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November, 2019

MOTUS Stand- alone

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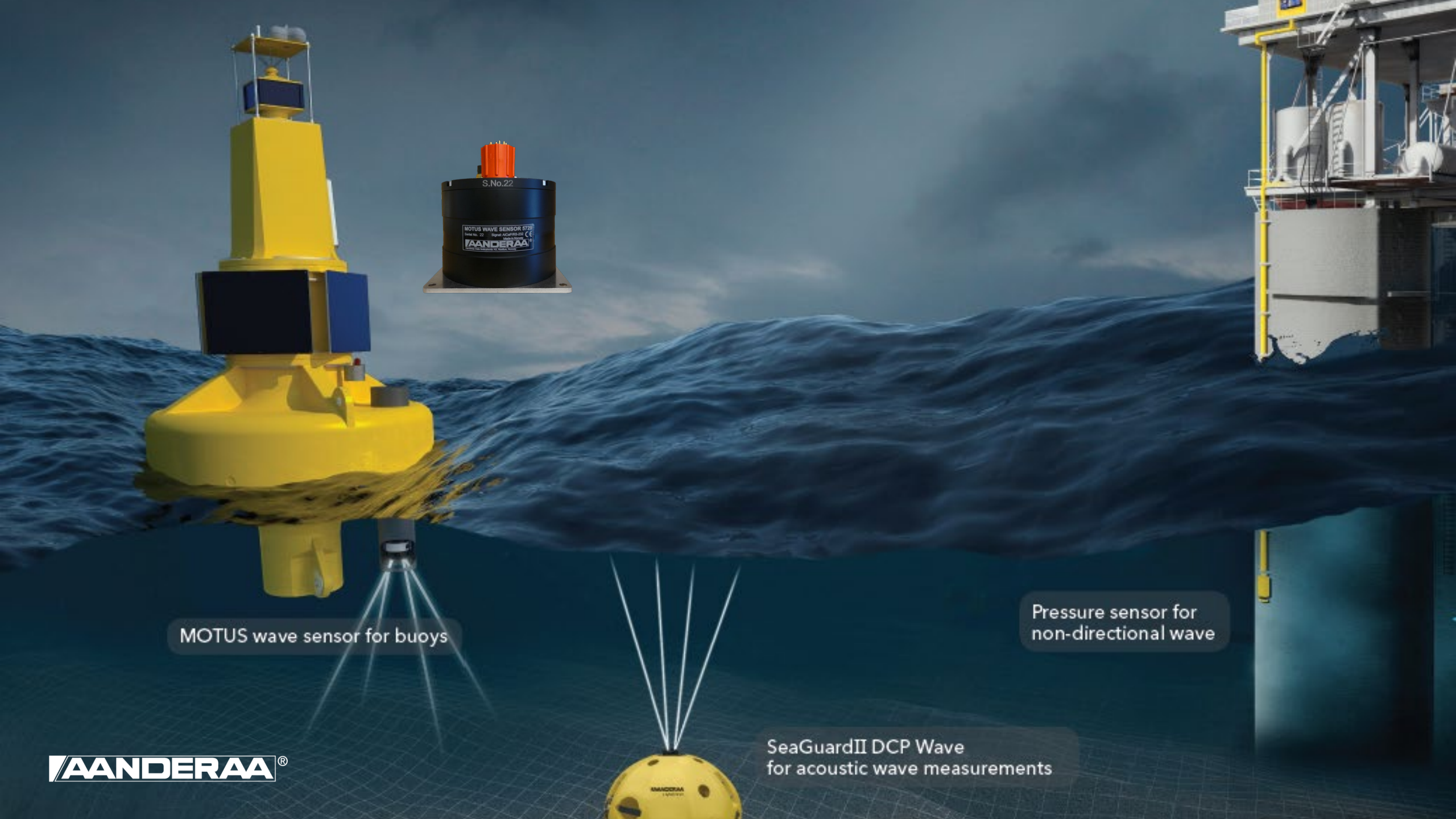
Introduction


S.No.22
MOTUS WAVE SENSOR 5729
AANDERAA
MOTUS wave sensor for buoys
Pressure sensor for
non-directional wave
SeaGuardII DCP Wave
for acoustic wave measurements
AANDERAA®

Introduction

Key Applications:

- Ports and Harbors
- Coastal monitoring
- Windfarms, demarcation buoys
- Research

The Aanderaa MOTUS Wave Sensor is available for stand-alone sale for use on third party buoys.

Experience high accuracy on your wave measurment using your own buoys

MOTUS Wave Sensor

- **Compact**
  - Autonomous, all wave parameters calculated internally
  - Size 130 x 130 x 110 mm
  - Weight: 1.23 kg
- **Low power consumption, wide supply voltage range**
  - <110 mW
  - 6 - 30 Vdc

- **Adaptable**
  - Highly configurable (output string, interval)
  - Can be integrated on most data buoys
  - Provides high accuracy wave data on non-ideal wave buoys
  - Configurable buoy frequency response compensation
  - Built-in compensation for installation outside of buoy center
  - Build-in option for connecting external compass to avoid directional deviation due to magnetic buoy structure

- **Rugged**
  - IP68, survives immersion down to 30 meters depth
  - Wet pluggable connectors

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MOTUS Wave Sensor

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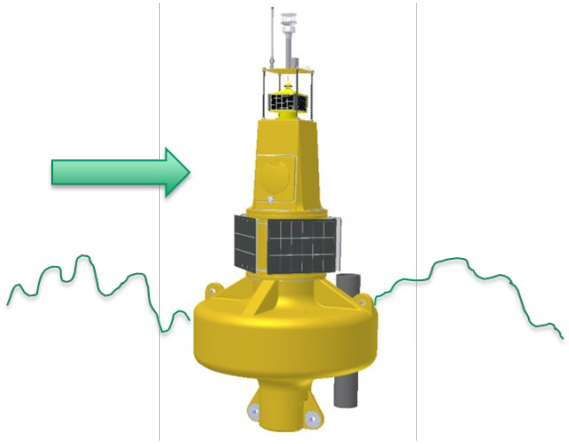
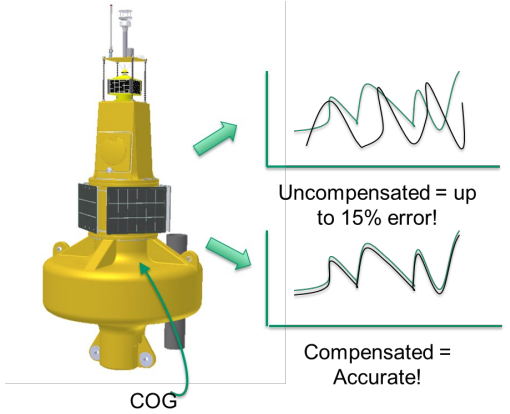
MOTUS Wave sensor

High accuracy
Low power



Compensation for
buoy response

Correction for magnetic
interference



Compensation for
Off-center positioning

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The Adaptable MOTUS Sensor

Compensation for location and buoy type

Open Protocol

External compass option

Robust packaging

Low Power

Remove effects of
Magnetic buoy parts

Smaller solar panels

Can be fitted on
the outside of buoy

Can handle rough
environments

Less Batteries

Integration
to most loggers

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MOTUS Wave Sensor

- In the Aanderaa MOTUS Directional Wave Sensor, accuracy is improved and noise reduced by sampling the movement **100 times a second**, advanced **filtering** techniques, and mechanical **dampening** to remove unwanted vibrations
- The **inertial measurement unit** (**IMU**) is the core of the

  Aanderaa MOTUS Directional Wave Sensor

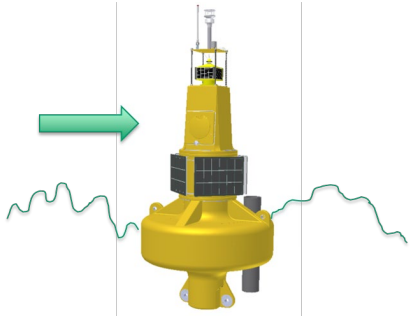
  - Sample rate, external noise, and sensor accuracy largely define reading accuracy
  - The fast sampling rate and external compass option ensure the performance of the MOTUS sensor
  - The accurate 9-axis IMU selected measures a body's orientation and linear acceleration as well as the magnetic field surrounding the body,
  - It uses a combination of accelerometers, gyroscopes, and magnetometers.

MOTUS parameters

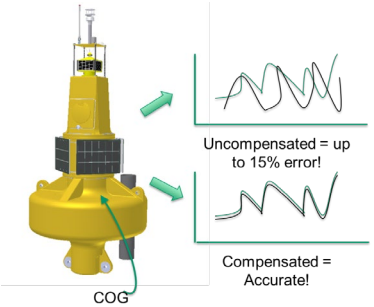
Significant Wave Height H_{mo}	Mean Wave Period T_{m02}	Principal Wave Directional Spectrum $DWS_p(f)$	Maximum Wave Height H_{Max}
Peak Wave Direction Height/Swell/Wind θ	Long Crestedness Parameter τ	Orbital Ratio Spectrum K(f)	Wave Period Tmax
First Order Spread σ	Mean Wave Direction θ_{avg}	Fourier Coefficients Spectra A1(f),B1(f),A2(f),B2(f)	Wave Height Max Crest C_{max}
Mean Spreading Angle θ_k	Wave Energy Spectrum E(f)	Significant Wave Height $H_{1/3}$	Wave Height Max Trough Tr_{max}
Peak Wave Period T_p	Directional Wave Spectrum $DWS_m(f)$	Mean Wave Period T_z	Heave Timeseries H(t)
New parameters:	**Mean Wave Period, $T_{1/3}$**	**Significant Wave Height, $H_{1/10}$**	**Mean Wave Periode, $T_{1/10}$**

3 Features making MOTUS suitable for integrators

- For larger buoys, the response to smaller waves may be suppressed. To compensate for this, the internal wave coefficients can be tuned to amplify the signals in the higher wave frequencies.



- The sensor can be placed in non-ideal positions if the buoy does not have room in the center. The Off-Center compensation can be enabled to remove the errors that can be up to 15% of the measured.



- Buoys may have magnetic parts affecting wave sensors and other sensors requiring a magnetometer or compcompass. The MOTUS can receive an external compass directly and utilize this to ensure correct wave direction data.

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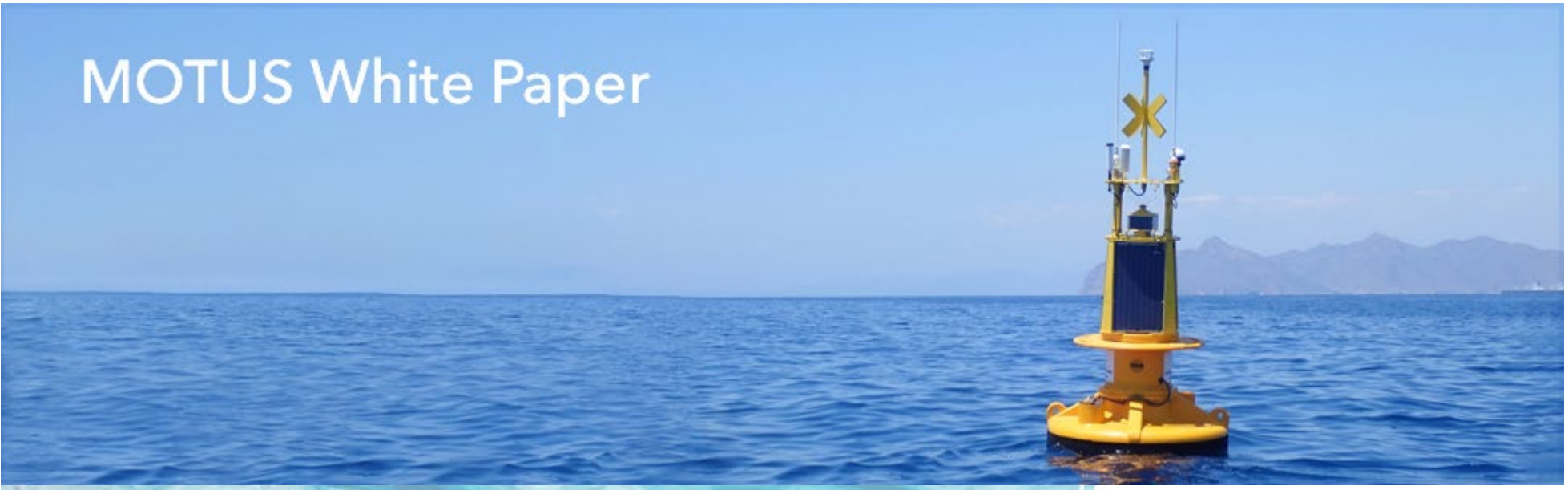
Materials for Wave Measurements



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Typical clients

System Integrators

System integrators utilize buoys from a variaty of buoy manufacturers including our own Xylem buoys. With the MOTUS sensor as stand-alone we can offer them the following;

- A sensor that can activly be adjusted to suit the platform they are utilizing.
- An evaluation tool to get an idea of the accuracy they can achieve on different platforms.
- 3 hours of remote integration support included in sensor price, bigger support packages are available from factory.
- Possibility for building their own system using Aanderaa components for measuring currents and waves with pre-configured systems.

Examples of integrators

AutoNaut

iXblue

NEOTEK

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Ports & Harbours

In many cases the ports have a buoy type they want to utilize and add additional parameters to. In many of these cases wave direction accuracy is seccondary, this is what MOTUS can do for them;

- Retrofit MOTUS on existing buoys, with or without datalogger
- Provide them with an package that they can integrate themselves for wave and currents
- Evaluate the dampening factor of their buoy type and provide them with an indication on the accuracy they can expect on their buoy type.
- Offer them a complete solution with dedicated buoy

MPA SINGAPORE

LE HAVRE port

Port of Antwerp

TANGER MED PORT AUTHORITY

Examples of ports

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Buoy manufacturers

For buoy manufacturers we can offer the MOTUS Wave Sensor as stand-alone or as a package with datalogger.

- A sensor that can activly be adjusted to suit their buoys
- An evaluation tool to get an idea of the accuracy they can achieve on their buoys.
- Integration package with support and in Europe rental of a known buoy for increased accuracy on their own buoy.
- Possibility for building their own system using Aanderaa components for measuring currents and waves with pre-configured systems.

Examples of companies

MOBILIS

Sealite®

GISMAN

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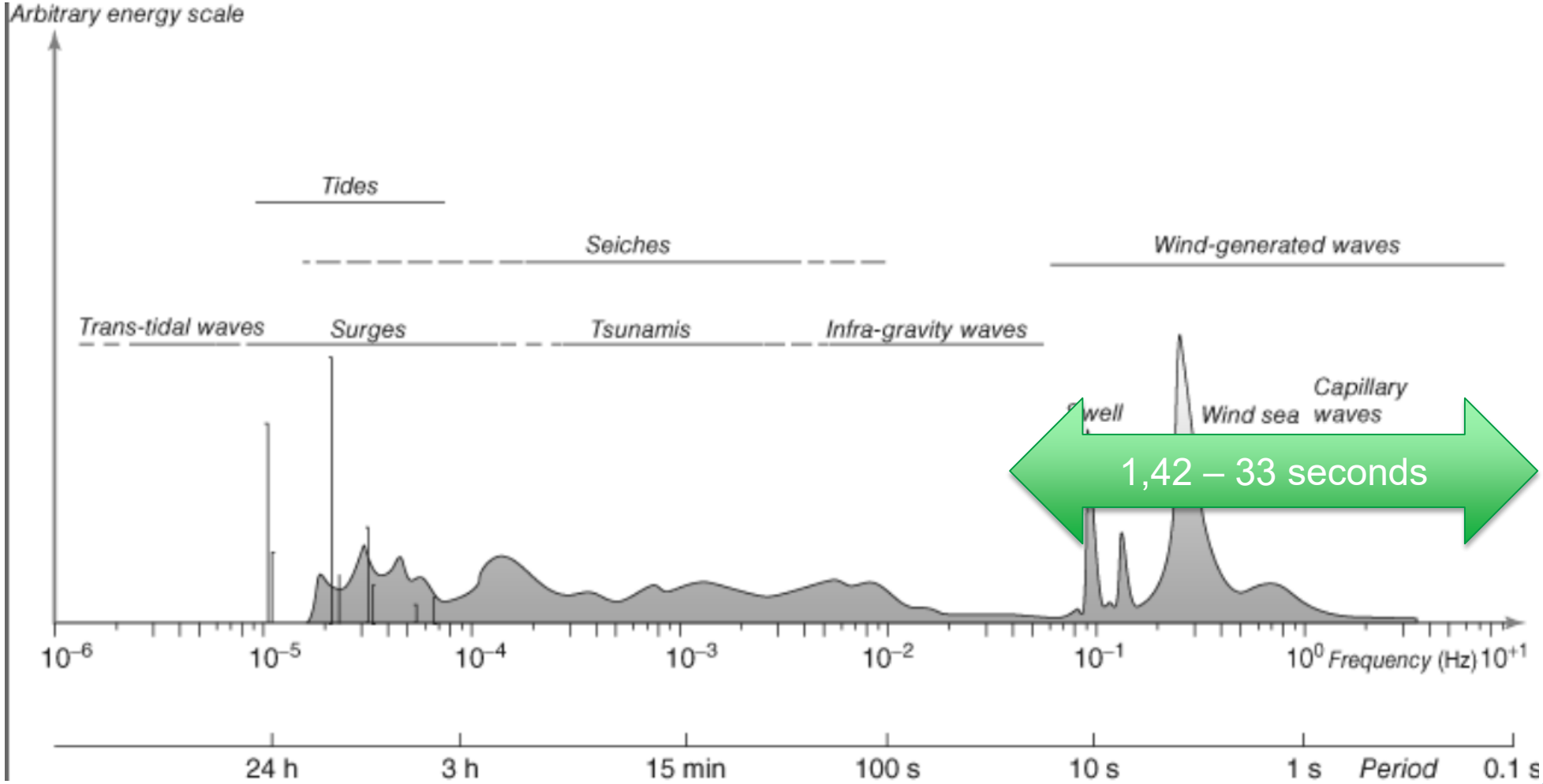
MOTUS Integration Considerations

4

Typical Wave period and Frequency



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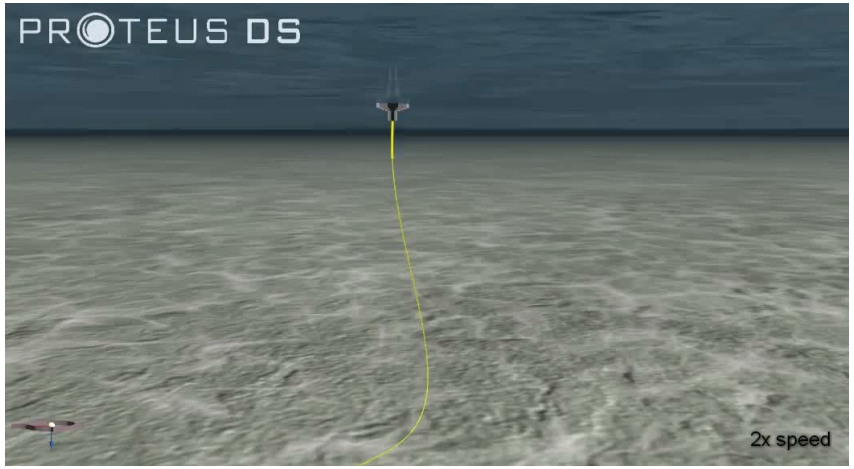
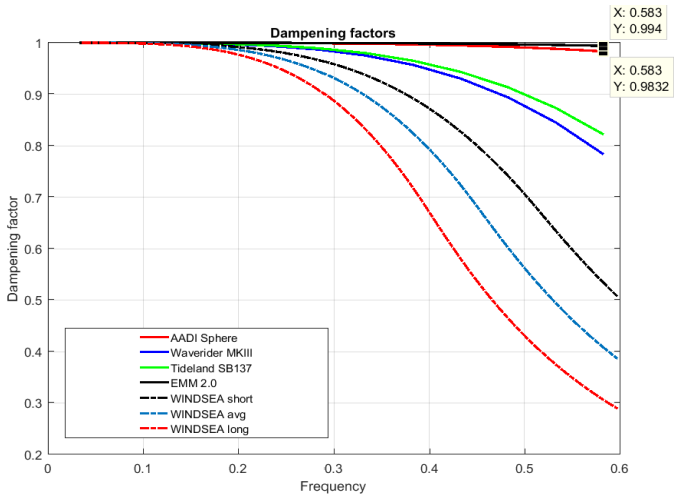
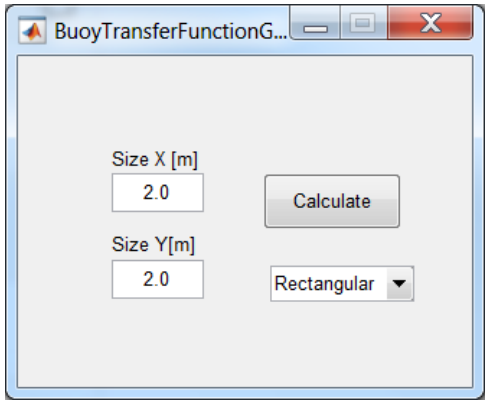
Size of Buoy

- Mooring and buoy size can impact on accuracy
- Larger buoys dampen smaller waves
- For integrators a tool have been developed for giving an idea of possible accuracy on buoy size
- For higher accuracy, a unknown buoy should be deployed with an known buoy to compensate buoy response

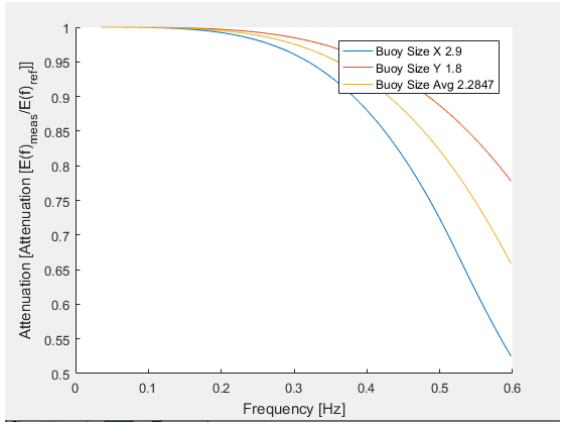




Reference combining multiple buoys



Input size and shape



Overview of the dampening factor

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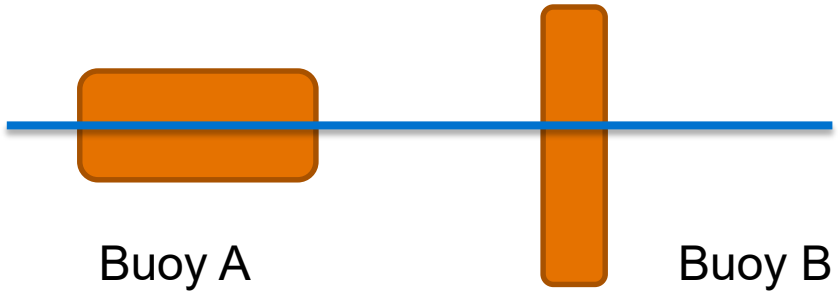
Buoyancy

- Buoyancy determines how the buoy follows the surface
- The larger the area at the waterline is vs mass of the buoy the quicker the buoy will compensate for the waves hitting the buoy
- Formula for resonant frequency (how quickly a buoy responds) is:

$$\omega_o = \sqrt{(a\rho g)/m}$$

- Resonant frequency should be higher than 8
- Tideland SB-138P is 8,7



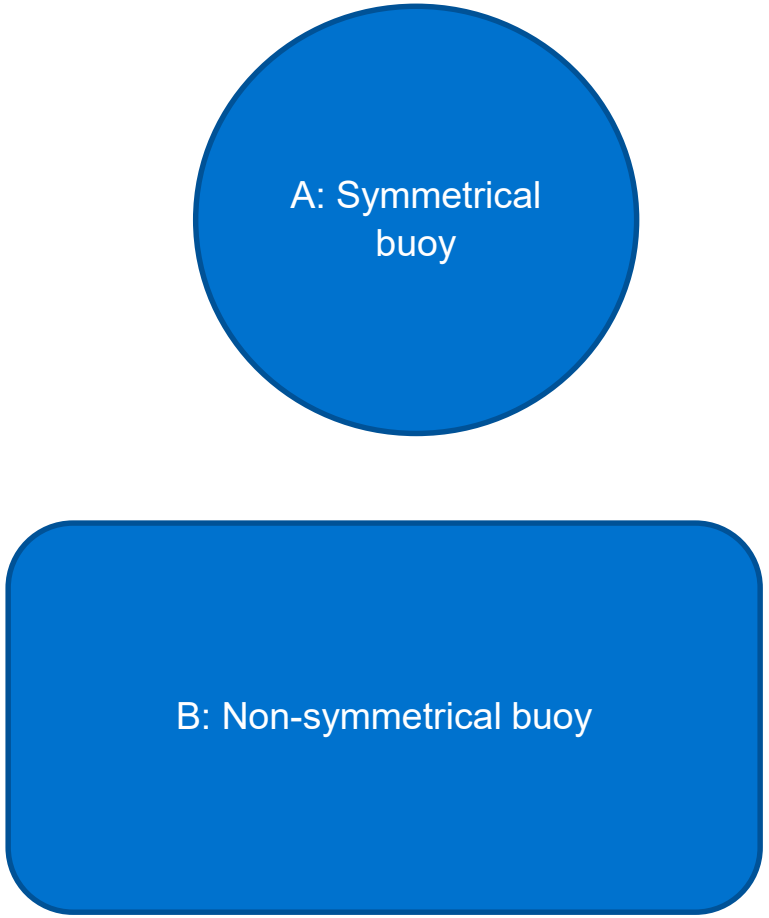
Buoy A will work well for wave measurements, while Buoy B will not

Shape

Symmetrical or non-symetrical buoys

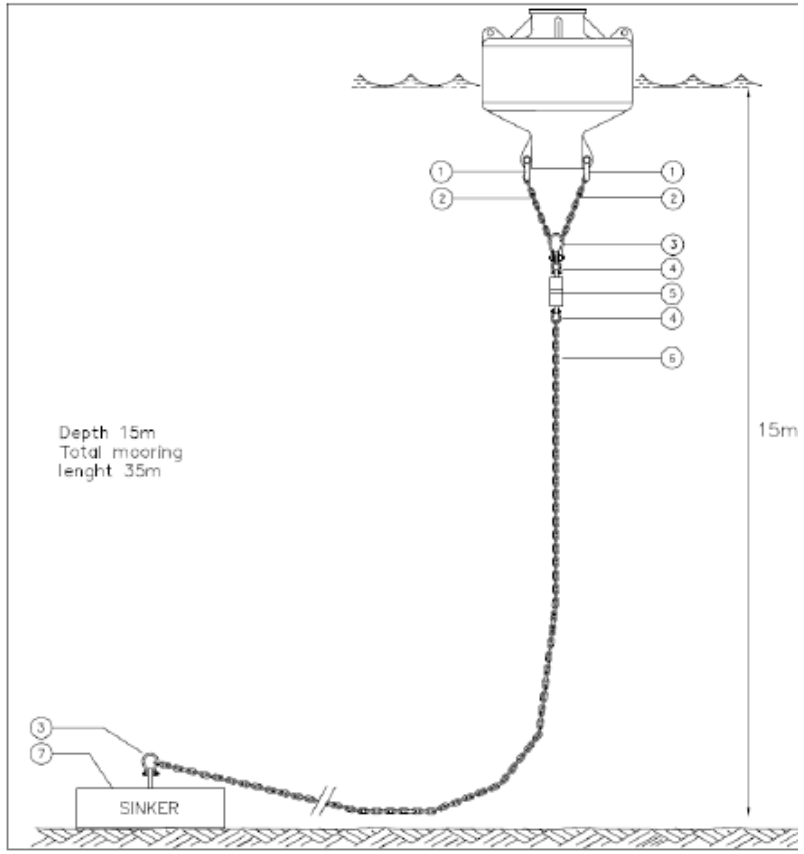
Type A gives better wave measurement data, especially for wave direction

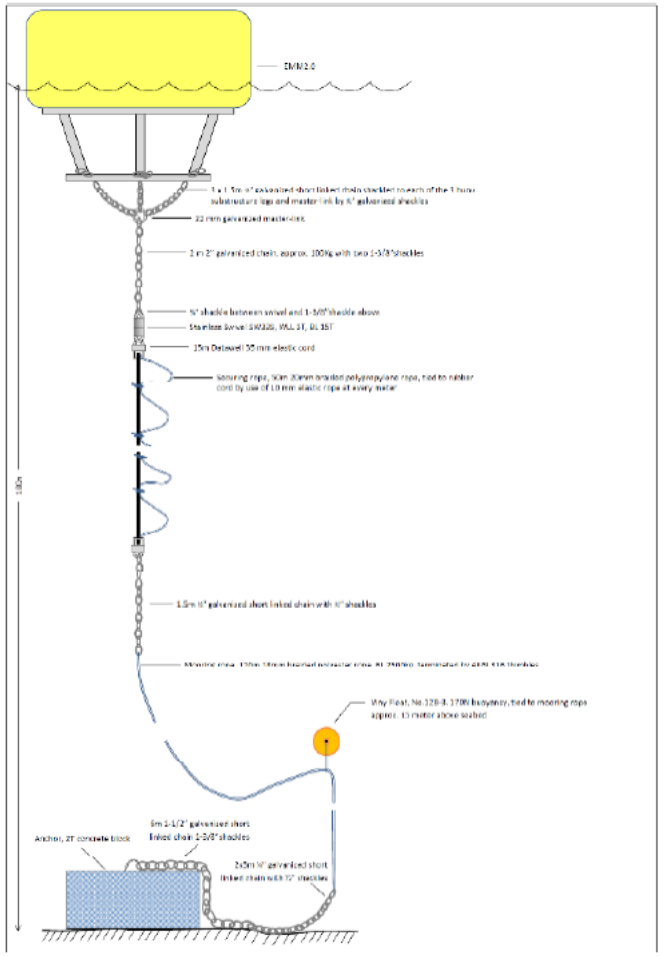
Non-symmetrical buoys can give good data in offshore locations with larger ocean waves



Buoys seen from above

Moorings





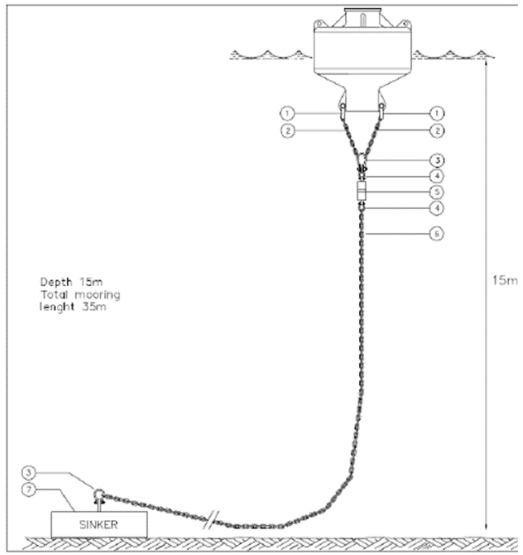
Under 20m, the mooring is constructed with bridle and chain, to stabilize the buoy we usually have around 250-300 kg of mooring in the water (1.75m buoy)

A high quality swivel is always used in a singlepoint mooring

Over 20m, the optimal wave direction mooring utilized a chain, elastic cord, swivel and rope.

Marine Growth

- Increases friction between the buoy and the wave and increases the forces that make the buoy follow the orbital current, this is an advantage for a wave measurement buoy.
- Heavy fouling on the mooring in combination with a steady current on the mooring can lead to reduced quality of the wave measurment



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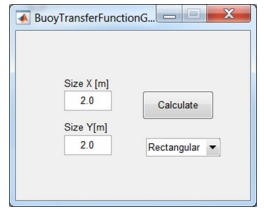
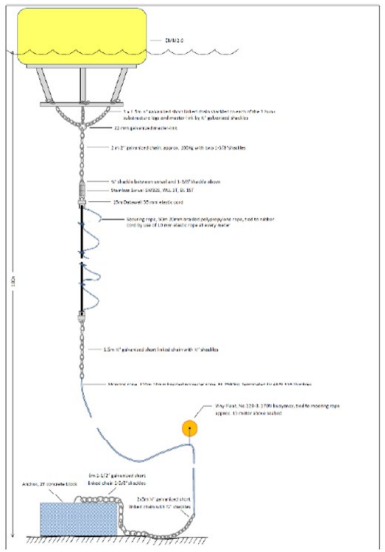
Integration Guideline

1. Understand what waves you are interested in measuring (wave period, size)
2. Run tool to determine if selected buoy is capable of measuring desired wave patterns
3. Position the MOTUS as close to the rotational center as possible.
   - If position is offset, configure MOTUS with offset variables
4. Determine if there is magnetic interference at selected location
   - If magnetic interference, utilize external compass away from source and connect directly to MOTUS



Integration Guideline

5. Configure MOTUS with selected datalogger
   - If SmartGuard datalogger, configure to AiCap protocol and plug in.
   - If other datalogger, configure as RS-232 and parse output string accordingly
6. Design mooring
   - If less than 20m, 1 point chain mooring gives good results.
   - If more than 20m, consider using a combination of elastic cord, rope and chain (to limit the weight of the mooring)
7. Determine accuracy requirements
   - If wave direction accuracy requirement less than 5Deg, consider correlating to existing reference buoy.
   - Ensure reference buoy is positioned close by
8. Integrate system and deploy



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Integration Packages

Add currents to your wave measurement

For integrators utilizing their own logger:

- Motus sensor
- Doppler current profiler
- Standard and custom specified cables

Packages with datalogger

- SmartGuard
- Motus sensor
- Doppler Current profiler
- Standard and custom specified cables
- Post processing software

- Motus sensor
- Single point current sensor
- Standard and custom specified cables

- SmartGuard
- Motus sensor
- Single point current sensor
- Standard and custom specified cables
- Post processing software

Additional Buoy Packages

Currents

- Single point
- Current Profile

Water Quality

- Dissolved Oxygen
- Conductivity
- Temperature
- pH
- Oil in Water
- More…

Meteorology

- Wind
- Atmospheric Pressure
- Air Temperature

Additional Buoy Packages

Aids to Navigation

- Lights
- AIS
- RACON

Communication & Data Management

- Data loggers
- GOES
- Satellite
- Acoustic Modem
- AIS

Power Solutions

- Solar
- Battery
- Power manager

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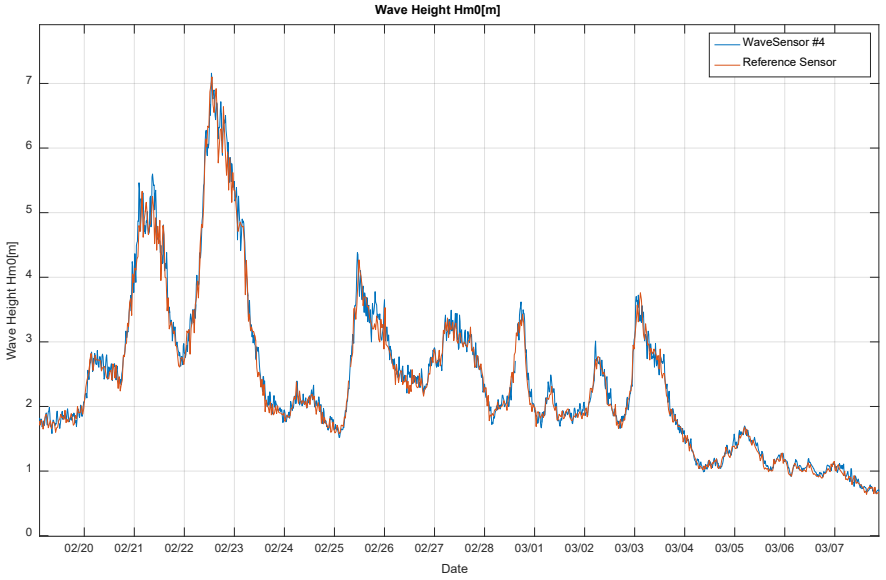
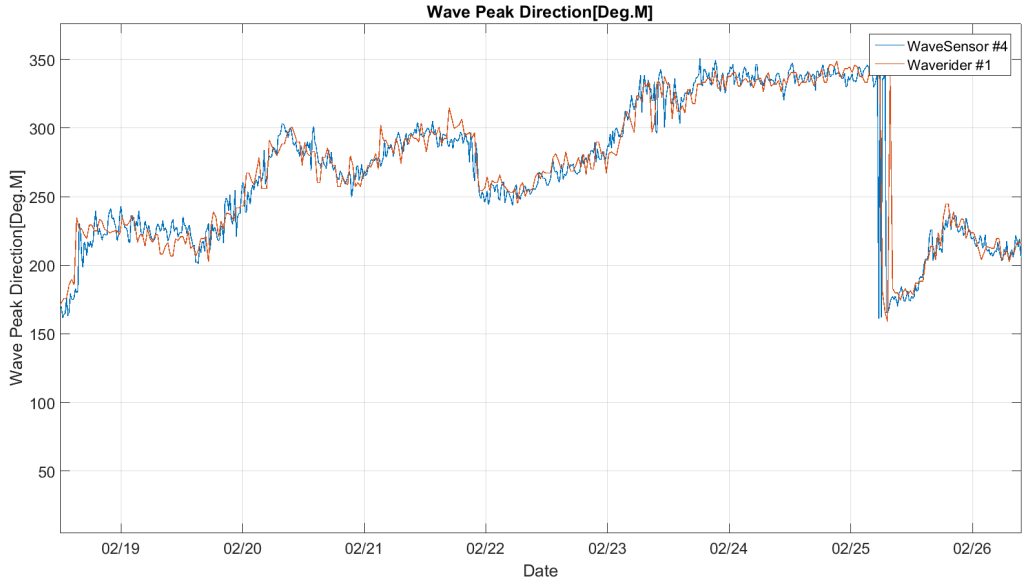
Results

Accuracy on internal buoys Tideland SB 138P / YSI EMM2.0





- Comparison of Significant wave height for Datawell and Tideland/EMM2.0 shows excellent agreement.
- Comparison of Wave Peak Direction for Datawell and Tideland/EMM2.0 shows excellent agreement.
- For more information, check out our Whitepapers at www.aanderaa.com

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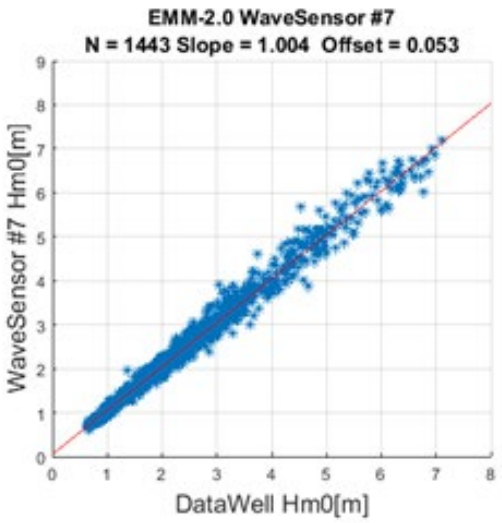
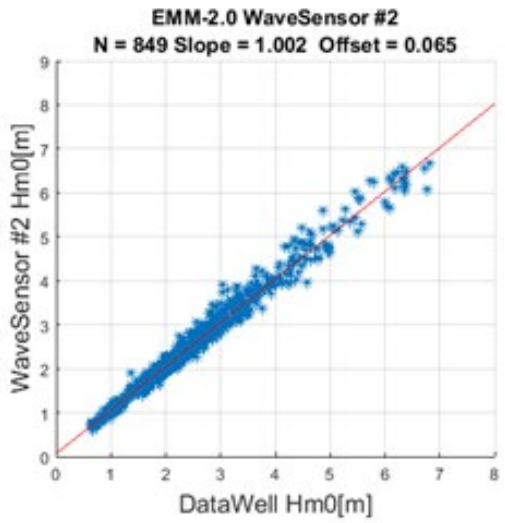
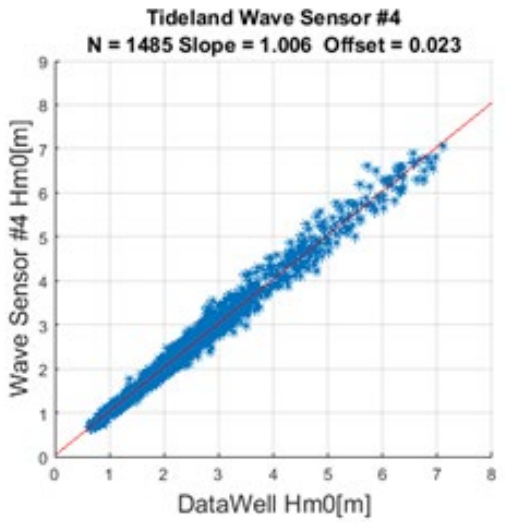
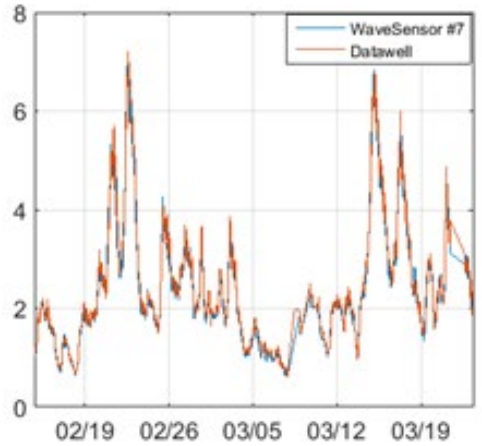
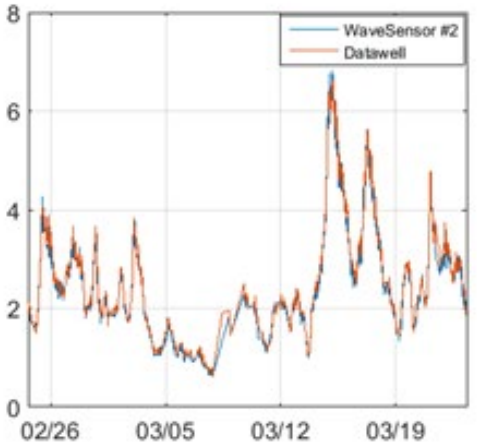
MOTUS vs. Waverider

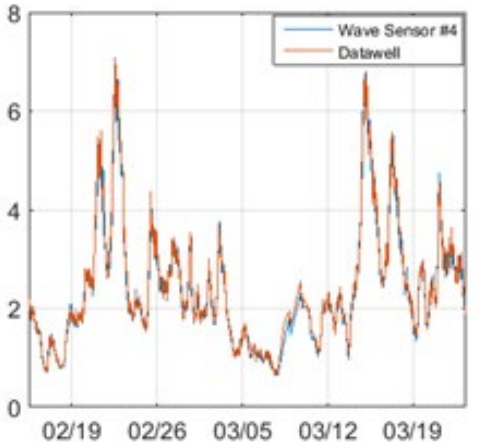












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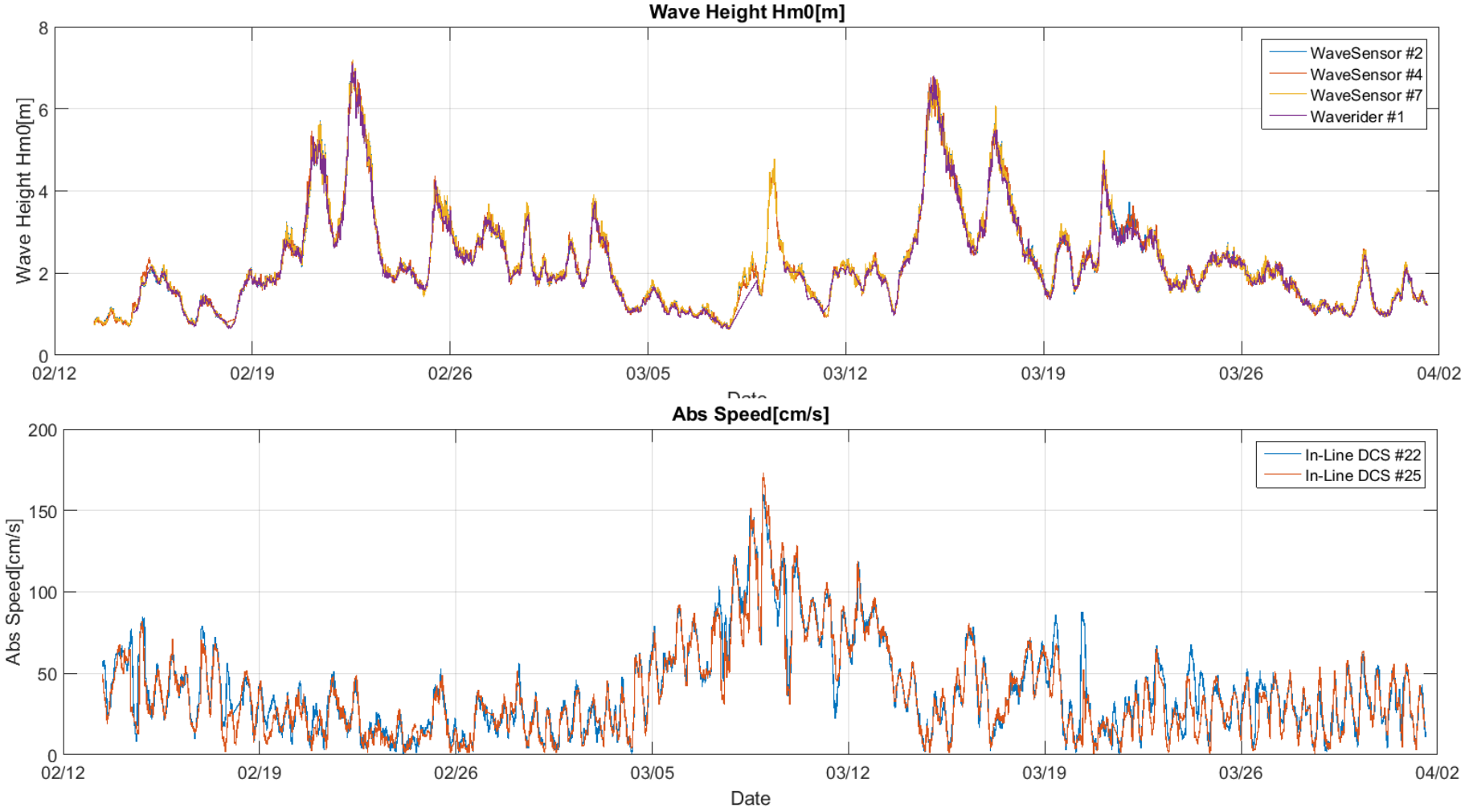
Current measurements in high sea state

- Current measurements correlate well between buoys even in high waves
- Wave measurements correlate well even in high current condictions



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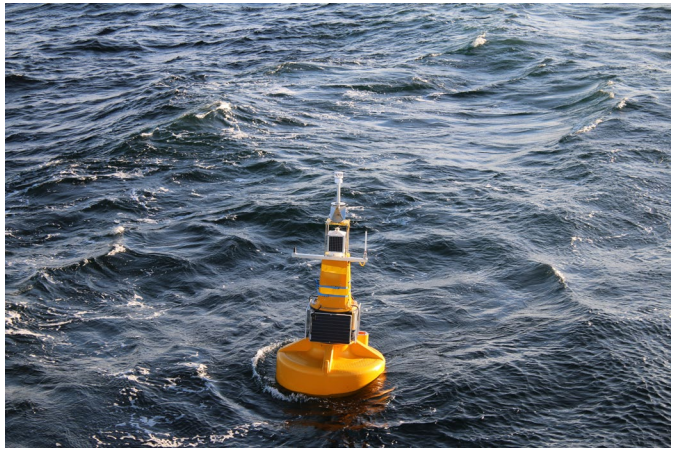
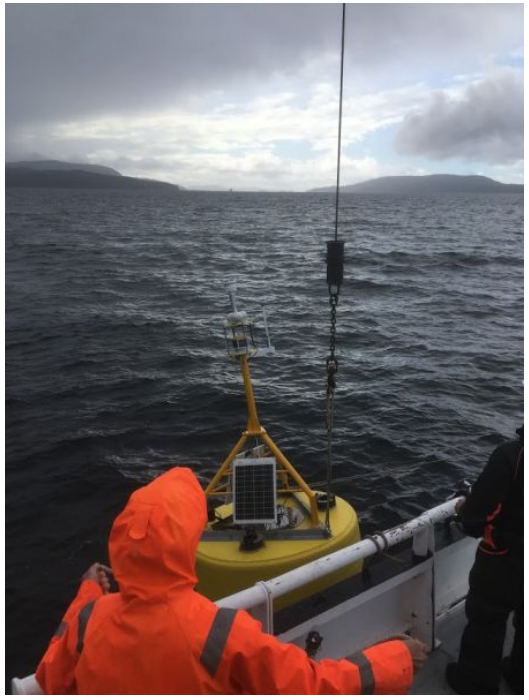
Buoys with MOTUS





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Interested in a complete solution?

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MOTUS WAVE BUOY – complete end to end solution

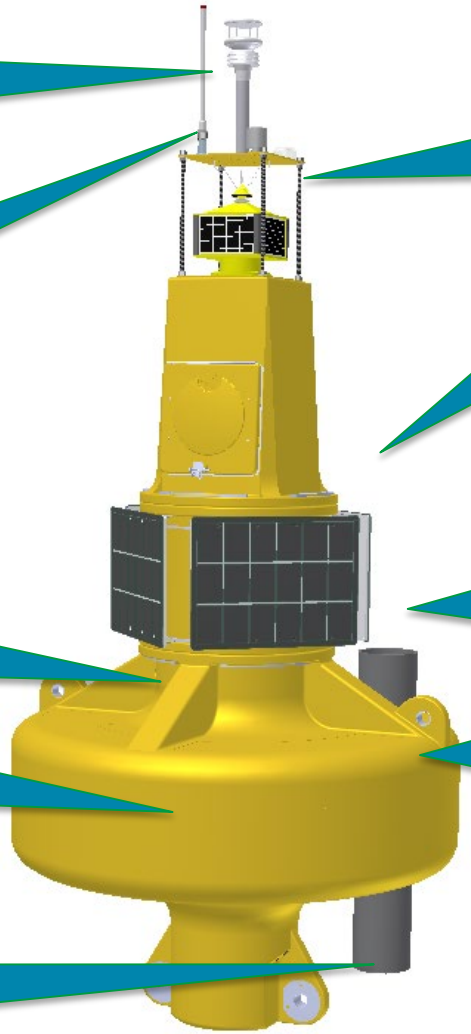
Meteorology

Real Time Communications

Wave Measurement Sensor

Data Management

Current Measurement Sensor

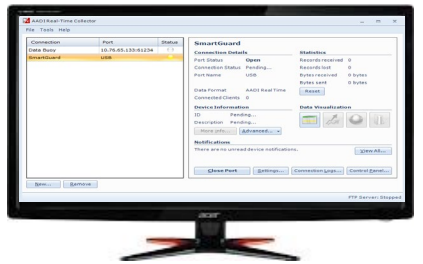


Aid to Navigation

Long Term Power Solutions

Customizable Water Quality Sensor Payload

Internationally Proven Buoy



Control & Display solutions

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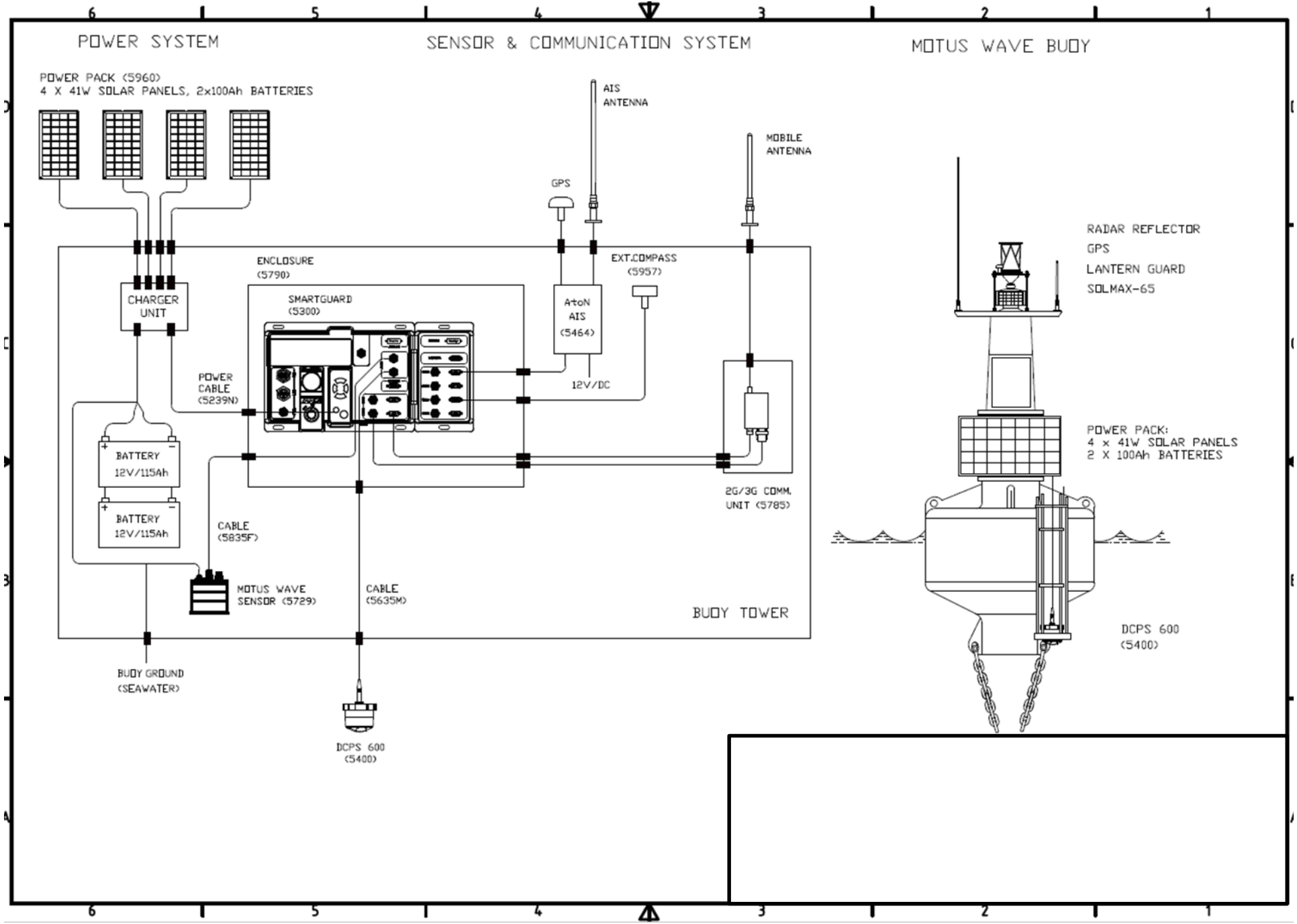
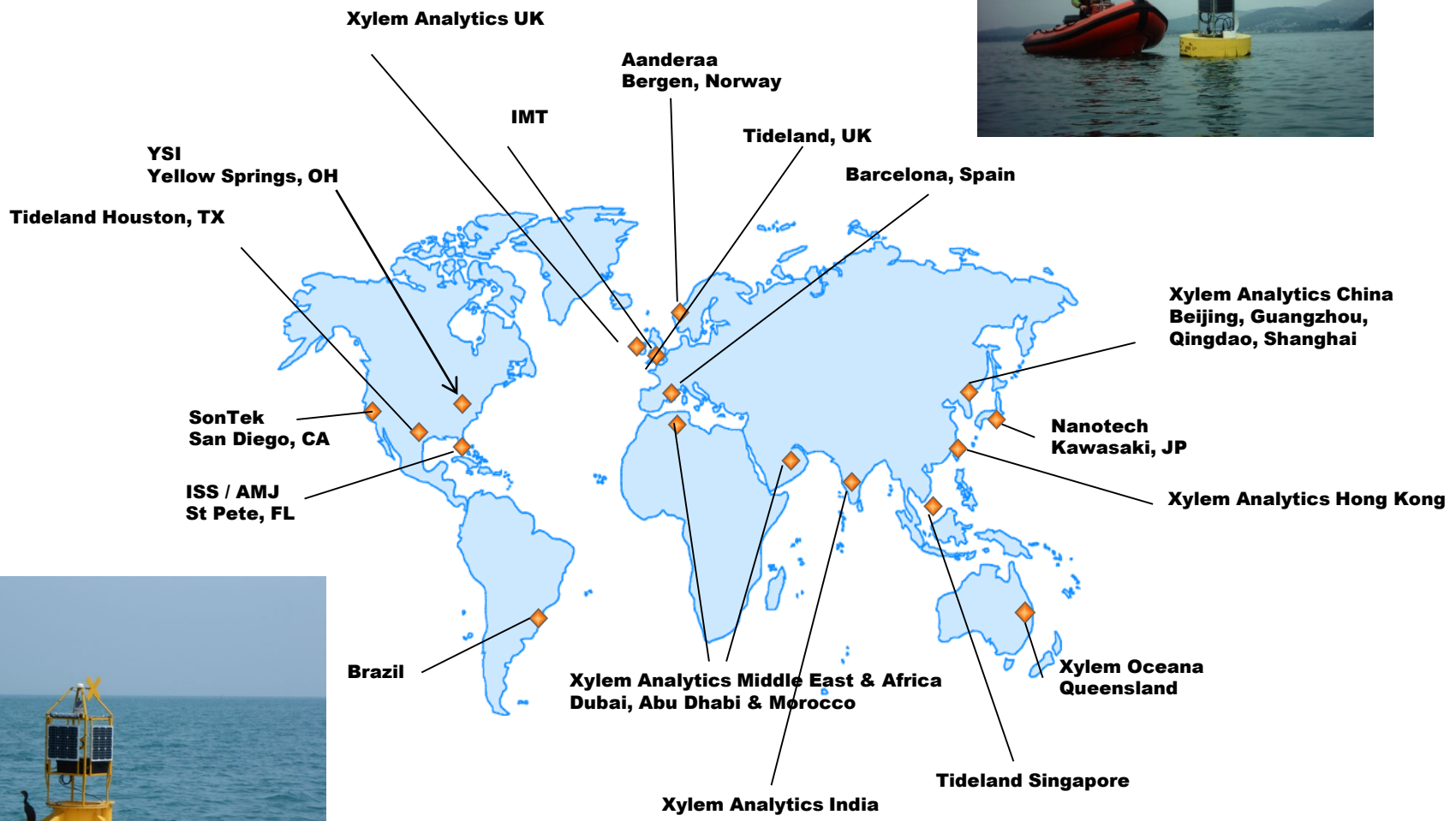


Xylem Expertise in Your Region



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Wave Sensors

MOTUS Stand-Alone

Turn your buoy into an intelligent data collecting platform. A directional wave sensor module suitable for integration to different buoys and loggers. It is intended for commercial as well as research use. The sensor processes wave data and is configurable to present parameters and wave spectrum directly. The sensor can be connected to a SmartGuard using the CANbus based AiCaP protocol. It can also be connected to a PC or third party systems through the RS-232 interface.

Aanderaa Pressure Based Sensor

Wave & Tide Sensor 5218/5218R are compact fully integrated sensors for measuring the wave and/or tide conditions. The sensor is designed to be mounted on the Aanderaa SEAGUARD® Platform or via cable connected to SmartGuard Datalogger. The sensor may also be used as stand alone with RS-232 output. The 5218R sensor is designed for use with long cables by means of an RS- 422 full duplex interface. The R-version can not be used in SeaGuard applications.

The sensor is also available in a vented version. This means that the sensor is automatically compensated for air pressure. This is done by use of a compensating unit placed in air and an air-pipe in the cable between the sensor and compensating unit.

The sensor application areas are in fixed installations, either deployed in a seabed installation in shallow waters, or mounted onto a fixed structure in the upper water column. Typical applications for the sensor are measurements of tide and wave in ports and harbors, marine operations, weather forecast, and climate studies.

Features | Documents | Contact Us

MOTUS Stand-Alone

- User configurable transferfunction to compensate for buoy frequency response
- Configurable compensation algorithm for installation outside of buoy center.
- Built-in solid state 9-axis accelerometer/gyro/magnetometer.
- Options for external compass ensuring high directional accuracy even if the wave sensor is installed close to magnetic components.
- A compact field friendly low power multi-parameter wave sensor.
- Wide range of parameters are calculated inside the sensor, configurable output

Related Products

Tide Sensor
The Aanderaa Tide sensors are compact fully integrated sensor for measuring the tide conditions.

SmartGuard
The next generation sensor and instrument HUB for Ocean, Lake, Reservoir, Estuary

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Questions

Contact:
Aanderaa.sales@xyleminc.com or your local Xylem Analytics representative