

An Update of Key Developments at AXYS Technologies



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Part 1 – Offshore Wind Resource Assessment

Traditional Approach

- Construct offshore met mast
- Up to \$15 million
- 2 years to build



New Technology – Floating LiDAR

The Challenge

→ How do you prove that floating LiDARs provide accurate data?



DONG
energy

“Difficult to see met masts in Dong Energy’s future”



AXYS TECHNOLOGIES INC.

www.axystechnologies.com

WindSentinel Track Record

7 Deployments to date

1. Race Rocks AXYS Trial

» October – November 2009

2. GVSU – US Department of Energy funded research

» Deployed and redeployed three times between October 2011 and December 2012, including 36 miles offshore on Lake Michigan

3. Fishermen's Energy of New Jersey - Private developer wind resource assessment

» Initial deployment February 2012



WindSentinel Track Record

4. National Cheng Kung University (NCKU)

» Deployment May 2013

5. United States Navy

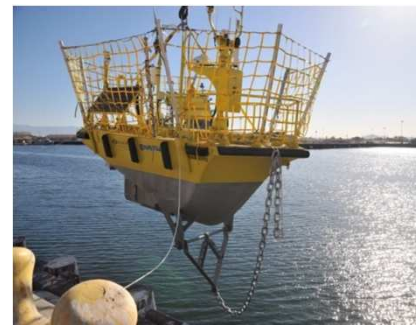
» Initial deployment June 2014

6. EDPI

» Deployment July 2014

7. Pacific Northwest National Laboratory (PNNL)

» 2 Buoys - Deployment Sept 2014



Upcoming Installations

- » Dominion – December 2014
- » Offshore Wind Accelerator East Anglia – February 2015



Multiple LiDARs

- » Vindicator III
- » ZephIR 300



The Roadmap for the Commercial Acceptance of Floating LiDAR

» Sponsored by the Carbon Trust's Offshore Wind Accelerator, a consortium of 9 offshore wind developers.

» Developed by international standards body DNV GL

» AXYS will reach Stage 2 in spring 2015 after a 6-month side-by-side study against a Met Mast (OWA).

» Vindicator LiDAR completed Wind Assessment validation study against the Met Mast in Janneby, Germany.



Summary

- » The Carbon Trust Roadmap has now supplied the first KPIs for the performance of floating LiDAR devices
- » Developers have now begun to adopt this technology to reduce the cost of offshore wind development



Part 2 – TRIAXYS *Next Wave II*

Directional Wave Sensor



The TRIAXYS *Next Wave II* sensor is used to measure platform motion, waves, and directional wave spectra.

- 1990s: TRIAXYS Sensor developed. Collaborative program between AXYS and Canadian Hydraulics Centre of the National Research Council of Canada.
- 2010: TRIAXYS *Next Wave* is developed.
- 2013: TRIAXYS *Next Wave II* is developed.



TRIAXYS *Next Wave II*

New Sensor



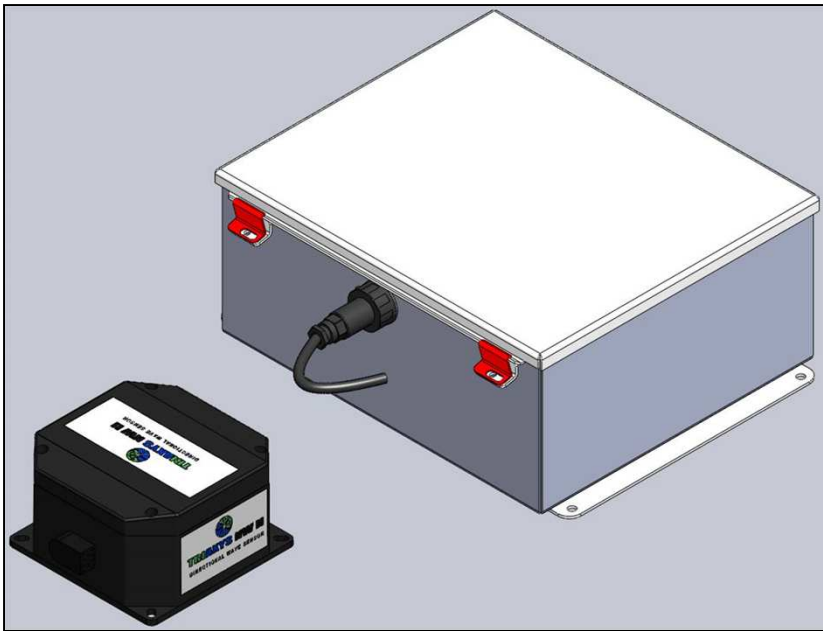
IMU consisting of accelerometers and gyroscopes measuring motion on six degrees of freedom.

- Flux-gate compass (gimbal-mounted) provides direction



TRIAXYS *Next Wave II*

Compact Size



- » 85% reduction in volume
 - 15cm (L) x 15cm (W) x 9cm (H)
- » 1.5kg
- » Intrinsically safe, fibreglass enclosure with IP66 protection classification
- » Option to use other enclosures for specific applications

TRIAXYS *Next Wave II*

Lower Power

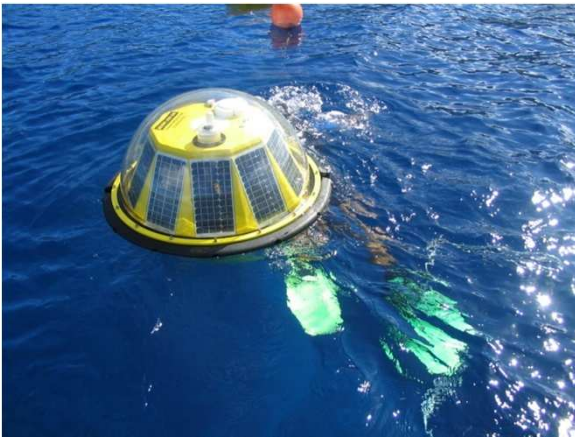


- » 50% reduction in power consumption
- » 12 VDC Nominal
- » 20 min sample every 30 min
 - 2.36 Ah/day
 - 28.32 Wh/day

Phase	Power (W)	Typical Duration (sec)
Sleep	-	-
Warm Up	0.48	50
Sampling	1.5	1200
Processing	2.34	35
Idle	0.48	180

TRIAXYS *Next Wave* II

2.00m Wave Calibration Results



Period (s)	5.00	10.00	15.00	20.00	25.00	35.00
No. Waves	214	106	71	53	42	29
Hav (m)	1.99	2.00	2.00	2.00	2.00	2.01
Tav (s)	5.01	10.02	15.08	20.04	25.06	35.18



TRIAXYS *Next Wave II*

Published Specification

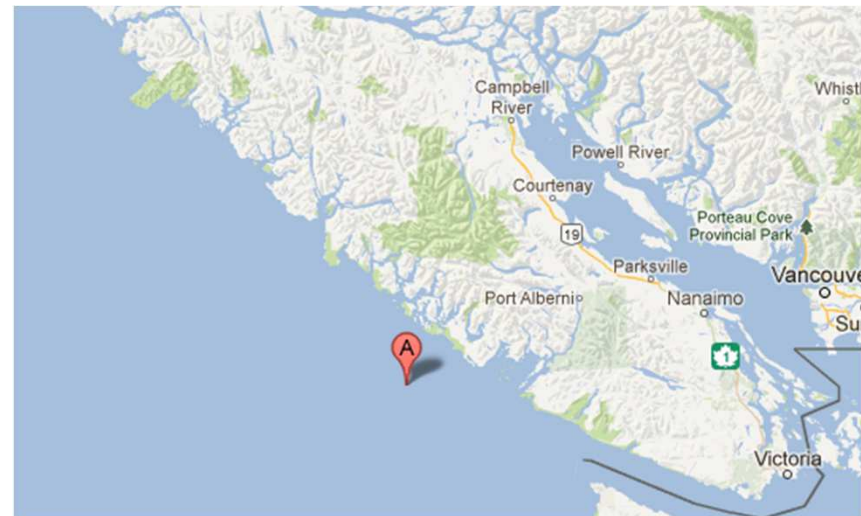
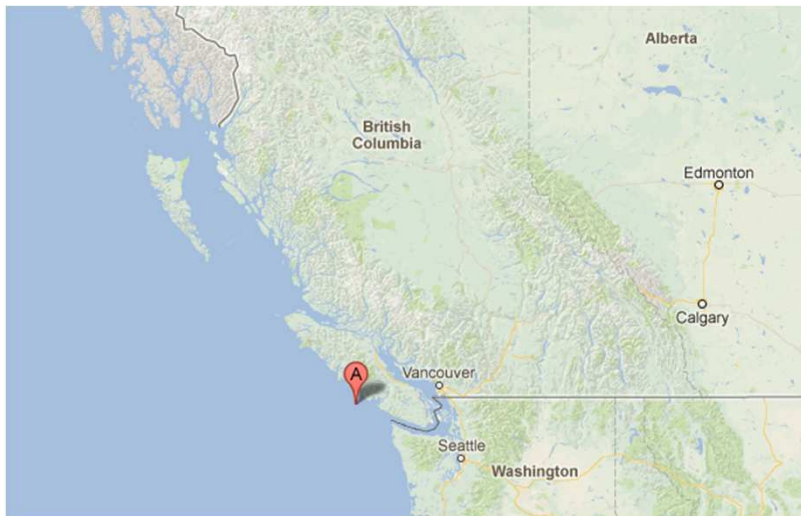
	<i>Range</i>	<i>Resolution</i>	<i>Accuracy</i>
Wave Height/Heave	±20m	0.01m	Better than 1%
Period	1.5–33 secs	0.1 sec	Better than 1%
Direction	0-360°	1°	3°
Sensor Size	15cm x 15cm x 9cm		
Sensor Weight	1.5 Kg		
Power Supply	10 to 20 VDC		
Input/Output	Power and data through single connector		
Communications	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 (Offsets can be applied)		
Data Storage	Internal 8GB: >5 years (expandable to 32GB)		



TRIAXYS *Next Wave* II

Testing

- » Deployed on La Perouse Bank
 - $48^{\circ} 50.3167\text{N}; 126^{\circ} 00.7154\text{W}$
 - Approximately 20 NM off coast of Vancouver Island
 - 75m water depth
 - In proximity to Environment Canada Station 46206 and Scripps Wave Station 195 (Datawell)



TRIAXYS *Next Wave II*

Testing

» Hs – Significant Wave Height (m); 1150 Samples, Approximately 24 Days

Graph



TRIAXYS *Next Wave II*

Testing

- » Tp – Peak Period (s)
 - 1150 Samples
 - Approximately 24 Days

Graph

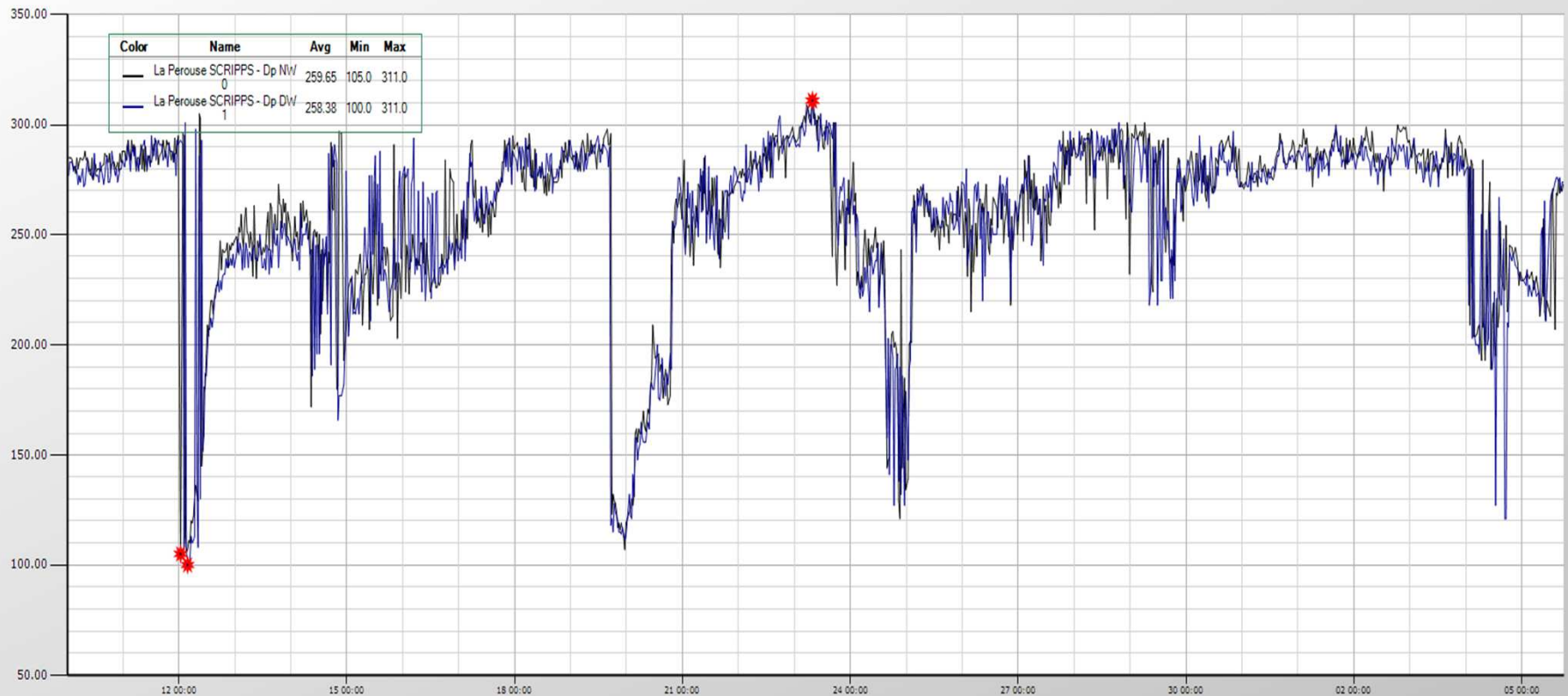


TRIAXYS *Next Wave II*

Testing

- » Dp – Peak Direction (deg)
 - 1150 Samples
 - Approximately 24 Days

Graph



TRIAXYS *Next Wave II*

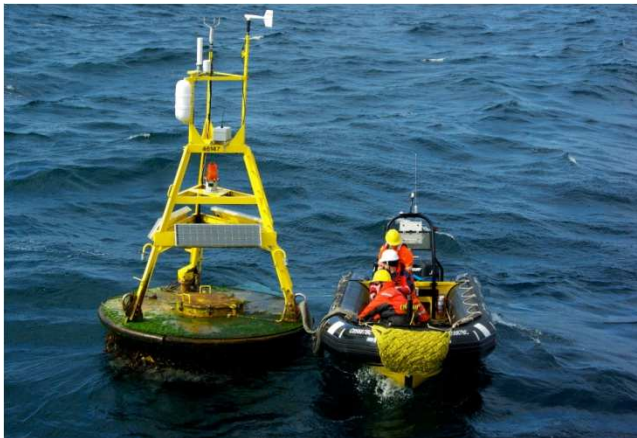
Testing

- » Ta – Average Period (s)
 - 1150 Samples
 - Approximately 24 Days

Graph



Part 3 – Remote Control of ODAS Buoys



- » Environment Canada required remote control & configuration of ODAS buoys in their network.
- » AXYS has delivered 18 systems which allow technicians to:
 - Power cycle the Processor Module & GOES transmitter
 - Make configuration changes to any sampling & transmitting parameters
 - 13 Systems installed
 - 1 power failure, Tuk recovered
 - 4 on test ready to deploy
 - PP-WET



Two Telemetry Methods

Sensor	GOES Resolution	Argos Resolution
Wind Speed	0.1 m/s	0.25 m/s
Wind Direction	1°	5.6°
Barometric Pressure	0.1 hPa	0.125 hPa
Sea Surface Temperature	0.01°C	0.1°C
Air Temperature	0.1°C	0.2°C
Wave Height (Hs)	0.1m	0.1m
Wave Height (Hmax)	0.1m	0.2m
Wave Period	0.1s	0.1s



Argos Latency

8 bytes	Current Wind & Pressure Data
8 bytes	Current Temperature, Wave & Housekeeping Data
8 bytes	T-1 Wind & Pressure Data
8 bytes	T-2 Wind & Pressure Data

Some Possible Failures in the Buoy System

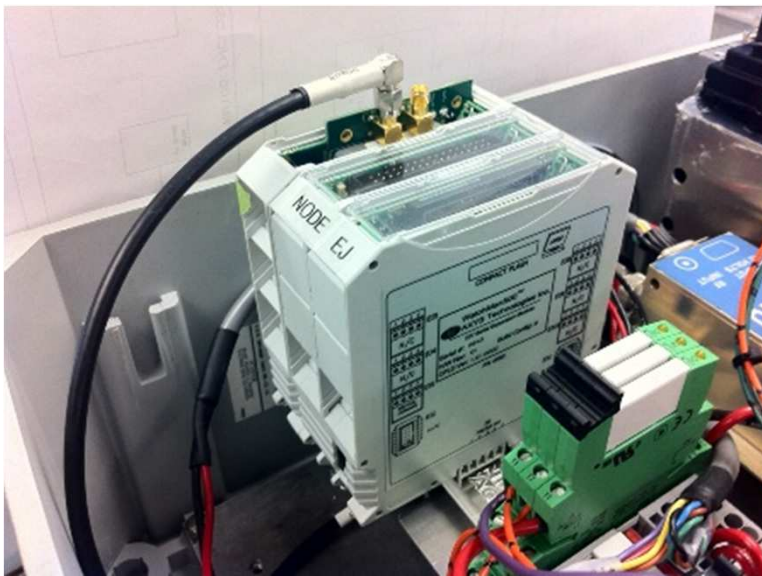


Environment Canada Requested an Iridium Solution

- » Based on proven reliability aboard Automatic Voluntary Observing Ships (AVOS)
- » Hourly Messaging possible
- » Nationwide coverage
- » Cost saving over Argos



Environment Canada Requested an Iridium Solution



- » WatchMan500 system would monitor WM100 & Iridium
- » Collect and log (2G) all GOES messages & when requested, transmit those messages, hourly
- » Pass config changes to WM100 – no code changes



WM100 is a menu driven system

--Transmitter Menu--

```
1 ARGOS ID          SIMAC
2 Format and Load Argos

3 GOES ID / ZAP    4572222A / 4754204E
4 GOES Ch / ZAP    066 / 196
5 GOES Tx Size     0328
6 Transmit Time    00 33 01
7 Transmit Int.    01

W Tx Window(sec) 15
N Tx Centering    ENABLED

8 GOES Transmitter Status Off-line
9 Display Current GOES Setup
A Format, Load, & ZAP Goes Message
B HDR baud=300
C Clear, R F/S Reset, S TxStats

M Return to Main Menu
```

Select an option..

WM100 is a menu driven system

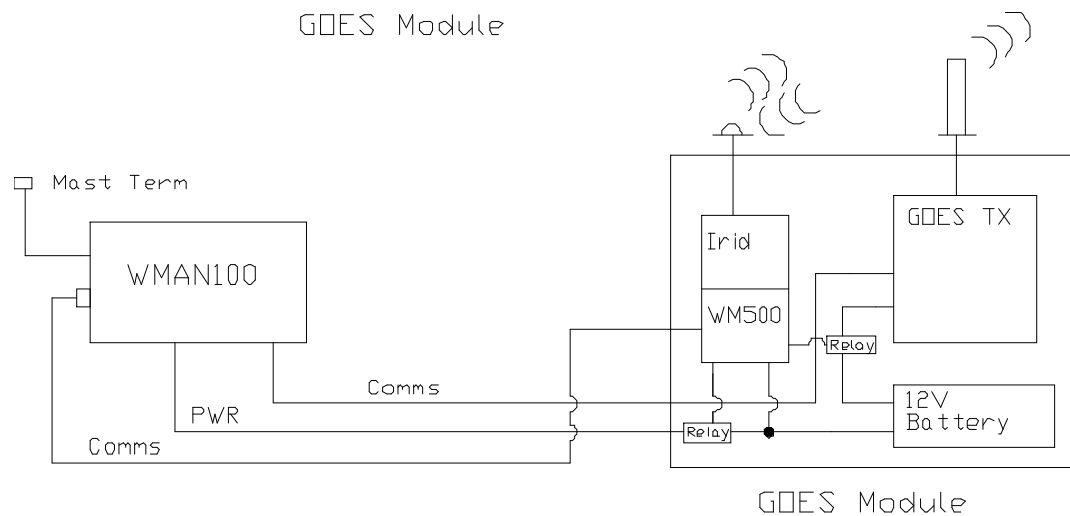
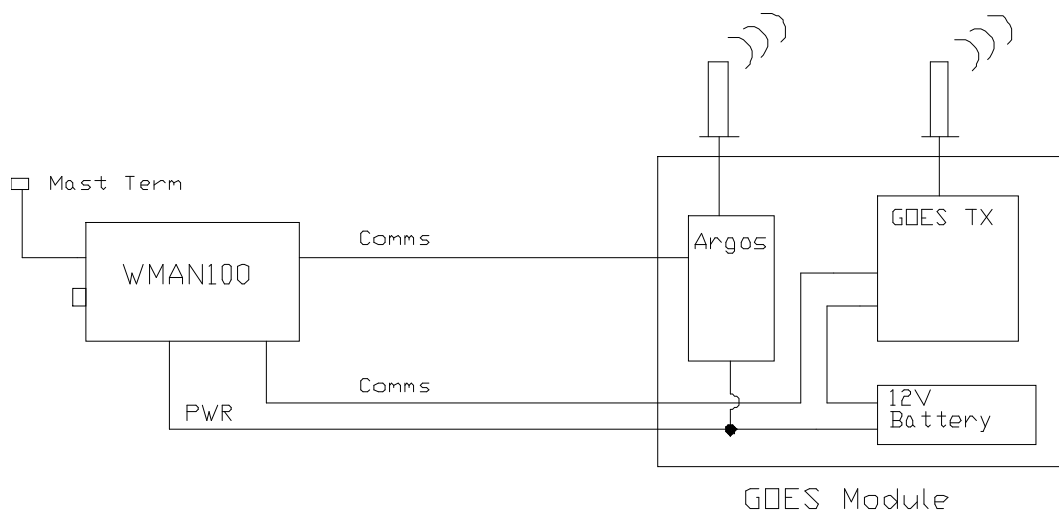
```
-- Acquisition/Coefficients Menu --
1 Present Station ID : 46206
2 AC INT(mins) 0060   AC DUR(mins) 10   AC START OFFSET(mins) 0036
3 WS1CON      0.000E+00  9.800E-02
4 WS2CON      0.000E+00  1.000E+00
5 WV1CON      0.000E+00  8.669E-02
6 WV2CON      0.000E+00  1.000E+00
7 TACON       9.579E+01 -3.593E-02
8 TWCON       9.579E+01 -3.593E-02
9 BP1CON      0.000E+00  1.000E+00
A BP2CON      0.000E+00  1.000E+00
B BATTCON     0.000E+00  2.932E-02
C SOLARCON    0.000E+00  1.000E-02
D LAMPCON     0.000E+00  2.128E-03
E WACON       0.000E+00  7.710E-03
F WLCON       0.000E+00  1.000E+00
G AZ #1 =    -1.900E+01
H AZ #2 =    -1.900E+01
I RHCON       0.000E+00  1.000E-01
J HsTp_Bin   14
```

M Return to Main Menu

Select an option..

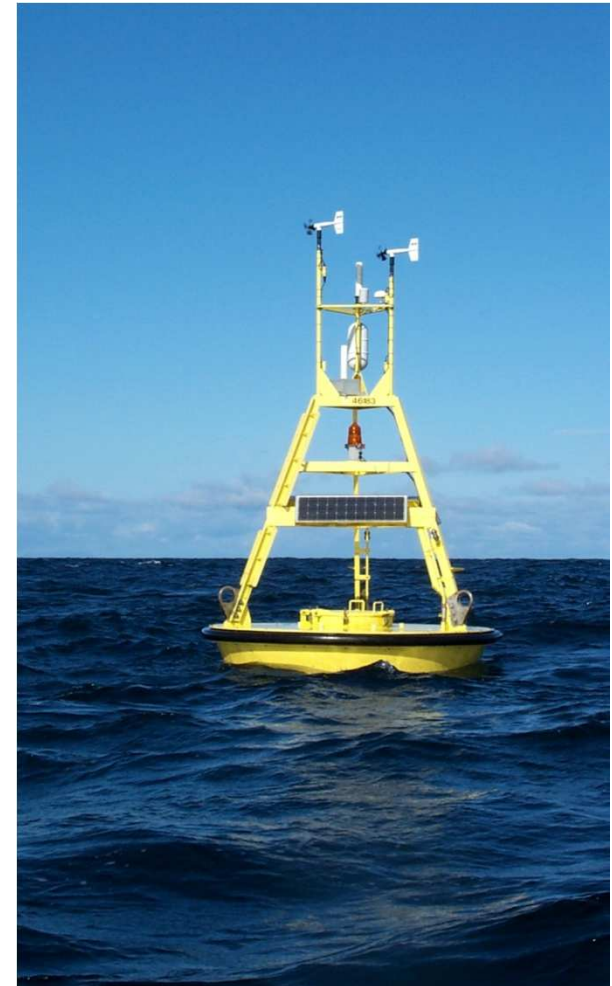


Before and After



The Solution Must Allow For

- » Delivery of complete buoy weather and wave data (including housekeeping & status) messages through Iridium
- » Ability to enable/disable GOES messages relay through Iridium (Backup Data Mode)
- » Ability to change sensor coefficients and suppress sensors
- » Ability to change check-in frequency during standby state.
- » Ability to allow for return messages of buoy/transmitter status/configuration
- » Ability to cycle the power to the WM100 and GOES transmitter.
- » Eliminating high Argos communications and CLS Moored Buoy Monitor Service costs.



No Code Changes to Existing Systems





















- » Command strings are sent to the buoy that mimic keystrokes at a terminal.
- » Anything that a Technician could do at the buoy could be done remotely.
- » Power cycle the GOES transmitter.
- » Power cycle the WM100.



Command Strings Mimic Keystrokes





















Common Header info for each message	\$DMX5A,111220,192248,0000000000000000,,1,1,0,8,A:<D12>:1:MTST1:::<R5>*00
Change Station ID to 46206	A:<D12>:1:46206:::<R5>*00
Disable GOES transmissions	T:<D15>8:::<R1>*00
Disable Transmissions and stay in menu	T:<D15>:8:<R1>*00
Change Transmitter parameters	3:0100e250::4:151::B:1:<R1>*00
Enable Transmitter and run	8:<D45>:::<R1>*00
Set GOES via Iridium to daily	\$DMX5A,111220,192248,0000000000000000,,1,1,0,18,86400*00
Reset WM100	\$DMX5A,111220,191832,0000000000000000,,1,1,0,3,1*00
Reset GOES Transmitter	\$DMX5A,111220,192248,0000000000000000,,1,1,0,4,1*00

Iridium Emails Indicating Check-ins

 sbdservice@sbd.iridium.com	SBD Msg From Unit: 300234010112320	Thu 02/23/2012 5:25 PM	Wman5001
 sbdservice@sbd.iridium.com	SBD Msg From Unit: 300234010112320	Thu 02/23/2012 4:29 PM	Wman5001
 @ sbdservice@sbd.iridium.com	SBD Msg From Unit: 300234010112320	Thu 02/23/2012 4:28 PM	Wman5001
 @ sbdservice@sbd.iridium.com	SBD Msg From Unit: 300234010112320	Thu 02/23/2012 4:27 PM	Wman5001
 @ sbdservice@sbd.iridium.com	SBD Msg From Unit: 300234010112320	Thu 02/23/2012 4:26 PM	Wman5001
 sbdservice@sbd.iridium.com	SBD Msg From Unit: 300234010112320	Thu 02/23/2012 8:27 AM	Wman5001
 sbdservice@sbd.iridium.com	SBD Msg From Unit: 300234010112320	Thu 02/23/2012 4:27 AM	Wman5001
 sbdservice@sbd.iridium.com	SBD Msg From Unit: 300234010112320	Thu 02/23/2012 12:27 AM	Wman5001
 sbdservice@sbd.iridium.com	SBD Msg From Unit: 300234010112320	Wed 02/22/2012 8:28 PM	Wman5001
 sbdservice@sbd.iridium.com	SBD Msg From Unit: 300234010112320	Wed 02/22/2012 4:37 PM	Wman5001
 sbdservice@sbd.iridium.com	SBD Msg From Unit: 300234010112320	Wed 02/22/2012 8:28 AM	Wman5001
 sbdservice@sbd.iridium.com	SBD Msg From Unit: 300234010112320	Wed 02/22/2012 4:27 AM	Wman5001
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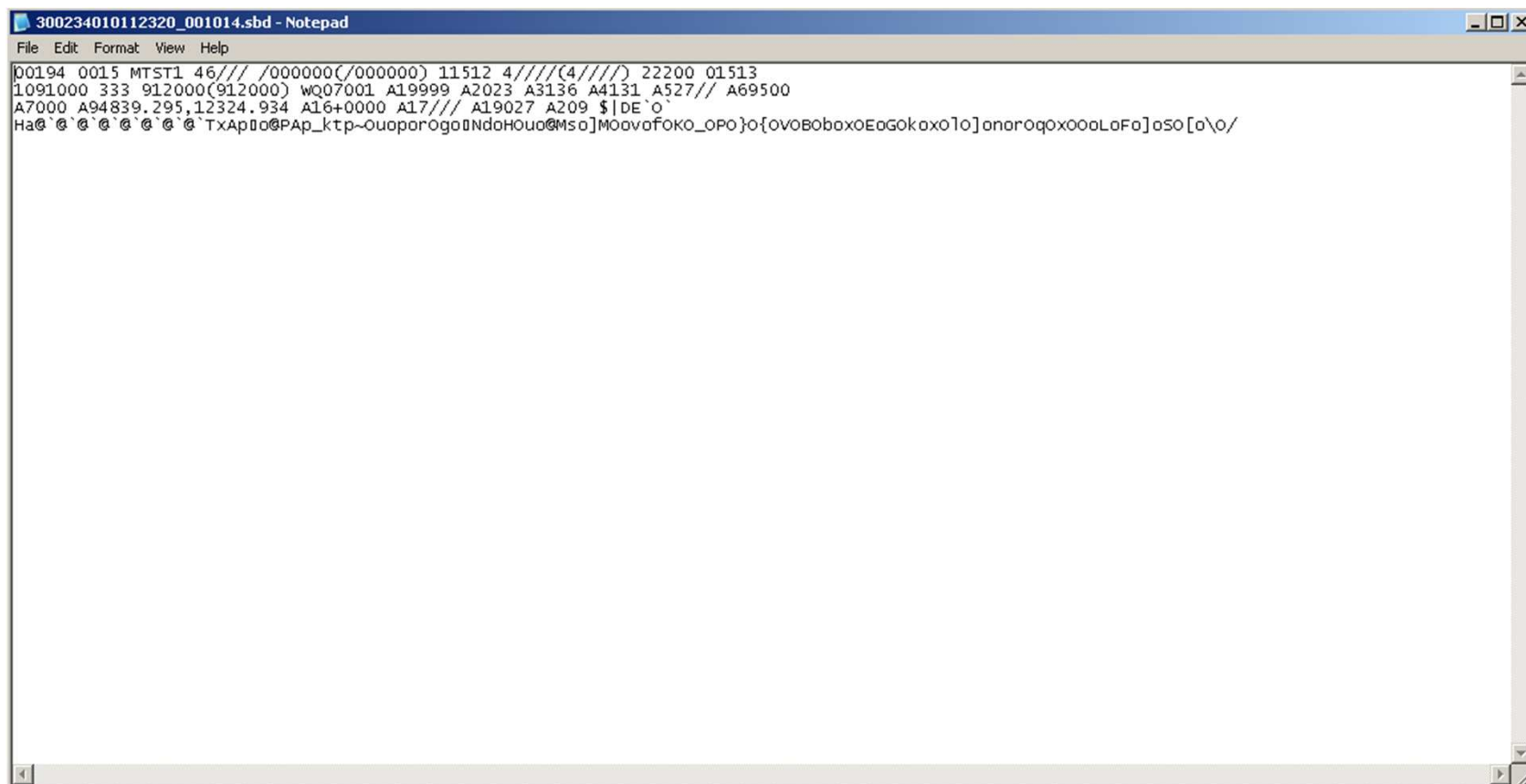


Iridium Email Containing GOES Message (0026 UTC)

 sbdservice@sbd.iridium.com	SBD Msg From Unit: 300234010112320	Thu 02/23/2012 5:25 PM	Wman5001
 sbdservice@sbd.iridium.com	SBD Msg From Unit: 300234010112320	Thu 02/23/2012 4:29 PM	Wman5001
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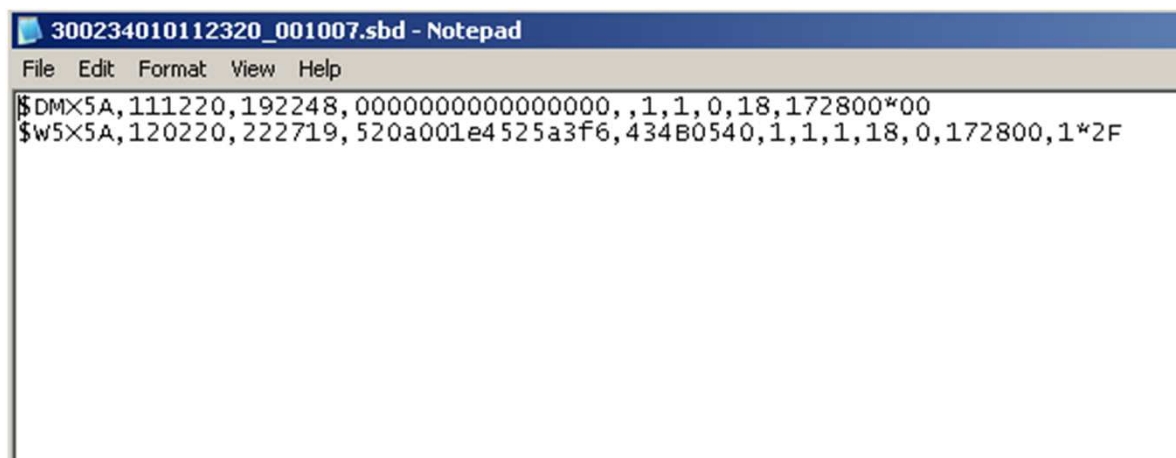


Iridium Email Containing GOES Attachment



```
300234010112320_001014.sbd - Notepad
File Edit Format View Help
00194 0015 MTST1 46/// /000000(/000000) 11512 4////(4////) 22200 01513
1091000 333 912000(912000) WQ07001 A19999 A2023 A3136 A4131 A527// A69500
A7000 A94839.295,12324.934 A16+0000 A17/// A19027 A209 $|DE`o`
Ha@`@`@`@`@`@`TxApI@PAP_ktp~OuoparogoINdaHOuo@Mso]MooovofOKO_OPO}o{ovOBobaxoEoGokaxoTo]anroqpx000LaFa]oSo[o\o/
```

Iridium Email Containing Command Response



A screenshot of a Notepad window titled "300234010112320_001007.sbd - Notepad". The window contains two lines of text representing Iridium command responses. The first line is "\$DMX5A,111220,192248,00000000000000000000,,1,1,0,18,172800*00" and the second line is "\$W5X5A,120220,222719,520a001e4525a3f6,434B0540,1,1,1,18,0,172800,1*2F".

```
300234010112320_001007.sbd - Notepad
File Edit Format View Help
$DMX5A,111220,192248,00000000000000000000,,1,1,0,18,172800*00
$W5X5A,120220,222719,520a001e4525a3f6,434B0540,1,1,1,18,0,172800,1*2F
```

Thank You!

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