Projects Utilizing Nortek Systems at Florida Atlantic University's Southeast National Marine Renewable Energy Center (SNMREC)

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SNMREC Background

- Technology Development Center and Offshore Test Birth
- Current Efforts
  - Onshore Dynamometer Testing Facility
  - Gulf Stream Resource Assessment
    - CTD & ADCP data collection
  - 20 kW Ocean Current Turbine Prototype
    - Suspended horizontal axis hydrokinetic turbine
    - 3 meter rotor diameter

Two-Project Intro

Turbulence and High Frequency Velocity Variation Site Assessment

- Discussion of the use of Nortek ADV for the measurement of high frequency current variation in the Florida Current

Ocean Current Turbine Hydrodynamic Performance Assessment

- Use of the Nortek Aquadopp profiler to measure the free-stream water velocity upstream of ocean current turbines as part of an integrated performance assessment package

Photos Courtesy of Nortek USA

Site Assessment

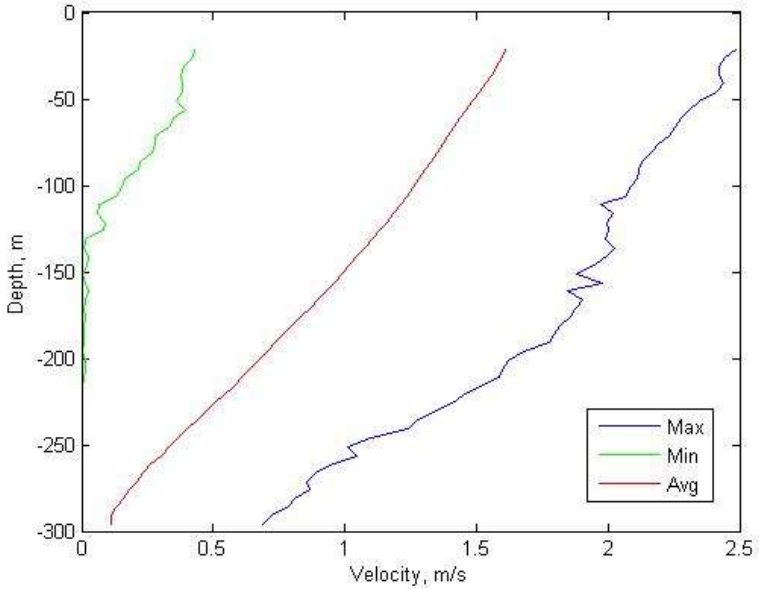
- Measurement of ocean turbulence and velocity fluctuations for ocean current turbine analysis
  - Location will be near the core of the Florida Current off of South East Florida
- The data will be used for numerical modeling of turbine performance as well as acoustic and structural analysis
  - The first step in creating an inflow model for Ocean Current Turbines

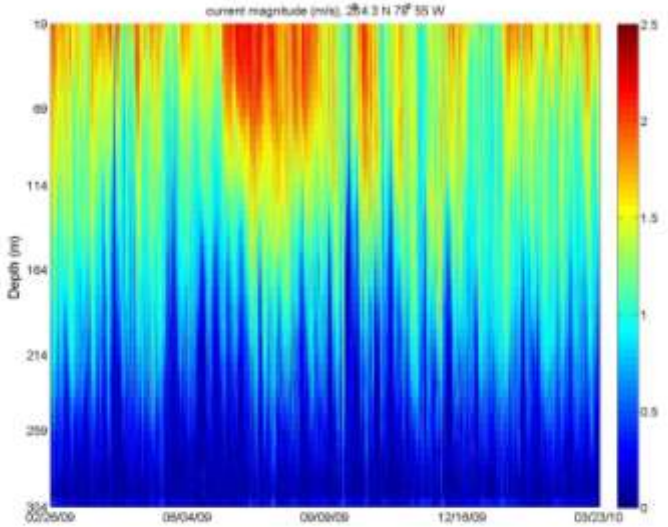
Sensors

- High frequency water velocity variations and turbulence will be measured using an ADV
  - 6 MHz Nortek Vector
  - 64 Hz sampling rate
- Lower frequency variations measured by use of a vessel mounted ADCP
- Overlap between both systems will be used to validate each other

Challenges

- Water depth is over 320 meters while area of interest is in the range of 50 to 100 meters below the surface
  - We plan to use a vessel deployable system
- ADV motion must be recorded to remove the effects of sensor motion and determine the orientation of transmission beam
  - Integration of an IMU into the ADV
    - MiniSense-2 MEMs Motion Sensor
      - 6 DOF + Magnetic heading





Testing

- A test comparing bottom mounted ADV to the tow fish mounted ADV will be done to insure that velocity data can be corrected
  - Will take place in shallow water
- ADV will be mounted so transmitter is parallel to the free-stream to reduce measurement uncertainty

Deployment Method

- Utilize a small tow fish deployed from a research vessel
  - The tow fish will allow for depth tracking via a pressure sensor on the tow fish
  - ADV and IMU data will be recorded internally
- The ADV will be held at a constant depth to insure that measurements are made within the same ADCP depth bin for comparison
  - An experimental station keeping system will be used to hold the vessel on location during testing

Data Processing

- Data will be stored in instrument fixed coordinates
- Post processing will be done to remove noise and sensor motions from the velocity data
  - IMU data will be used to correct velocity and transform instrument fixed to ENU (East, North, Up) coordinates
- Post processing will be done with MATLAB

Turbine Design Issues

- Lack of field-collected hydrodynamic performance data
- Unvalidated modeling and simulation methods
- Unknown deployment risks
- Certification criteria in developmental stages

Possible Solution

- Develop a hydrodynamic performance assessment package
  - Instrumentation
  - Data Analysis tools
- Develop correlations between varying test parameters and the hydrodynamic performance of the system

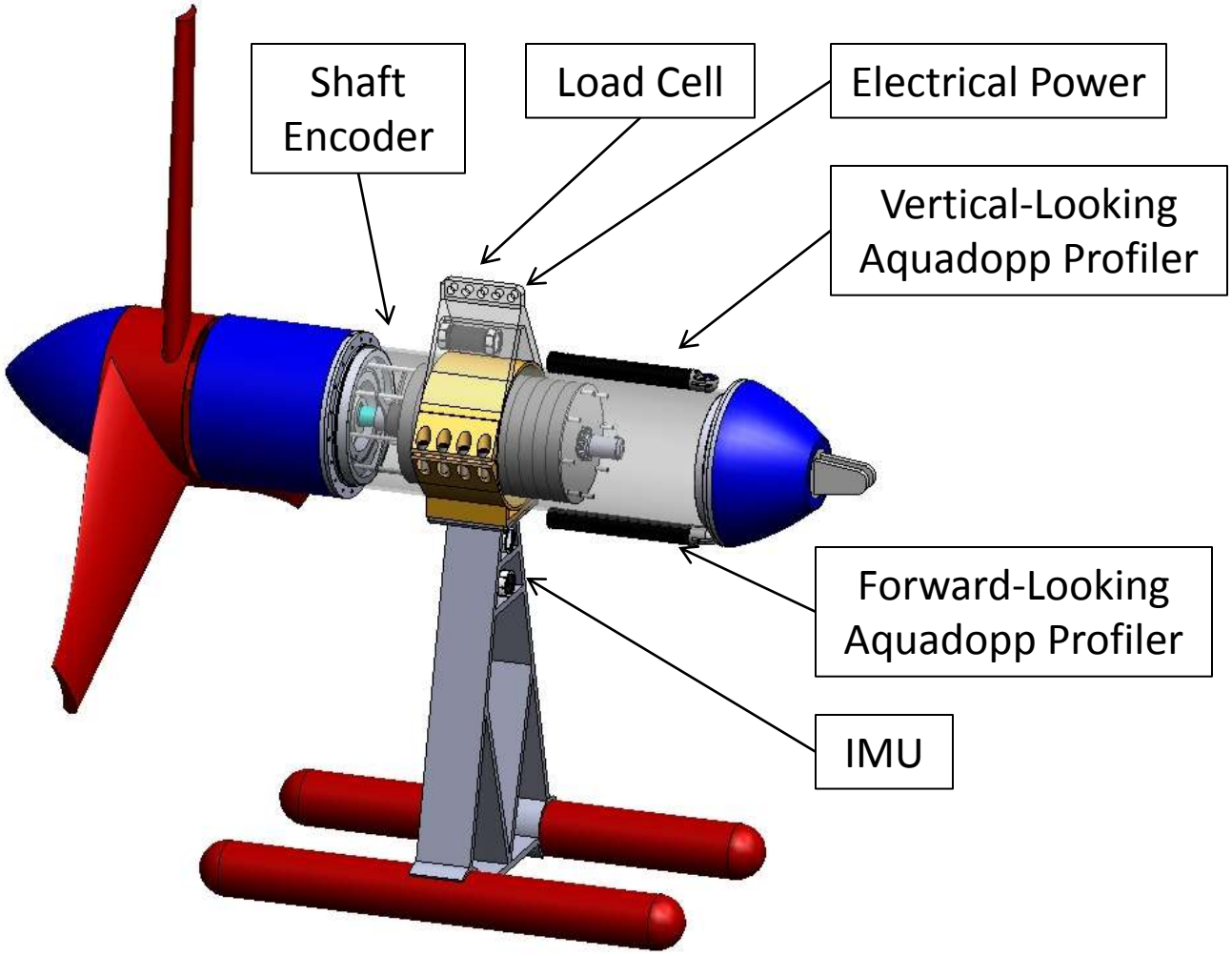
Measurements

- Six degree-of-freedom motion
  - XSENS mTi IMU
- Motion-compensated transverse and longitudinal current profiles
  - Two Nortek Aquadopp Current Profilers (2 MHz)
- Hydrodynamic drag
  - Load Cell
- Rotor RPM
  - Incremental Shaft Mounted Encoder
- Electric Power Output
  - Top-side monitoring system

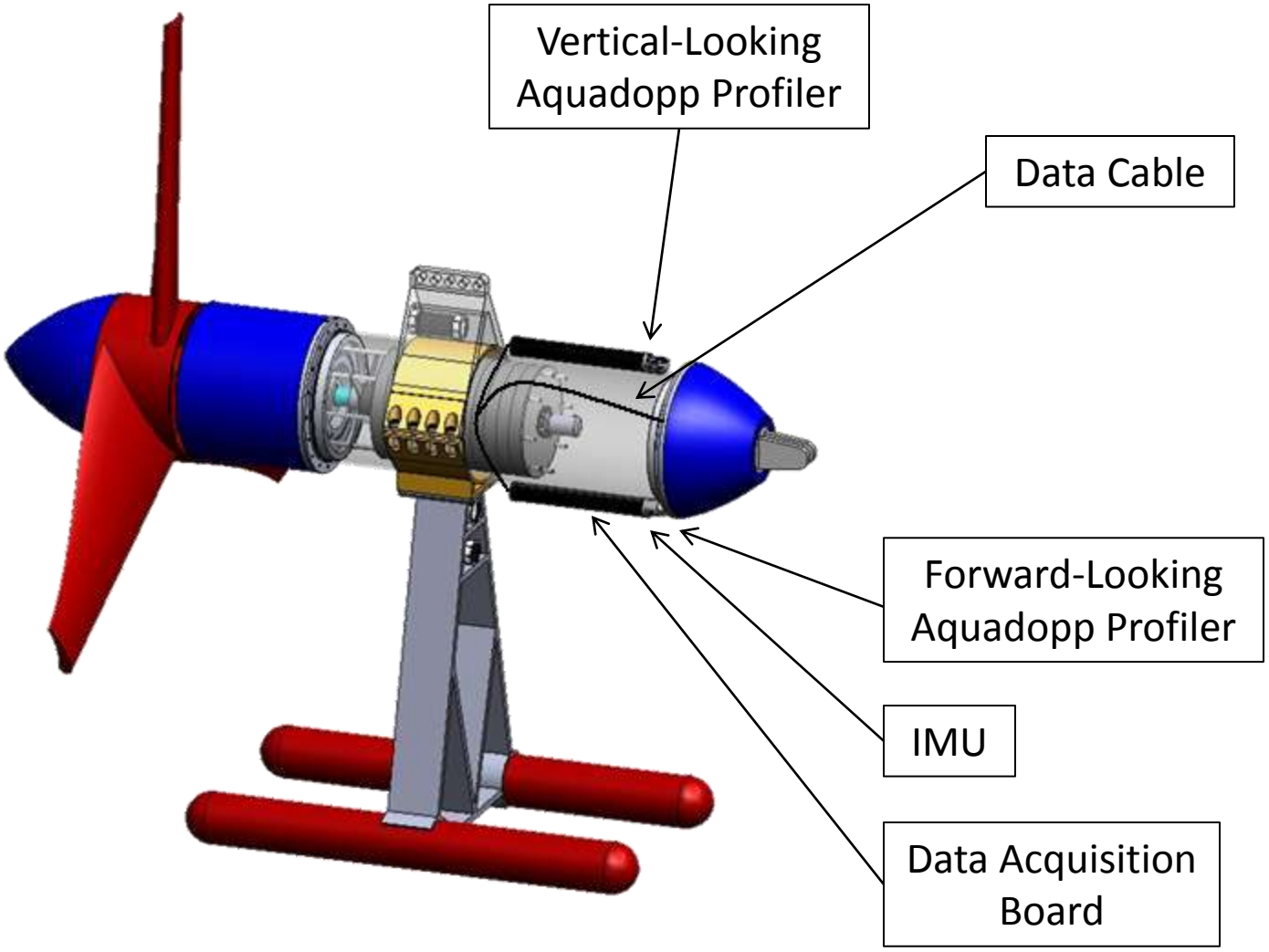
Development

- Part I
  - Integrate an IMU and two Aquadopps into the current SNMREC prototype's Condition, Health, and Monitoring system
- Part II
  - Develop a stand-alone hydrodynamic performance assessment instrumentation package for future prototype systems that may not have a Condition, Health, and Monitoring system.

SNMREC Layout



Stand-Alone Layout



Data Collection

- Simultaneously sample data from each sensor
- Apply a universal time stamp to each data stream
- Write the data to a removable data storage device for post processing

Data Collection

- Resulting Data files
  - Turbine Motion
  - Transverse and longitudinal velocity Profiles
  - Rotor RPM
  - Electric Power
  - Hydrodynamic Drag

Correlation Studies

- Correlation Studies
  - Current speed vs. turbine motion
  - Current speed vs. drag
  - Current speed vs. rotor RPM
  - Current speed vs. electrical output
  - Turbine motion vs. RPM
  - Turbine motion vs. electrical output

Final Product

- A log of raw, field-collected performance data
- Measured correlations between ocean current characteristics and system performance
- Software tools to aid in the analysis of future systems

Questions

- Ocean Turbulence Measurements
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- Turbine Hydrodynamic Assessment
  - Matt Young
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