Open Sea Operating Experience to Reduce Wave Energy Costs

Technical Note

TRIAXYS Metocean Data 2016-2018

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EXECUTIVE SUMMARY

This Technical Note extends the first published dataset obtained from the TRIAXYS buoy deployed at BiMEP. It covers two periods:

- December 2016 to October 2017
- March 2018 to July 2018

Sensor is located at 87 m water depth, 300 m up-wave of the OCEANTEC's Wave Energy Converter, MARMOK-A5 (43°28'12.19"N, 2°52'17.88"O). Statistical wave data are calculated from 20-min time series.

The document introduces main characteristics, specification and accuracy of the TRIAXYS buoy, together with relevant references of the manufacturer. Besides, it is provided a short description of the full list of wave parameters.

Finally, an indicative example of the data recorded for two wave parameters, namely significant wave height (Hs) and peak period (Tp), is given.

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1. TRIAXYS BUOY DATA-SHEET

The TRIAXYS™ Directional Wave Buoy, manufactured by AXYS Technologies Inc. (AXYS) [2] has the following characteristics and components:

PHYSICAL DESCRIPTION

- Diameter: 1.10m outside
- Bumper Weight (including batteries): 230 kg
- Light: Amber LED.
- Programmable IALA ODAS flash sequence with three miles' visibility.

MATERIALS

- Hull: Stainless steel
- Dome: Impact resistant polycarbonate
- Solar Panel Assembly: Fibreglass over foam
- Clamping ring: Stainless steel

POWER SYSTEM

- Batteries: 4 @ 12 Volt,100 Amp h/battery
- Solar Panels: 10 @ 6 Watt
- Maximum Power Point Tracking (MPPT) Regulator External
- On/Off Switch: Turns buoy on when Magnetic Key is removed.

TELEMETRY OPTIONS

- VHF/UHF- IsatData Pro- INMARSAT M2M- IRIDIUM- HSPA Cellular (compatible with GPRS) - AIS Aid to Navigation

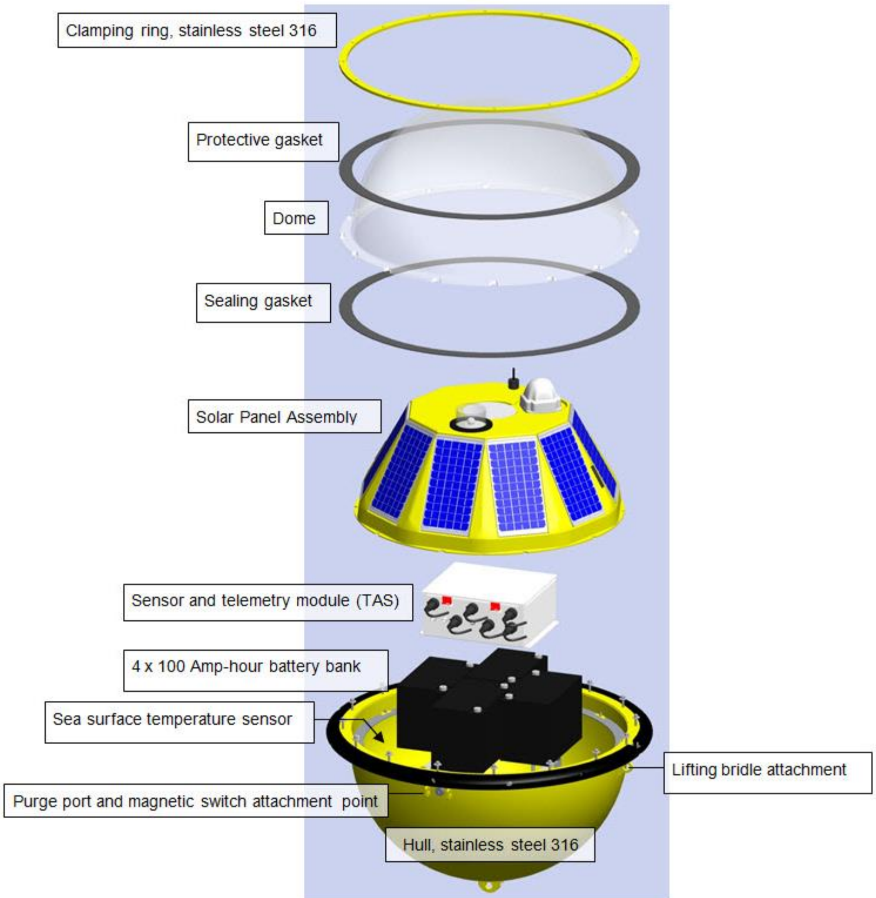

FIGURE 1: TRIAXYS COMPONENTS

Specifications of TRIAXYS sensors are shown in the next table.

TABLE 1: SPECIFICATIONS TRIAXYS SENSOR [4]

Data	Description
Direction	0-360°
Sensor Size	15cm x 15cm x 9cm
Sensor Weight	1.5 Kg
Power Supply	10 to 20 VDC
Input/Output	Power and data through single connector
Communications	9,600 or 19,200 baud, 8 bits, 1 stop bit, no parity
Operating Temperature Range	-30°C to +65°C
Storage Temperature Range	-40°C to +70°C
Sampling Frequency	Variable; default 4 Hz
Frequency Range	0.64 Hz (1.5 seconds) to 0.030 Hz (33 seconds)
Frequency Spacing	Variable; default 0.005 Hz
Sample Duration	Variable (1 to 34 minutes)
Sampling Interval	Variable (5 to 1440 minutes)
Frequency Bands	Variable; default 123
Location of Sensor	Any
Data Storage	Internal 8GB: >5 years (expandable to

Last, the resolution and accuracy of the system is summarized in Table 2.

TABLE 2: TRIAXYS RESOLUTION AND ACCURACY [2]

	RANGE	RESOLUTION	ACCURACY
Heave	+-20m	0.01m	Better than 1%
Period	1.5 to 33 sec	0.1 sex	Better than 1%
Direction	0 to 360º	1º	3º
Water Temp.	-5 to +50ºC	0.1ºC	+-0.5ºC

2. LOCATION AND OPERATION TIME

TRIAXYS buoy is located in front of MARMOK-A5 at BiMEP test site (43°28'12.19"N, 2°52'17.88"O). It was installed in December of 2016 with the objective to provide information to the research activities during the testing of OCEANTEC's MARMOK-A5 floating offshore Oscillating water column wave energy device.

The published data includes information from December 2016 to October 2017 and from March 2018 to July 2018. No data is available from November 2017 to February 2018 due to the scheduled maintenance and re-fitting work in the buoy.

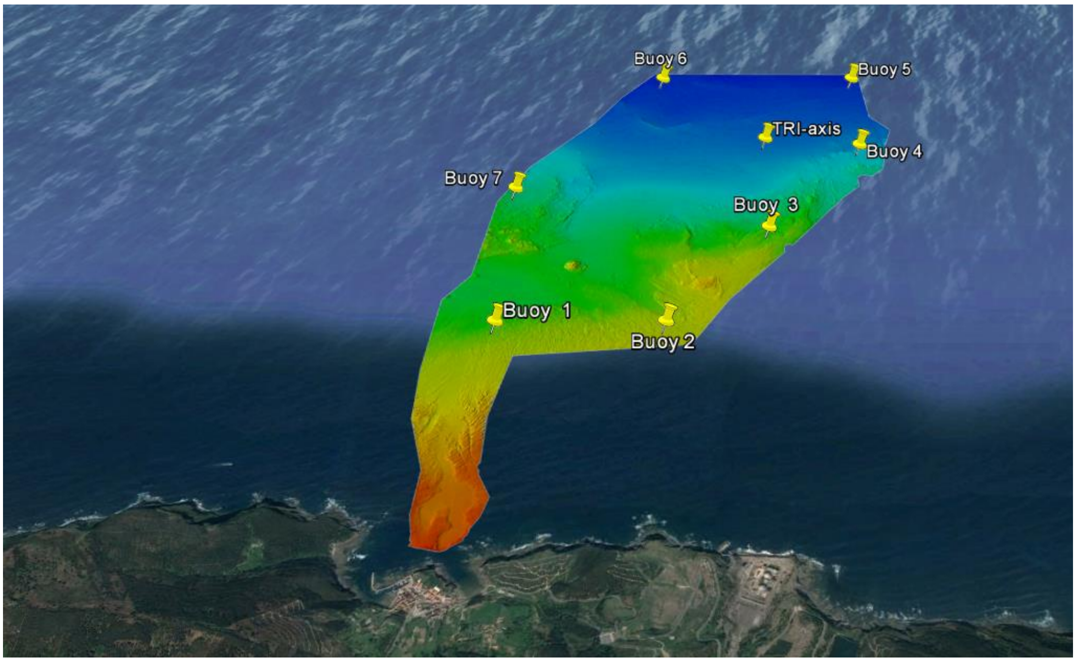

FIGURE 2: TRIAXYS LOCATION AT BIMEP TEST SITE

The next figure shows the TRIAXYS buoy in front of MARMOK-A5.

FIGURE 3: TRIAXIS LOCATED IN FRONT OF MARMOK-A5

3. DESCRIPTION OF WAVE RESOURCE DATA

The data presented consist of 20-min wave statistical parameters such as H_{max}, $H_{1/10}$, $H_{1/3}$, H_{avg}, T_{max}, $T_{1/10}$, T_{avg}, Tz, Tp, Ts, Mean Direction, Mean Spread.

A wave analysis is run directly on the TRIAXYS™ sensor [4] , providing zero-crossing statistics, spectral statistics and both directional and non-directional wave spectra from the measurements acquired from the wave conditions.

The software used onboard the TRIAXYS sensor includes a motion analysis algorithm to analyse the measured data from the accelerometers, rate gyros, and the compass, and an algorithm to resolve the directional and non-directional spectra of sea state from the previously analysed data.

The following table presents the full list of parameters provided by the TRIAXYS buoy. For data user convenience, a definition of these parameters have been developed by TECNALIA based on [5] and [6] . Whenever in doubt the reader is advised to contact Axys Technologies [2] for further clarifications.

TABLE 3: PARAMETERS OBTAINED FROM THE BUOY

Parameter	Unit	Description
DataTimeStamp	Day/month/year/hour	Data acquisition date
H_{avg},	m, s	Wave height and period average, Refer to the means of the heights and periods of all waves in a record
H_{max}, T_{max}	m, s	Maximum wave height and period, refers to the wave having the height and period of the highest individual wave in a record
MaxCrest	m	Maximum wave crest
H_{sig}, T_{sig}	m, s	Significant wave height and period. The waves in record are counted and selected in descending order of wave height from the highest wave, until one-third of the total number of waves reached. The means of their heights and periods are calculated as $H_{1/3}$, $T_{1/3}$
$H_{1/10}$, $T_{1/10}$	m, s	Highest one-tenth wave, the waves in the record are counted and selected in descending order of wave height and period from the highest wave, one-tenth of the total number of waves is reached, the means of their heights are calculated and denoted as $H_{1/10}$
MeanPeriod	s	Mean period refers to the mean period of all waves in a record

Parameter	Unit	Description
MeanDirection	º	Mean direction, Refers to the mean direction of all waves in a record
MeanSpread	º	Mean Spread
PeakPeriod	s	Peak period, is the inverse of the frequency at which the wave spectrum has its highest energy density, and is also referred to as the dominant wave period
PeakDirection	º	Is the direction of the wave spectrum that has its higher energy density
PeakSpread	º	Peak Spread
TP_5	s	Peak wave period in seconds T_{p5} has less statistical variability than T_p because it is based on spectral moments. The T_{p5} is determined from calculating F_{p5} which is the average frequency.
H_{M0}	m	Is the spectrally derived significant wave height, which can be calculated as: $H_{m0} = 4\sqrt{m_0}$, where m_0 is the zeroth moment of the spectral distribution of surface elevation.
T_e	s	Energy period, can be determined from the two spectral moments (m-1 and m0), calculated above, as: $T_e = m_{-1}/m_0$ Alternatively, it can be estimated based on T_p as: $T_e = \alpha T_p$ The coefficient α depends on the shape of the wave spectrum: $\alpha = 0.86$ for a Pierson–Moskowitz spectrum, and α increases towards unity with decreasing spectral width.
DurationMs	s	Duration of each period

In the next figures (Figure 4, Figure 5) there is an example of the data recorded for two wave parameters, namely significant wave height (Hs) and peak period (Tp).

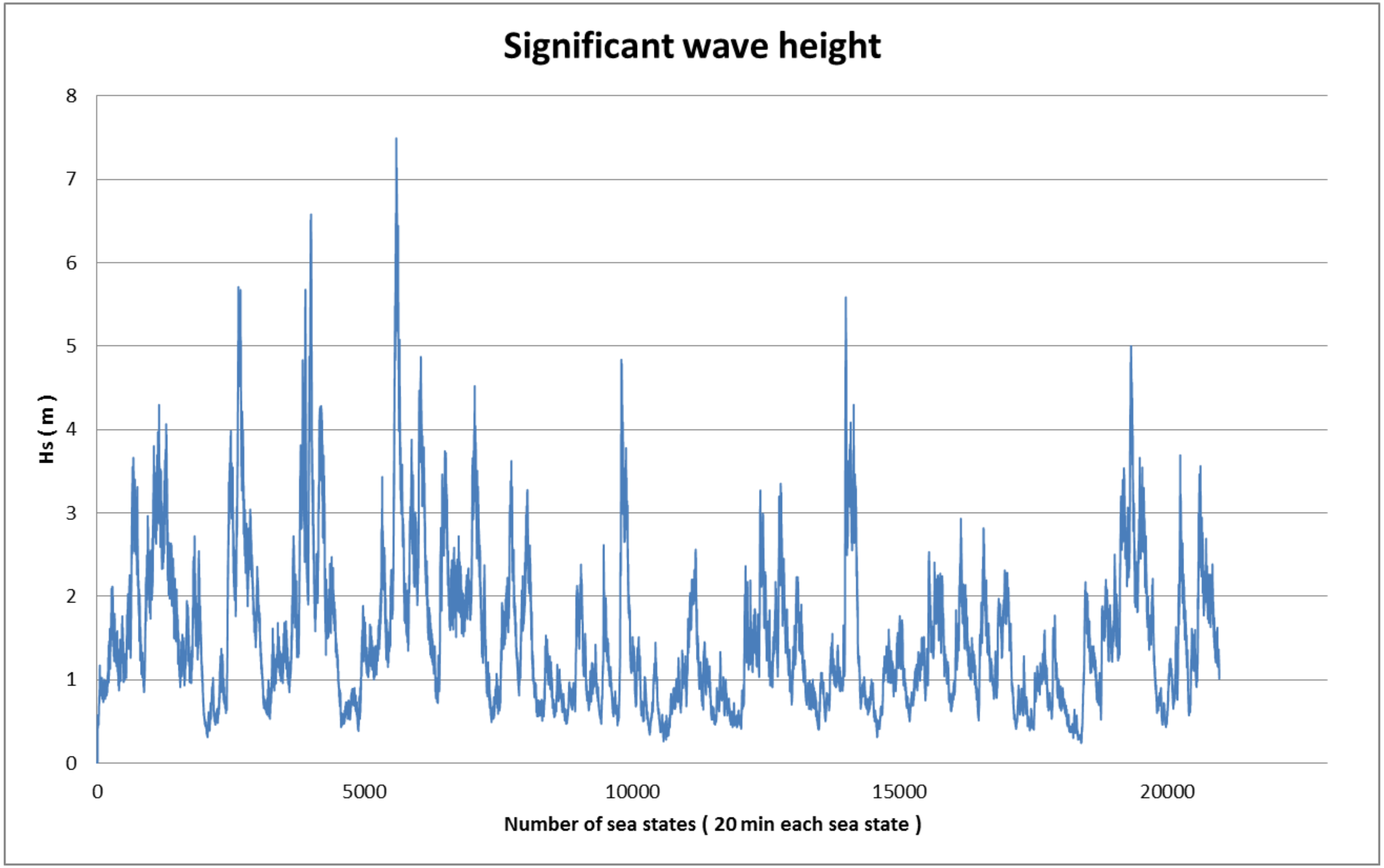

FIGURE 4: SIGNIFICANT WAVE HEIGHT PER SEA STATE , 2016-2017

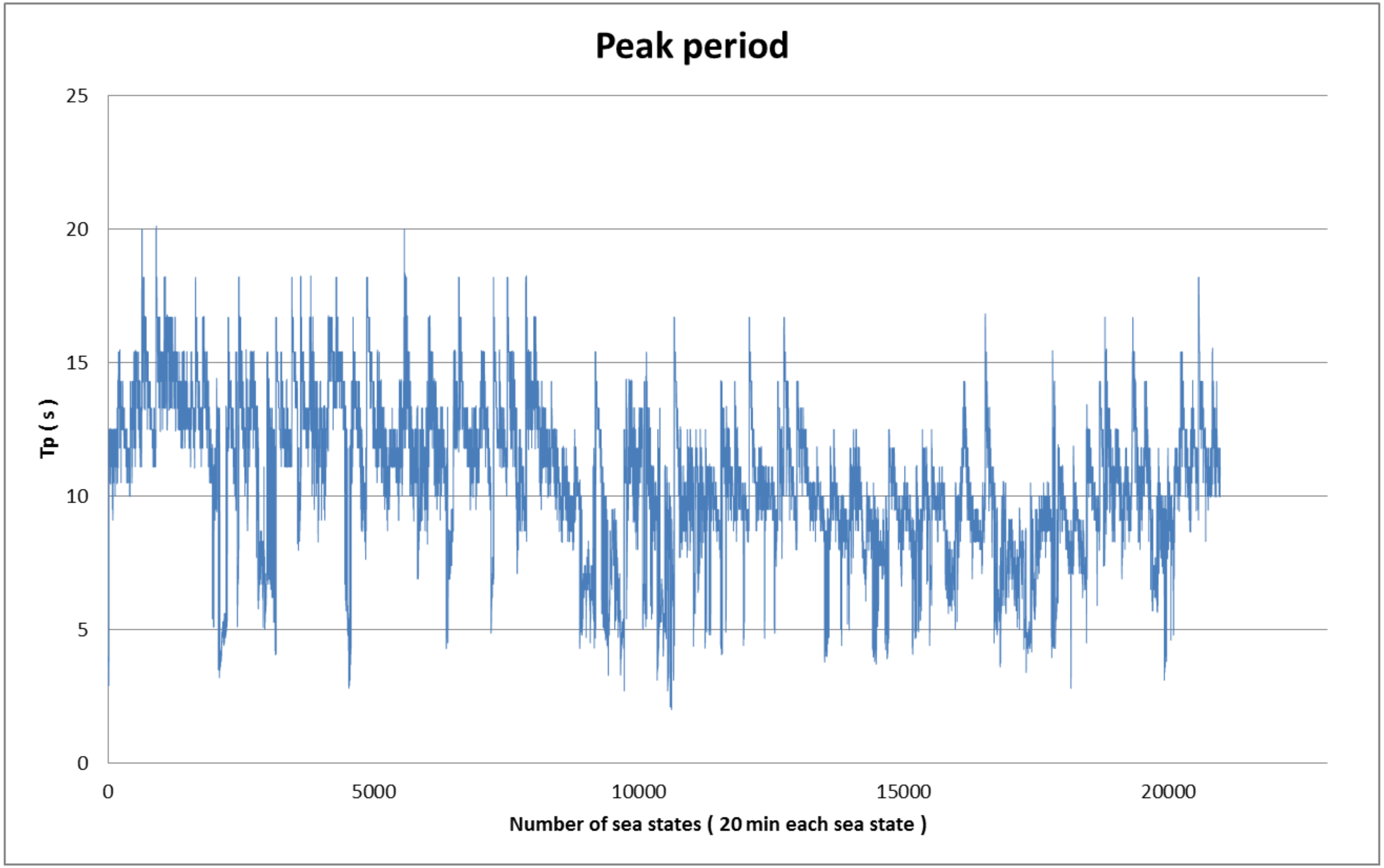

FIGURE 5: PEAK PERIOD PER SEA STATE 2016-2017

4. REFERENCES

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[6] J. Pastor 1, Y. Liu 2,*"Wave Climate Resource Analysis Based on a Revised Gamma Spectrum forWave Energy Conversion Technology" 1 Department of Mechanical Engineering, University of Louisiana at Lafayette, Lafayette, LA 70504, USA; 2 Department of Mechanical Engineering, Mississippi State University, Mississippi State, MS 39760, USA * Correspondence. Sustainability 2016, 8, 1321; doi:10.3390/su8121321