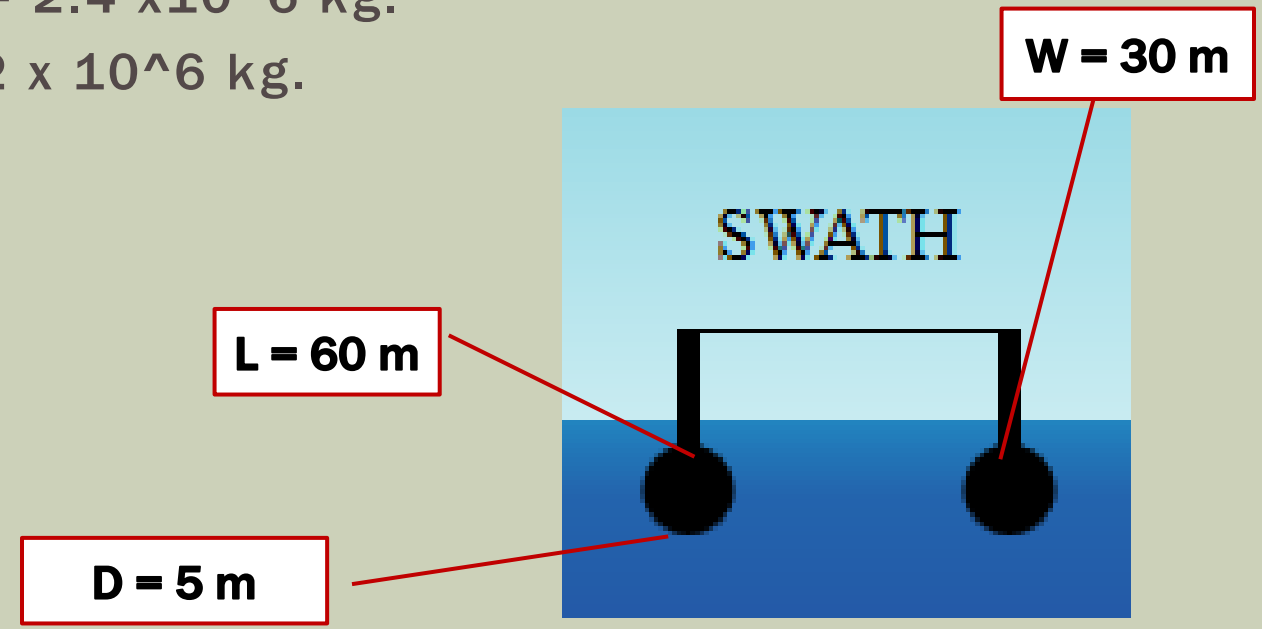
DESIGN CONCEPTS

- Structure
  - SWATH
  - Tower
  - Trusses
- Power Generation
  - Generators
  - Turbine Components
- Innovations
  - Autonomy
  - Two Turbines

Margaret Gidula

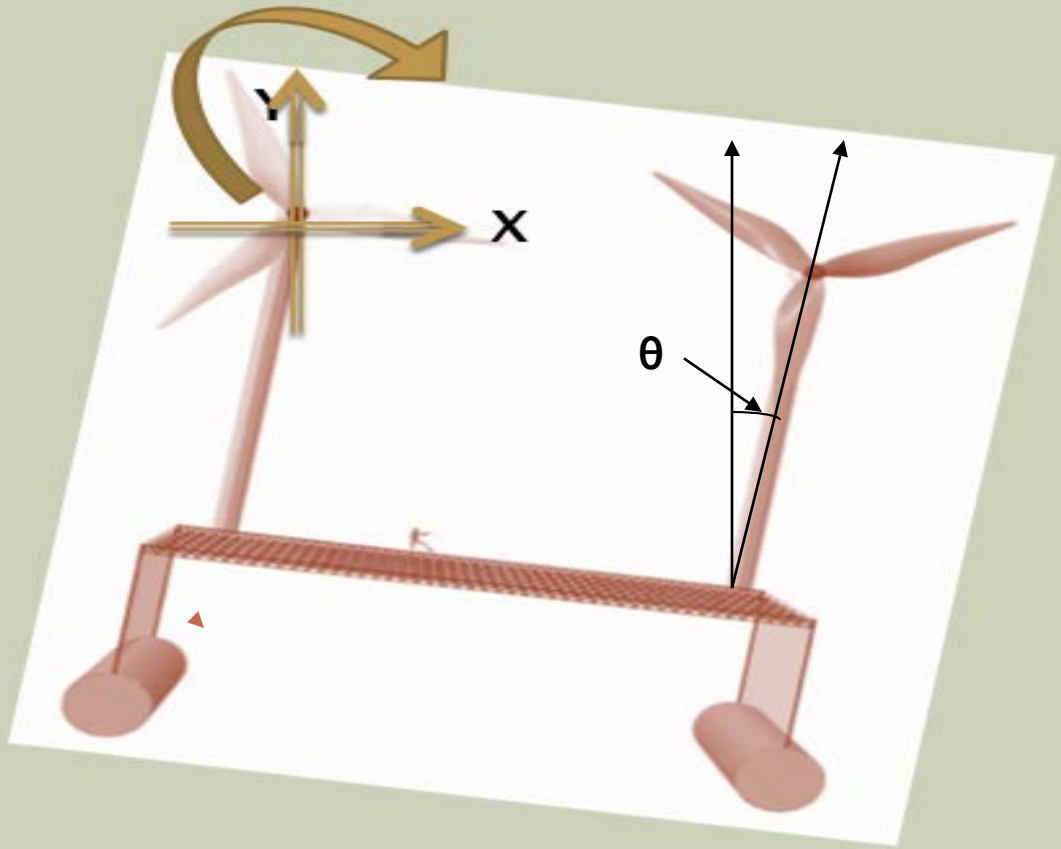
DESIGN CONCEPTS: STRUCTURE

- Small-Waterplane-Area Hull (SWATH)
- L:W ratio = 2:1
- Displacement Mass: Foundation Mass 2:1
- Buoyancy = (Mass of Displaced Fluid – Mass Structure)
- Displaced Fluid = 2.4 x10^6 kg.
- Foundation = 1.2 x 10^6 kg.
- Ballasted Hulls



DESIGN CONCEPTS

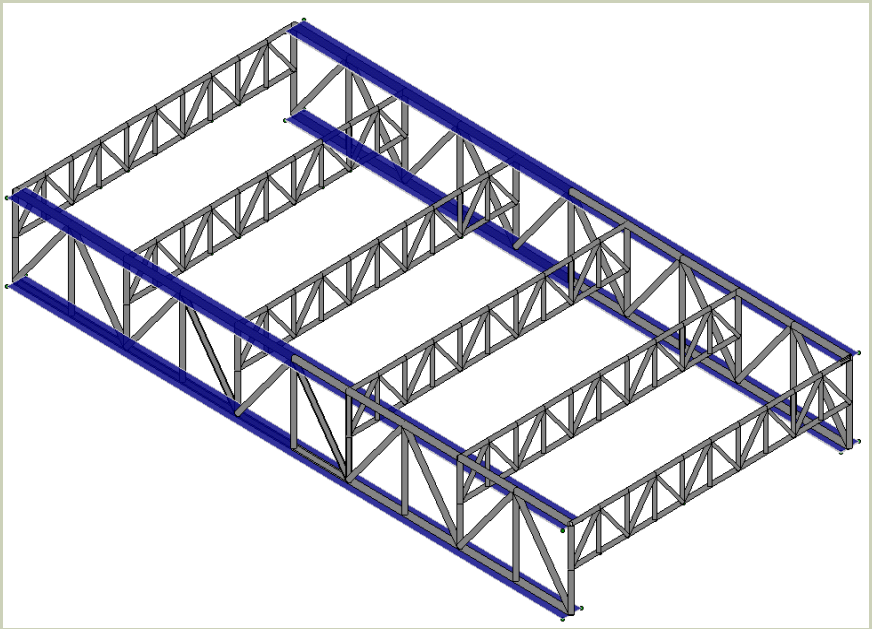
- Pool Testing
  - Deflection Measurement
- Floating allows for more flexibility
- Ballast System considered but not necessary for scale down model



DESIGN CONCEPTS: TOWER AND TRUSS

Lattice

Tubular Column



Frame Structure

Margaret Gidula

DESIGN CONCEPTS: PONTOON RELIABILITY

- Pontoon failure would be catastrophic
- Safety factor of 1.2; therefore 20% extra buoyancy
- Ballast pumps able to evacuate water

Nick Smith

DESIGN SELECTION: GENERATOR

- Power Output – 100 Kw
- Start up speed – 3 m/s
- Max wind speed – 25 m/s
- Rated rotational speed – 50 rpm
- Optimal wind speed – 12 m/s
- Survival speed – 40 m/s
- Weight – 2400 Kg

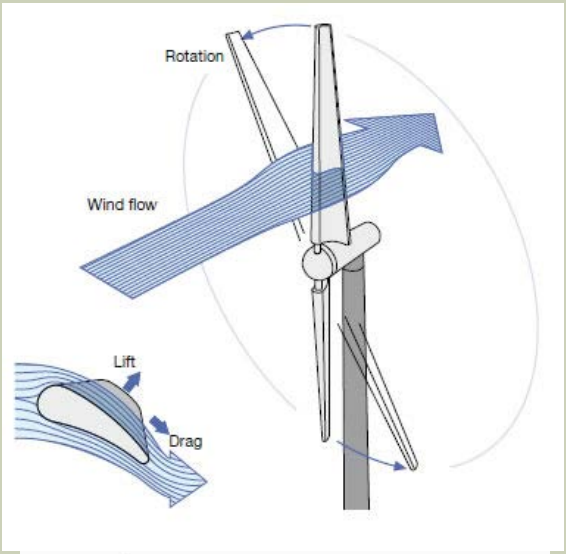
Rotor Size and Maximum Power Output	
Rotor Diameter (meters)	Power Output (kW)
10	25
17	100
27	225
33	300
40	500
44	600
48	750
54	1000
64	1500
72	2000
80	2500
Sources: Danish Wind Industry Association, American Wind Energy Association	

Nick Smith

DESIGN CONCEPTS: TURBINE BLADE DETAILS

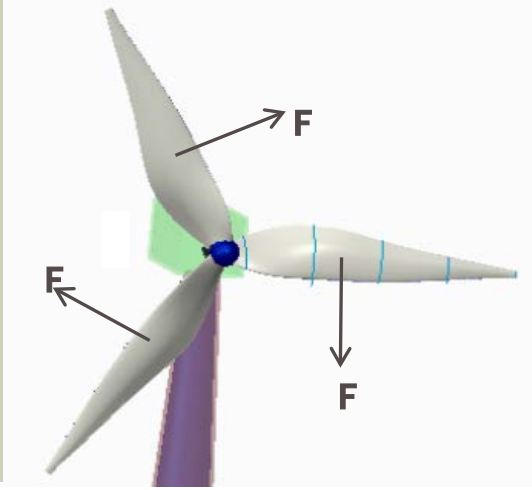
Three-Blade Configuration

Property	Value
Max rotational speed	19 rpm
Blade composition	Epoxy glass fiber + carbon fiber
Length per blade	9 m
Mass per blade	1,200 kg



Blade Forces

Force	Design
214 N	Per one blade
642 N	Per three blades



Stephen Davis

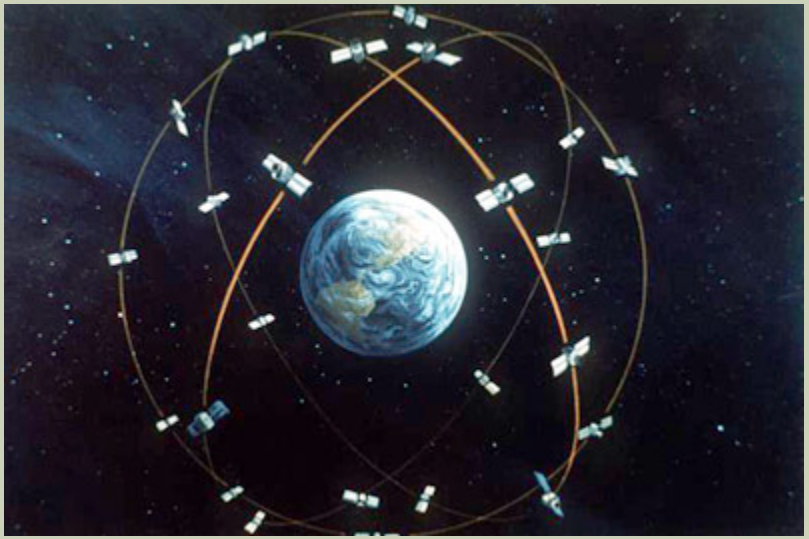
AUTONOMY PACKAGE

- Four main stages: Full Scale
  - GPS
  - Power Stage
  - Controller
  - Filter Stage
- Prototype
- Timing Delays
  - Simulate actually Turbine maneuvers

Stephen Davis

GPS

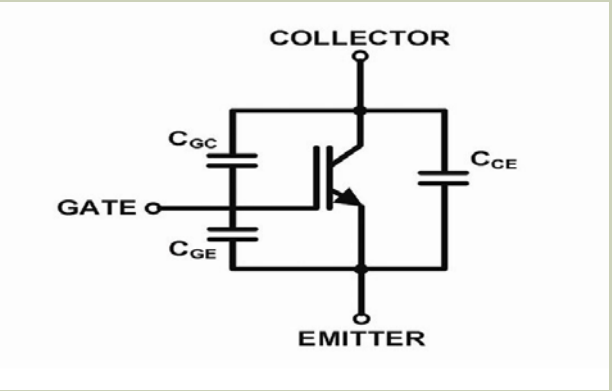
- Communication hub on land will send signal to the wind turbine giving it route to take
- Hardware onboard will interpret the signal and give the controller instructions



Stephen Davis

POWER STAGE

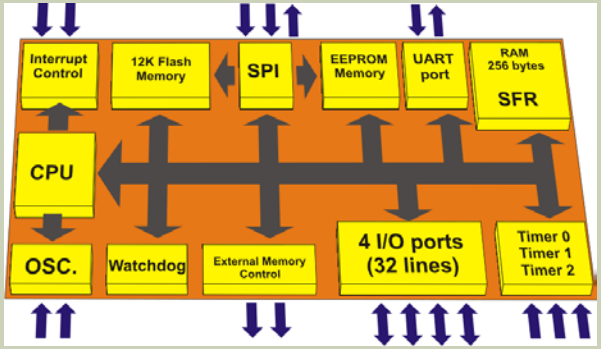
- Semiconductor switch arrays
- 6 different switches grouped into 3 pairs.
- Each bridge will be connected to a phase of the 3-phase AC motor.
- During operation the connection to the motor is closed using relays



Stephen Davis

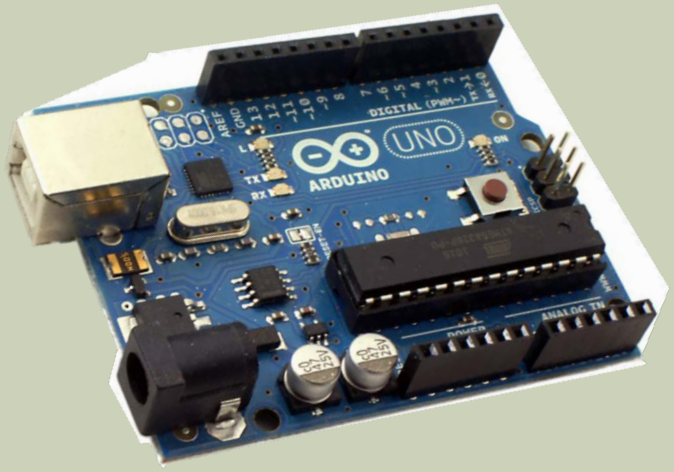
CONTROLLER

- Controller turns the IGBT switches on and off.
  - can turn the on and off up to 32,000/sec
- Main components of controller: Digital Signal Processor(DSP) and Safety processor(SP)
- DSP- Controls torque and charge behavior
- SP- monitors acceleration and the motor currents consistency.



DESIGN CONCEPTS: AUTONOMY

- Biggest contributor to industry
- Using Arduino to control motors
- Using timing delays to simulate real world application of GPS



OUTLINE

- Abstract
- Problem Definition
- Design
- Prototyping and Testing
- Future Recommendations

PROTOTYPE DESIGN CRITERIA

- Autonomy-Static Location
  - Arduino Technology
- Serviceability and Rotation Limit
  - Maximum Displacement of 5°
    - Ballast System
- Efficiency of Electricity Generated
  - Comparison Onshore vs. Offshore

Kevin Foppe

PROTOTYPE

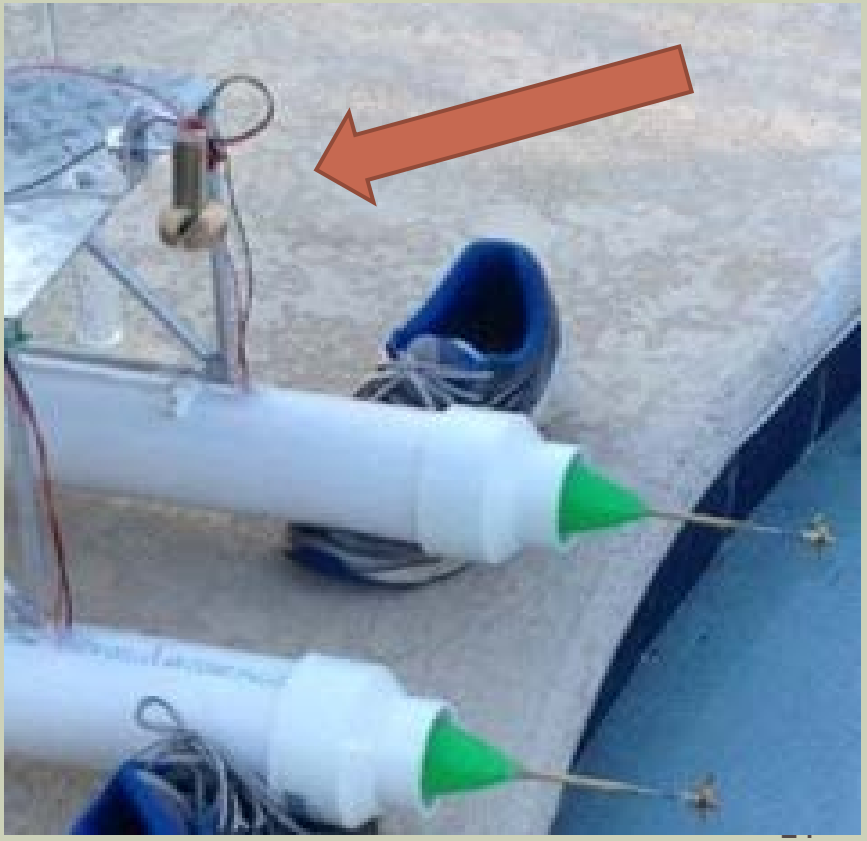
Parameter	Dimension (inches)
Height of Tower	8 in.
Width of Deck	18 in.
Length of Deck	24 in.
Truss Height	8 in.
Pontoon Diameter	3 in.
Length of Propellers	3 in.
Diameter of Motor Cones	2 in.

Kevin Foppe

MODELING

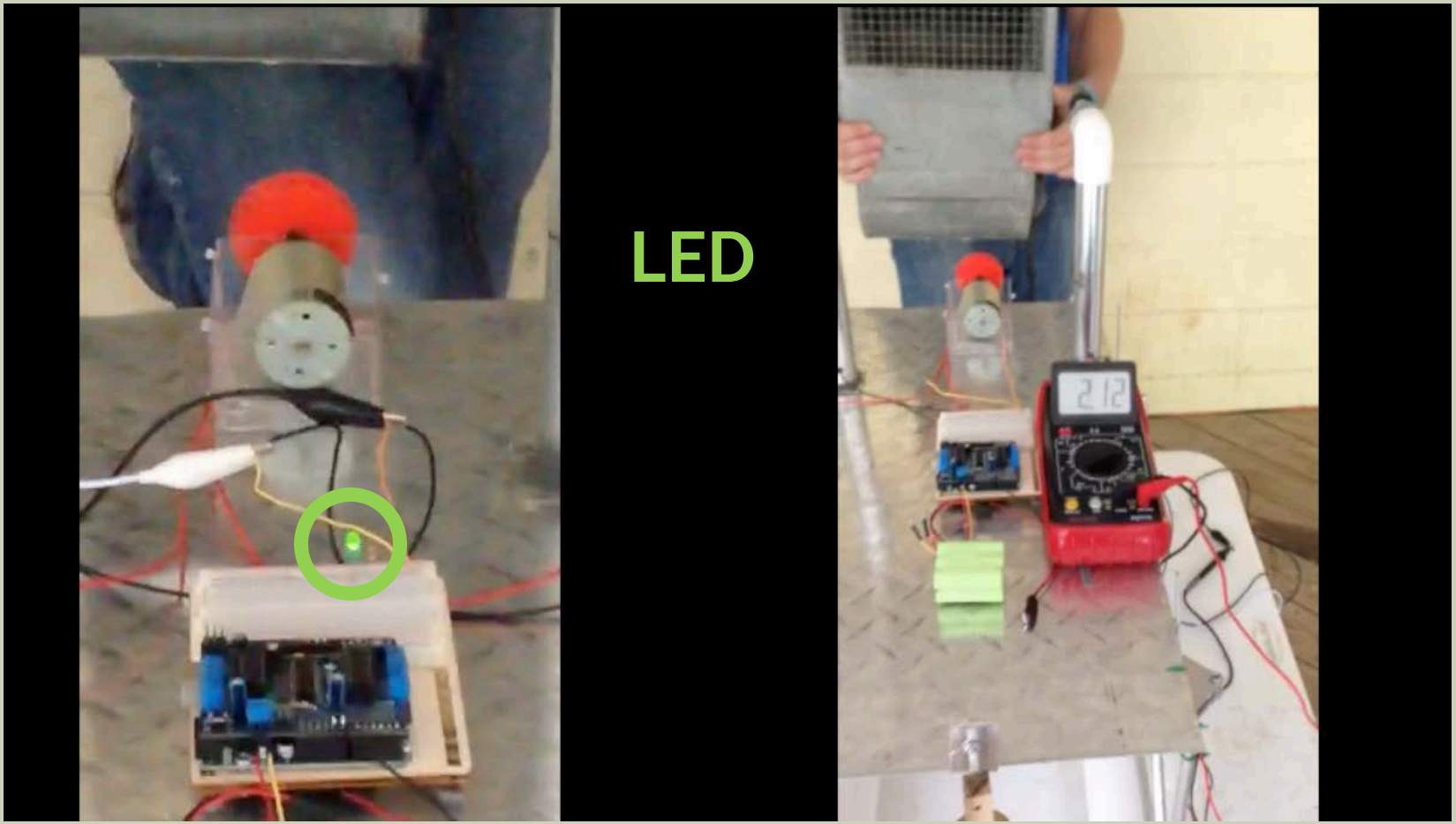
Ballasts

Pitch Sensor



Kevin Foppe

TESTING



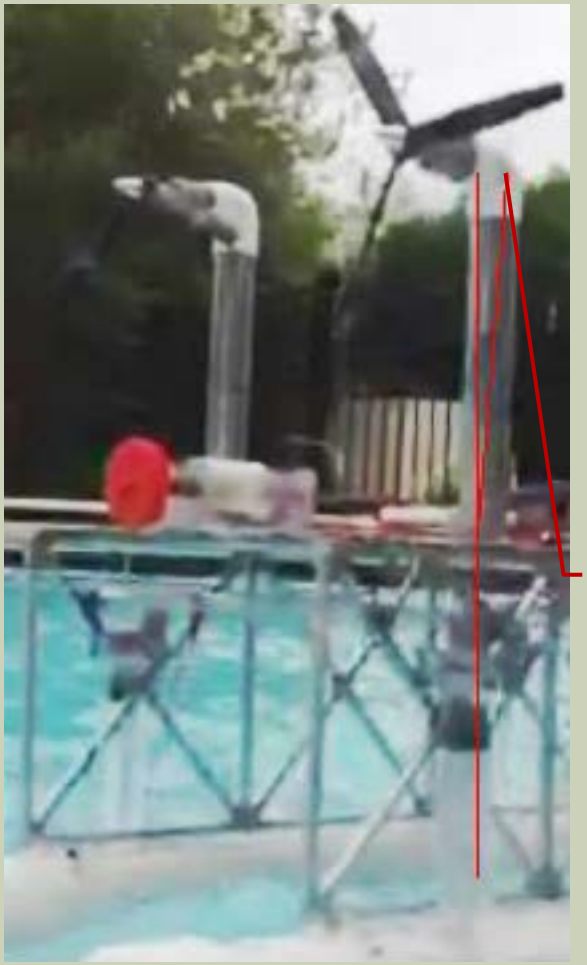
Mark Price

TESTING

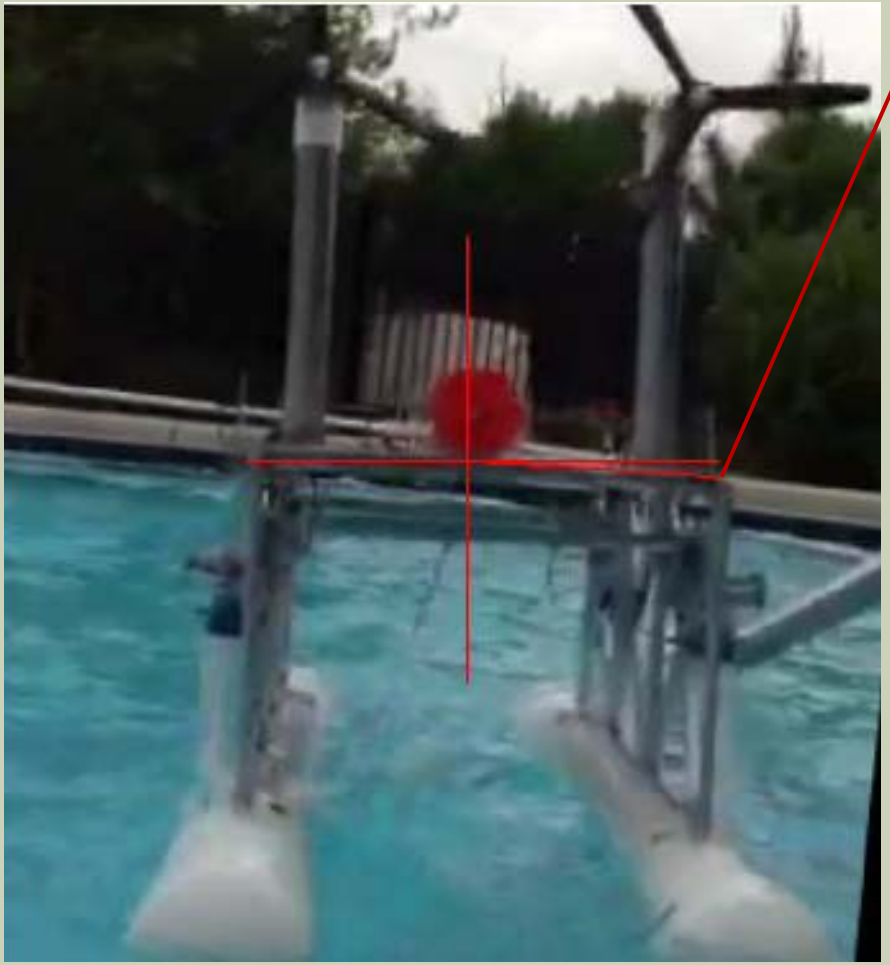
- Deflection Testing
  - About X axis
    - Waves
  - About Y axis
    - Wind
    - Waves

2” waves on prototype

= 17’ waves on full scale



TESTING



- Results:
  - Angle of Rotation = 4°
  - Serviceability Limit = 3-5°

CONCLUSION

- Design Functional Offshore Wind Turbine
  - Innovate Existing Industry
  - Autonomy
- Construct Prototype
  - Demonstration of Power Generation
  - Testing

OUTLINE

- Abstract
- Problem Definition
- Design
- Prototyping and Testing
- Future Recommendations

Jason Davis

FUTURE RECOMMENDATIONS

- Specific Concerns for the Prototype
  - Stability
  - GPS v. Timing Delays
  - Anchoring
  - Adjust proportions

THANK YOU

- QUESTIONS?