industrial systems and control

Supervisory Control Software and Data Acquisition on Mocean's BlueX Wave Energy Converter

Background to ISC

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- Control engineering consultancy based in Glasgow
  - Founded 1987 - as a spin-out from Strathclyde University
- Works across many sectors:
  - Renewables, Oil/Gas; Power Generation; Automotive; Marine
- Small – 5 full time, 4 part time employees
- However, we work with some very large companies:
  - BP; Shell; General Motors; Toyota; Boeing; BAE Systems; Rolls Royce Marine; SSE; Scottish Power; Alstom; EDF

Mocean Energy BlueX WEC

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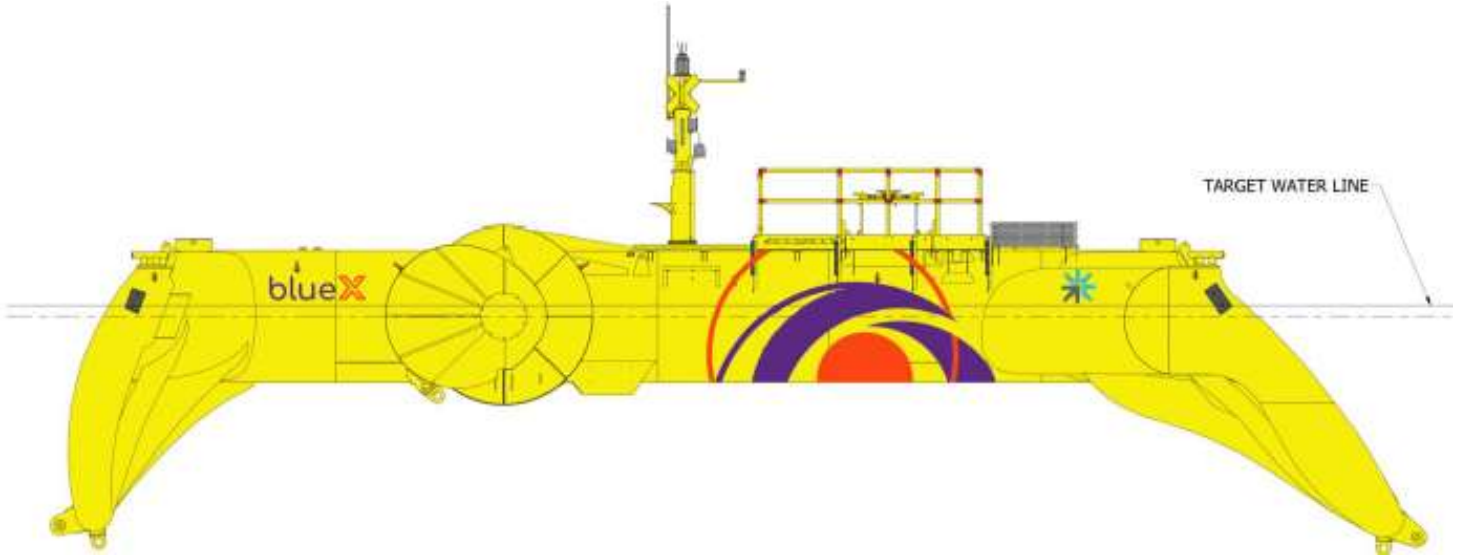

- Hinged raft; single hinge connecting forward and aft section
- Hinge rotational kinetic energy transformed into electricity via the power take off (PTO) system
- Hinge encloses rotary permanent magnet generator (PTO)
- Power systems and energy storage enclosed in the forward hull section
- Communications tower connects to remote SCADA host on-shore

Control Subsystems Topology

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Remote Station UI

4G

Data Server

Network Switch

Power Subsystems Controller

Rectifier, Energy Storage

cRIO-9048

Forward Hull Instrumentation

AI, DI, DO

NI-9148

Nacelle Instrumentation

AI, DI, DO, Serial (BISS)

WEC Instrumentation

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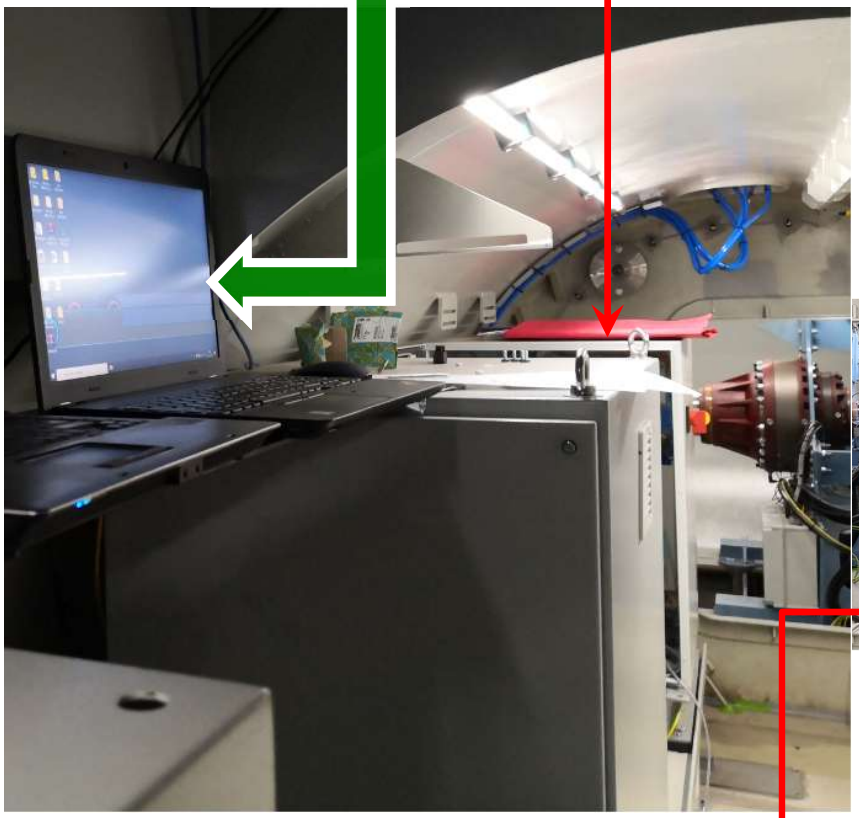
Development PC



4-20mA and ±10V signals for motion, temperature, generator and power systems currents and voltages, hinge torque, oxygen/hydrogen, vibration, mooring tension, generator and hinge velocity BiSS encoders, overvoltage relays, smoke detectors, earth leakage, bilge pumps control signals, …

Control Functionality

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1. WEC state transition mechanism
2. Power generation / export, manual / auto mode
3. Subsystems configuration (generator segment, rectifier damping etc.)
4. Subsystems brainbox coils status monitoring
5. Rectifier and Inverter CAN messages, alarms and warnings
6. Weather and battery status monitoring
7. Sensor data acquisition and conditioning
8. Data logging and transfer to data server
9. Safety system and fault handling
10. Remote user interface

High-Level Controller Architecture

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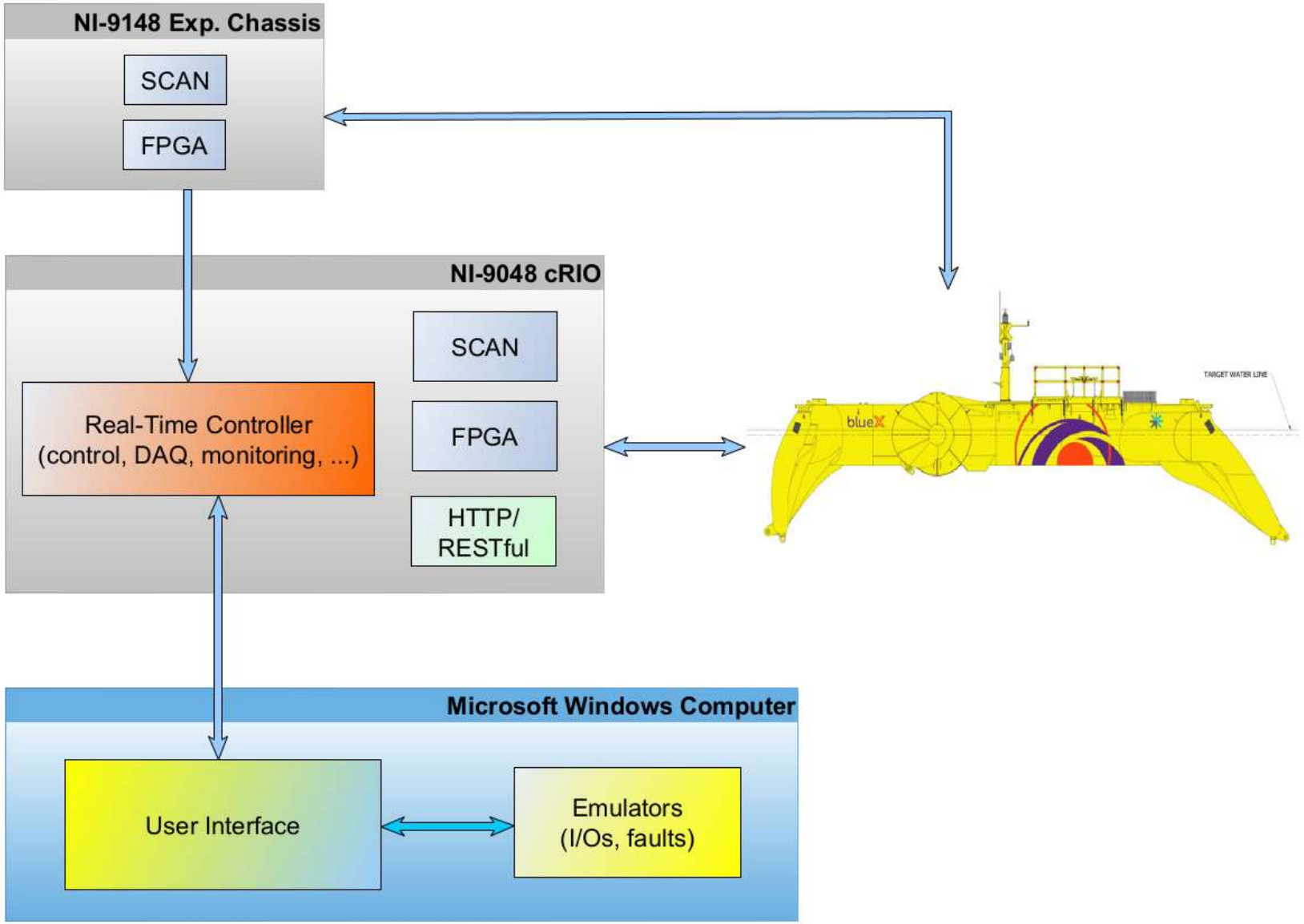

WEC Operating Modes

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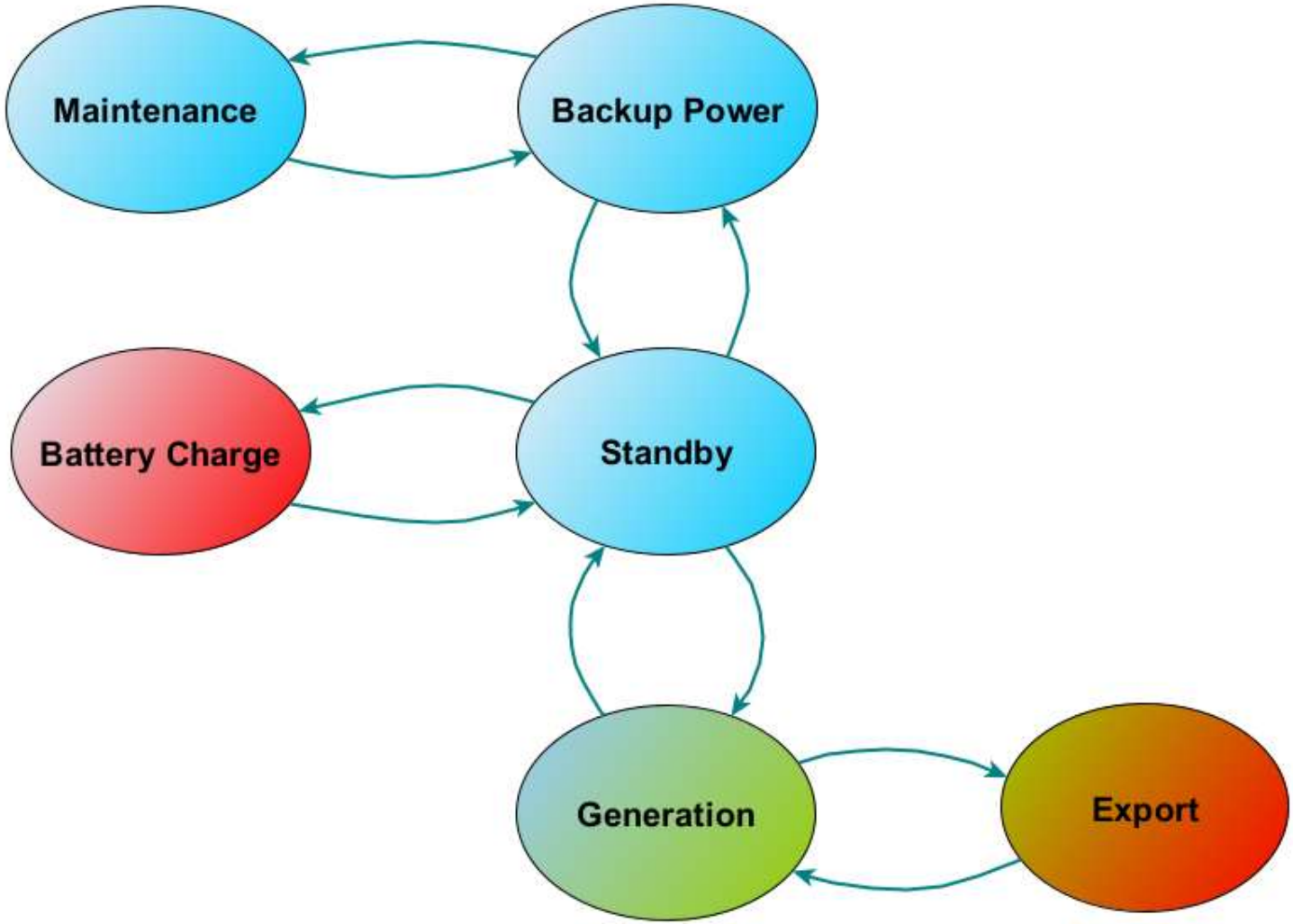

Fault and Survival Conditions

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- Fault Condition:
  - Either indicated by measurements or from the Rectifier/Inverter status
  - HLC transmits to Standby state transition and generates warning messages
  - HLC system reset can be performed once the fault is resolved
- Survival Condition
  - Dedicated to the condition of generator overvoltage
  - HLC transitions to Survival mode to isolate the generator coils
  - Finally, it transitions to Standby mode and inform operator

Remote User Interface (over 4G)

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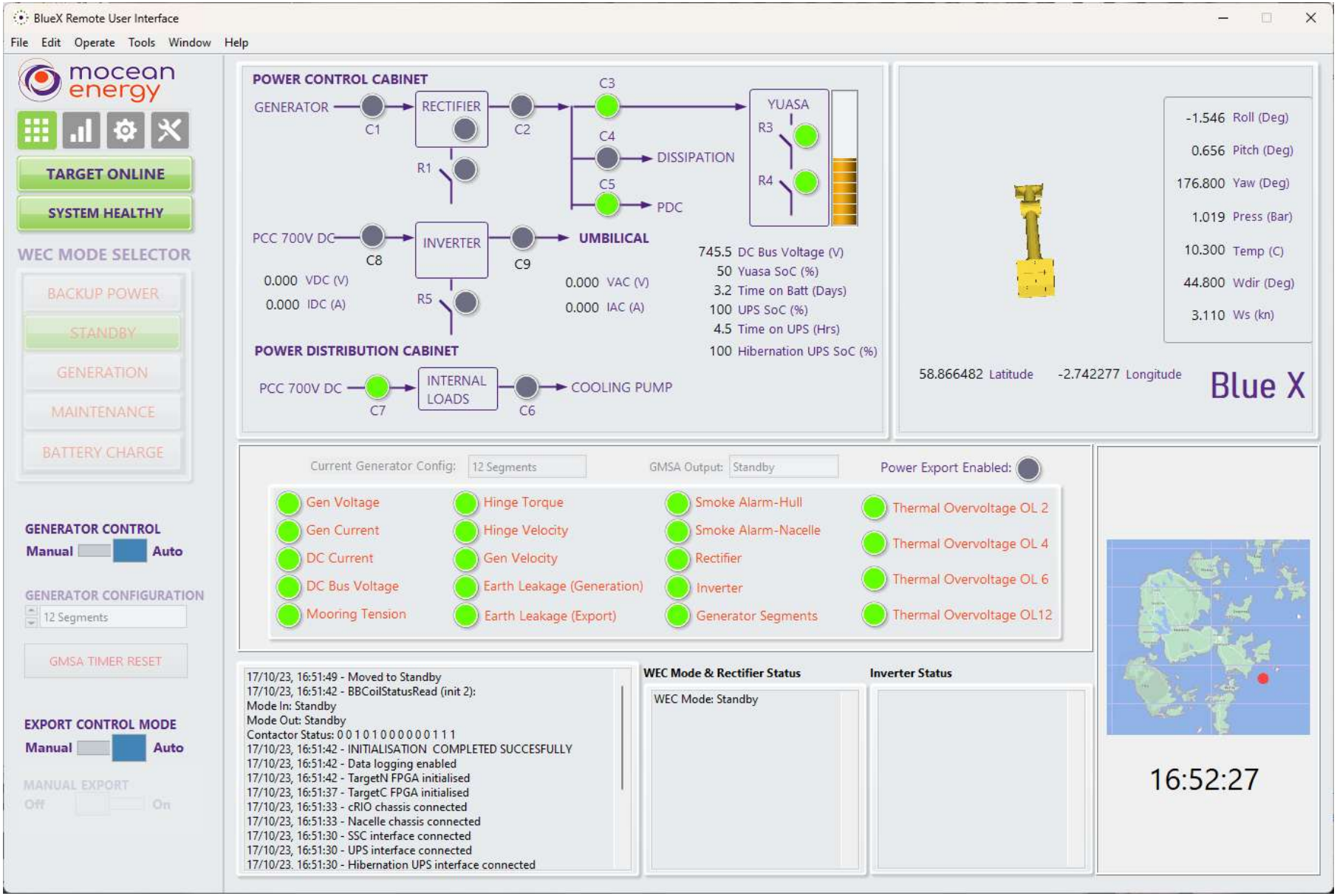

BlueX in Action

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- Operational at sea continually and unmanned for 13 months.
- Generated extensive performance data that can be applied for Mocean's other commercially available devices (Blue Star and Blue Horizon).

https://www.youtube.com/watch?v=fbhyaiGvOLM

Challenging Aspects

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- EMI interference corrupting measurements
- Data lag, alignment and time synchronisation
- Coordination of multiple different loosely coupled systems
- Integration of multiple instrumentation and communications protocols
- Incremental requirements and development over several phases
  - Initial design, fabrication, standalone deployment (comms added)
  - Later, operation with different generator segments
  - Later still, combine wave power with subsea energy storage to power subsea equipment - RSP demonstrator https://www.mocean.energy/renewables-for-subsea-power-project-completes-milestone/

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ISC Services - Improving Performance Through Understanding and Application of Control Technologies

- Consultancy
- Software engineering
- Training courses

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