

# TRIAXYST™

# DIRECTIONAL WAVE BUOY

## USER'S MANUAL

### Version 13

Manufactured by:



# AXYS

---

T e c h n o l o g i e s I n c

AXYS Technologies Inc  
2045 Mills Road West  
Sidney, British Columbia  
Canada V8L 5X2  
Telephone: (250) 655-5850 Fax: (250) 655-5856  
Email: [info@axys.com](mailto:info@axys.com)

August 2012

This Operations Manual contains trade secrets and confidential information, which are proprietary to Axys Technologies Inc. Its use, reproduction, or disclosure in whole or part without the express written permission of Axys Technologies Inc. is prohibited. This Operations Manual is also an unpublished work protected under copyright laws. If this work becomes published, the following shall apply:

Copyright 2012 AXYS Technologies Inc  
All Rights Reserved  
0226113Z  
August 2012

## Model Identification by Serial Numbers

The TRIAXYS™ Directional Wave Buoy and the TRIAXYS™ Digital Receiver are identified by unique Serial Numbers. Software version numbers are identified for the two EPROMs in the TRIAXYS™ Sensor and Telemetry Module and for the WaveView software. Always provide the TRIAXYS™ Directional Wave Buoy serial numbers in any correspondence with AXYS Technologies Inc. This manual is supplied for use with the TRIAXYS™ Directional Wave Buoy, TRIAXYS™ Digital Receiver and WaveView software. The current revision manual is only applicable to the most current release of firmware and software. Caution is advised when using a manual where the TRIAXYS™ Directional Wave Buoy, TRIAXYS™ Digital Receiver and WaveView software revision numbers are not the same as the ones identified in this manual.

Item	Location	Serial Number/Version
TRIAXYS™ Directional Wave Buoy	Stamped onto the outer vertical edge of the flange of the stainless steel hull between the two sections of the rubber fender	

## Manual Revision History

### Customer Service Contact Information

For Questions, Comments or Requests on the TRIAXYS™ System  
 Contact AXYS Technologies Inc:

Via e-mail: info@axys.com or www.axystechnologies.com  
 Via phone: (250) 655- 5850 or 1-877-792-7878  
 Via fax: (250) 655-5856

Via mail: Axys Technologies Inc.  
 2045 Mills Rd. West Sidney, BC  
 Canada  
 V8L 5X2

Your input into operational functionality and features of this revolutionary system is greatly appreciated and will be taken into account during periodic system design reviews. You will receive all update notices that affect your system.

**CONNECT BUOY BATTERIES AFTER RECEIVING THE TRIAXYS™ BUOY FROM THE  
FACTORY**  
**TRIAXYS™ Wave Buoy Battery Shipping Notice**

TRIAXYS™ Directional Wave Buoys are shipped with all four rechargeable batteries disconnected as dictated by the International Air Transport Administration (IATA) Dangerous/Hazardous Goods Regulations.

You must open the buoy and reconnect the batteries prior to testing and deploying your TRIAXYS™. Please follow the instructions below for connecting the batteries. If you have questions please call AXYS Technologies Customer Service at 1-877-792-7878, or email: [info@axys.com](mailto:info@axys.com)

**TRIAXYS™ Wave Buoy Battery Connection Instructions**



**Figure 1**

**Figure 2**

1. **Removal of the Dome and Clamping Ring.** Refer to **Section 7** of the TRIAXYS™ Manual: Remove the M8 washers and nuts, take off the Clamping Ring and remove the dome (Fig 1 & 2).
2. **Prop Open the Solar Panel Assembly (SPA)**

**WARNING!** The SPA is attached to the sensor module (TAS) and Solar Panel Interface Board via cables. Do not lift the entire solar panel assembly off the hull or the connections may be damaged.

**WARNING!** DO NOT use the circular antenna as a handle to prop open the SPA (Figure 3) as this type of contact will ruin the tuning of the antenna.

Refer to **Section 6.3** of this Manual: Ensure the magnetic key is attached and remove the (10) SS 316 nuts and washers holding down the SPA. Using one of the flip-up black handles, lift one side of the SPA and prop it open, using your hands to support the weight of the SPA until it is resting on an appropriate prop.

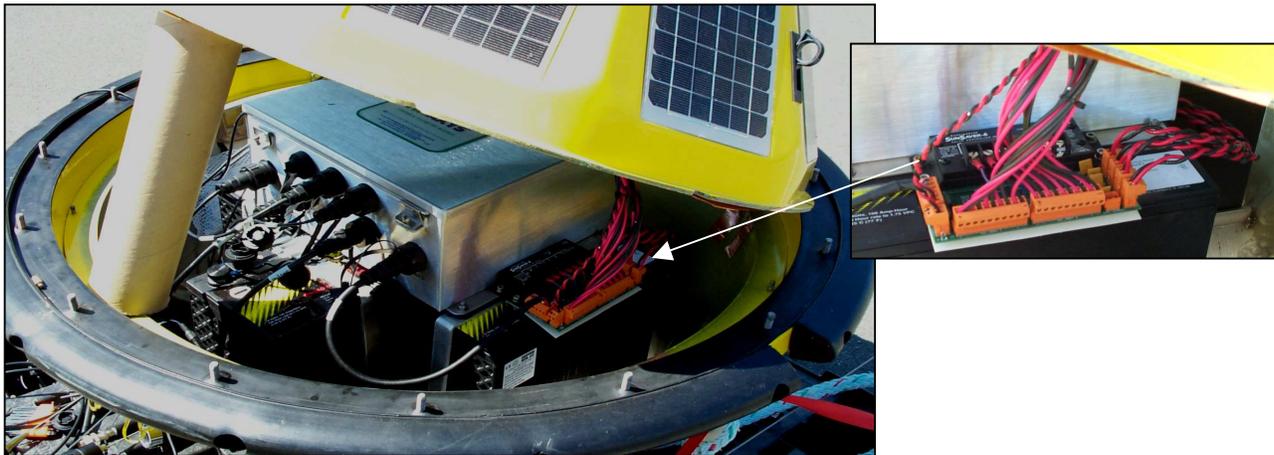


**Fig 3:** VHF antenna/IR Port: do not use these as handles when propping open the SPA.

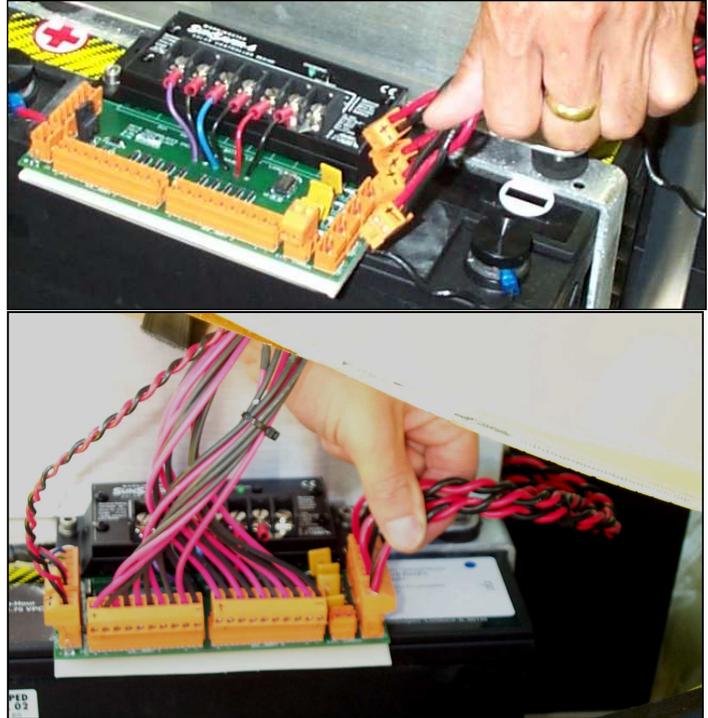
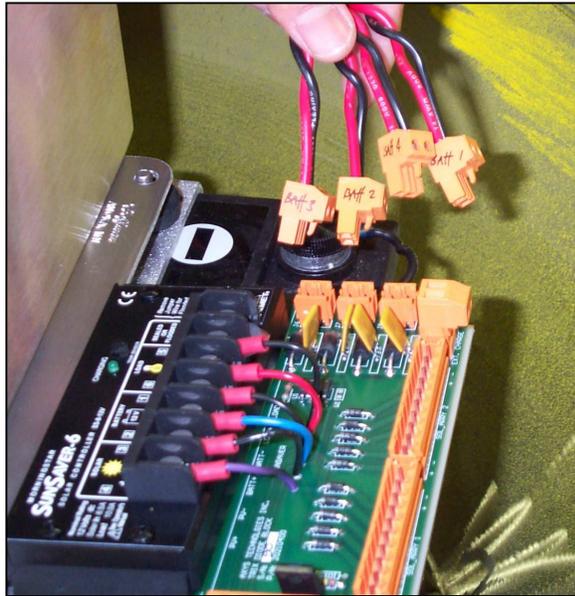


**Fig 4:** Prop open the SPA. Do Not Remove the SPA completely.

3. **Locate the Power Distribution Module:** The Power Distribution Module is located beside the TAS module as shown.



4. **Locate the Battery Connectors** and plug them into the corresponding Terminals There are four battery connectors that are labeled battery 1 thru 4. These must be plugged into the corresponding terminals, which are also labeled (see Figures 6 & 7).



Plug each battery connector into the corresponding terminal.

**5. Removal of the Desiccant Pack from Sealed Bag:**

**CAUTION!:** Desiccant Packs inside the hull of the buoy should be replaced every time the TRIAXYS™ is opened. The pack serves to absorb any moisture that remains inside the buoy once the dome is replaced after servicing. Please ensure that a new desiccant pack is placed in the hull each time the buoy is opened. All TRIAXYS™ buoys are shipped with a spare desiccant pack.

The TRIAXYS™ was shipped with a desiccant pack sealed inside a plastic bag. It is located in a pouch attached to the inside wall of the buoy's hull. Just before sealing up the buoy please remove the desiccant pack from its plastic bag and replace it inside the netting bag. This will ensure any remaining moisture in the buoy is absorbed prior to turning on the TRIAXYS™. Your Spares Kit also contains a spare desiccant pack.

**6. Replacement of the SPA, Dome and Clamping Ring:** Refer to Section 6.3.2 and 6.2.2 in the TRIAXYS™ Wave Buoy Manual for instructions on replacement of the SPA, Dome and associated clamping ring and bolts.

## Purge Port Procedure

The purge port can be used to remove any moist air that remains in the buoy with a dry gas if the Dome has been installed. It can also be used to sample for or remove any possible hazardous gases that may be present inside the buoy hull.

NOTE: Whenever handling this buoy, use proper hazardous gas ventilation procedures and/or an explosive gas detection apparatus if available. This product contains Sealed Lead Acid batteries, which when exposed to extreme temperatures (>40deg C) and/or overcharging, can result in the production of Hydrogen Gas in quantities sufficient to combust in the presence of an open flame or spark. Although the TRIAXYS Directional Wave Buoy carefully controls the battery voltage in order to prevent overcharging, it is recommended that proper handling procedures be followed. There is a purge port on the side of the buoy for forced ventilation of an inert gas (for example Nitrogen) to actively remove any potential hazardous gas build up.

NOTE: Another method of hydrogen generation is through electrolysis. If any electronic equipment is exposed to salt water, there is a potential to generate hydrogen and oxygen in sufficient quantities to support combustion. If a buoy is suspected of having water intrusion, it is very important that these procedures be followed. Always assume that the buoy contains hydrogen.

### HYDROGEN SAMPLING PROCEDURE

- Install the Dome Cover onto the buoy and let the buoy cool for as long as possible.
- Install the Magnetic Key to turn the buoy off.
- Remove the purge port plug.
- If you have a Hydrogen gas detector (Industrial Scientific Model LTX3 12 or equivalent), insert the sample tube in through the purge port and sample the air. If no hydrogen gas is detected, proceed to Section 7.2.1. If gas is detected continue with the purging procedure to evacuate any residual Hydrogen gas from the hull. If no gas detector is available, the hull should be purged as a matter of standard procedure.

### PURGE PROCEDURE:

- Loosen the dome nuts to aid in the ventilation of the buoy
- Tip the buoy up so that the purge port is as high as possible.
- Insert a loose-fitting tube through the purge port into the buoy.
- Pump inert gas (for example Nitrogen) into the buoy for approximately ten minutes at a rate of 2 cfm or greater.
- Turn off the gas and remove the tubing. Resample with the gas detector if available to verify a safe buoy atmosphere or proceed to Section 7.2.1.

# CONTENTS

1. INTRODUCTION .....	1
Features and Specifications .....	1
Polycarbonate Dome - Part #1439 .....	5
Stainless Steel (AISI 316) Hull - Part #1522 .....	6
Rechargeable Batteries .....	7
1.4.1 Power Budget .....	7
1.4.2 Power Regulation and Monitoring .....	8
Solar Panel Assembly (SPA) .....	8
TRIAXYST™ Sensor and Telemetry Module (TAS) .....	9
1.6.1 Power Distribution Module .....	10
1.6.2 Internal Data Logging .....	11
Water Temperature Sensor .....	12
Telemetry Options .....	12
1.8.1 VHF Transmitter .....	12
1.8.2 GSM Transmitter .....	12
1.8.3 IRIDIUM .....	14
1.8.4 INMARSAT D+ Satellite Transceiver .....	14
1.8.5 Orbcomm Satellite Transceiver .....	16
1.8.6 ARGOS Satellite Transmitter .....	17
Obstruction Light .....	17
Infrared Port and Communications Set-up .....	17
Magnetic On/Off Switch .....	17
1.11.3 Magnetic Key .....	18
Cover and Shipping Palette .....	18
TRIAXYST™ Digital Receiver - (TDR) .....	18
2. TRIAXYST™ PROGRAMMING, OPERATION AND TEST MENUS .....	20
1. Communications Setup .....	20
2.1.1 Starting Hyperterminal .....	21
Main Menu .....	24
Run-Time Parameters Menu .....	25
2.3.1 Station ID .....	25
2.3.2 Acquisition Interval (AC INT) .....	25
2.3.3 Acquisition Duration (AC DUR) .....	25
2.3.4 Start Time Offset .....	26
2.3.5 WatchCircle/Beacon Options .....	26
Telemetry Options .....	28
2.4.1 Primary Telemetry Options .....	28
2.4.2 Secondary Telemetry Options .....	34
Real Time Clock .....	39
2.5.1 Set the Date and Time .....	39
2.5.2 Display the Current Time .....	39
2.5.3 Sync Clock With GPS .....	39
Data Logging and Upload .....	39
2.6.1 Logging of Processed Data .....	40
2.6.2 Upload Data Files .....	40
2.6.3 Erasing Logged Data without Opening the Buoy .....	41
Calibration Mode - Service Technicians Only .....	42
2.7.1 Compass Calibration .....	42

System Diagnostics Menu .....	42
2.8.1 Sensor Display at 4Hz .....	43
2.8.2 System Display at 1Hz .....	43
2.8.3 Voltage and Current Display .....	43
2.8.4 Wave Processing Diagnostics .....	44
2.8.5 System Tests .....	46
2.8.6 Reset Boot Times .....	47
3. MOORINGS .....	55
1. Deployment Procedures .....	58
Recovery Procedures .....	58
General Deployment/Recovery Notes .....	58
4. SOFTWARE AND DATA FORMATS .....	59
1. Software .....	59
4.1.1 Cyclic Merging .....	59
4.1.2 Data Sampling and Re-sampling .....	59
4.1.3 Motion Analysis .....	60
4.1.4 Frequency Bands .....	60
4.1.5 Low Frequency Energy .....	60
4.1.6 Directional Wave Analysis .....	61
TRIAXYS™ Data Formats .....	61
4.2.1 File YYYYMMDD.RX .....	62
4.2.2 File YYYYMMDD.WAVE .....	62
4.2.3 File YYYYMMDD.STAT .....	62
4.2.4 File YYYYMMDD.FOURIER .....	63
4.2.5 File YYYYMMDD.NONDIRSPEC .....	63
4.2.6 File YYYYMMDD.DIRSPEC .....	64
4.2.7 YYYYMMDD.HNE .....	65
Logged Data Format .....	66
4.3.1 Processed Wave Data .....	66
4.3.2 4Hz Wave Data .....	66
Orbcomm Transmitted Data Format (Optional) .....	67
INMARSAT D+ (Optional) .....	67
Iridium and GSM (Optional) .....	67
ARGOS Transmission (Optional) .....	67
4.7.1 Description of ARGOS Parameters .....	68
4.7.2 Powering ARGOS ON and OFF .....	70
5. BASE STATION SYSTEM CONFIGURATION .....	72
1. TRIAXYS™ Digital Receiver (TDR) .....	72
VHF Radio Receiver .....	73
5.2.2 Modem .....	74
5.2.3 Antennae .....	74
5.2.4 Operation of the TDR .....	75
GSM Base Station Hardware .....	75
Internet Reception of Buoy Data .....	76
6. TRIAXYS™ APPLICATION SOFTWARE .....	77
7. ASSEMBLY/DISASSEMBLY PROCEDURES .....	78
1. Purge Port .....	78
Dome .....	78
7.2.1 Dome Removal .....	78
7.2.2 Dome Installation .....	79
7.2.3 Damaged Dome Studs .....	79

- 7.2.4 Solar Panel Assembly..... 79
- TRIAXYS™ Sensor and Telemetry Module..... 80
  - 7.3.1 Retrieving Data from the Sensor and Telemetry Module..... 80
  - 7.3.2 Replacing the TRIAXYS™ Sensor and Telemetry Module ..... 81
- Batteries..... 81
  - 7.4.1 Removal of Batteries ..... 82
  - 7.4.2 Replacement of Batteries..... 82
- 8. CARE AND MAINTENANCE ..... 83
  - 1. Dome..... 83
    - Flange Gasket ..... 83
    - Shipping/storage Cover ..... 83
    - Paint Specification ..... 83
    - Hull Vacuum Test Procedure..... 83
- 9. SET-UP AND CHECK-OUT PROCEDURES ..... 84
  - 1. Inside the Buoy ..... 84
    - Sensor and Telemetry Module..... 84
    - Solar Panel Assembly ..... 84
    - Dome Installation..... 84
    - Once the Buoy is Assembled and Powered ..... 84
  - Moorings..... 86
    - 9.6.1 Deployment Procedures ..... 86
    - 9.6.2 Recovery Procedures..... 87
    - 9.6.3 General Deployment/Recovery Notes ..... 87
- 10. GLOSSARY ..... 88
- 11. REFERENCES..... 91
- APPENDIX A - AXYS WARRANTY AND SERVICE LIMITED WARRANTY ..... 92
- APPENDIX B - OBSTRUCTION LIGHT FLASH SEQUENCES & CODES ..... 94
- APPENDIX C: SAMPLE TRIAXYS BUOY FIELD CHECKOUT/DEPLOYMENT RECORD..... 95
- APPENDIX E - TRIAXYS™ FAQ..... 96

## 1. 1. INTRODUCTION

The TRIAXYS™ Directional Wave Buoy can be used to measure non-breaking waves in any of the World's Oceans where a surface following buoy can be deployed. The TRIAXYS™ Directional Wave Buoy is a precision instrument designed and manufactured by AXYS Technologies Inc, which incorporates new technologies that make it an easy to use, rugged and economical buoy for accurate measurement of directional waves. The TRIAXYS™ sensor unit is comprised of three (3) accelerometers, three (3) rate gyros, and a fluxgate compass interfaced to the proprietary TRIAXYS™ Processor. The TRIAXYS™ Processor was developed from the successful low-power Watchman™ payload specifically designed by AXYS Technologies Inc. for the marine environment.

TRIAXYS™ directional wave processing software uses an iterative algorithm based on the Fast Fourier Transform (FFT) analysis to solve the full non-linear equations of buoy motion in six degrees of freedom. The six degrees of freedom are defined by the measured accelerometer (3) and rotational rate gyro (3) signals. Roll, pitch and yaw angles are measured as well as accelerations, displacements and velocities from which heave, surge and sway are determined. The use of surge and sway velocities instead of roll and pitch angles provides a more accurate measure of wave kinematics that defines the direction of wave propagation.

The TRIAXYS™ Directional Wave Buoy holds a Canadian design patent (#91015) and also holds design patents in the United Kingdom (patent #2090912) and United States of America (U.S. Design Patent #D440, 171).

The TRIAXYS™ Directional Wave Buoy can be used as a self-contained data logging system or can be integrated with a variety of telemetry mechanisms. Figure 1.1 shows the types of telemetry available, as well as options for distribution of data once on shore. The buoy is capable of monitoring its moored location through the use of an onboard GPS receiver coupled to a buoy mooring WatchCircle algorithm. This enables secondary transmitters to be activated or initiate a warning on the base station data display.



*Photo Courtesy of AMEC Ltd.*



*Photo courtesy of Telecom Italia.*

**Figure 1: TRIAXYS buoys in operation**

### 1.1. Features and Specifications

The TRIAXYS™ Buoy has many unique features that enhance operational functionality including being Solar Powered, designed with integral impact resistance and having a non-snagging sleek profile to allow easy deployment and servicing. The standard TRIAXYS™ Directional Wave Buoy is comprised of the following:

### **Main Components:**

- Hull Assembly includes:
  - AISI 316 Hull, with Purge Port, Lifting Bridle and Magnetic Key
  - Solar Panel Assembly, including ten 6-watt solar panels.
  - Polycarbonate Dome and SS Clamping Ring.
- Obstruction Light
- Infrared Port
- Inmarsat D+ with GPS receiver (Inmarsat D+ optionally activated) TRIAXYS™
- Directional Wave Sensor and Telemetry Module Four 100 Amp-hours Batteries
- Water Temperature Sensor
- Cover and Shipping Palette
- Spares Kit including:
  - DB9 to Bulgin IR Access Port Cable
  - Spare Dome Nuts and Washers
  - Spare O-ring for the Purge Port
  - Spare Nylock nuts for fastening the TRIAXYS™ Sensor and Telemetry Module
  - Spare Nuts and Washers for fastening the Solar Panel Assembly
  - PCMCIA Compact Flash Data Logger
  - Internal Flash Ram data logger for Processed and Raw 4Hz data

### **Optional Components/Features**

- The TRIAXYS™ Directional Wave Buoy may have some, or all, of the following options:
  - VHF Transmitter System (29-50 MHz)
  - One Synthesised VHF TRIAXYS™ Transmitter with antennae
  - One Synthesised VHF TRIAXYS™ Digital Receiver (TDR), which includes the VHF
    - Receiver, Modem and Power Supply.
    - One copy of the AXYS WaveViewT Software (includes the Archive, Analysis and Display Routines).
    - One Ringo 3 dB Gain Antenna with 30m RG-2 13/U Antenna Cable.
- Two way Inmarsat D+ for wave stats, buoy configuration and position.
- ARGOS Transmission, with or without GPS position data.
- Iridium Satellite Telemetry
- GSM or CDMA Cellular Telemetry (requires WaveViewT Software)

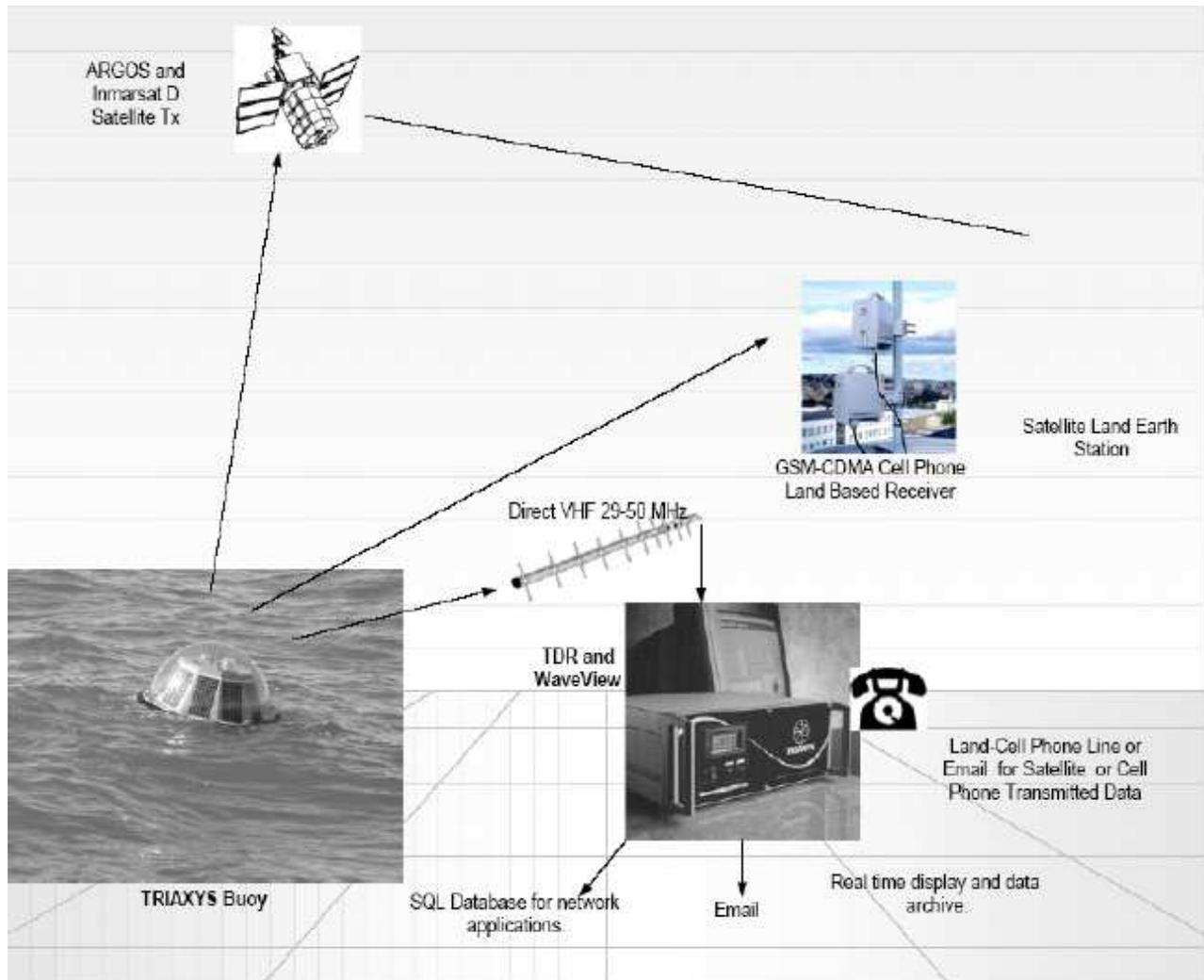
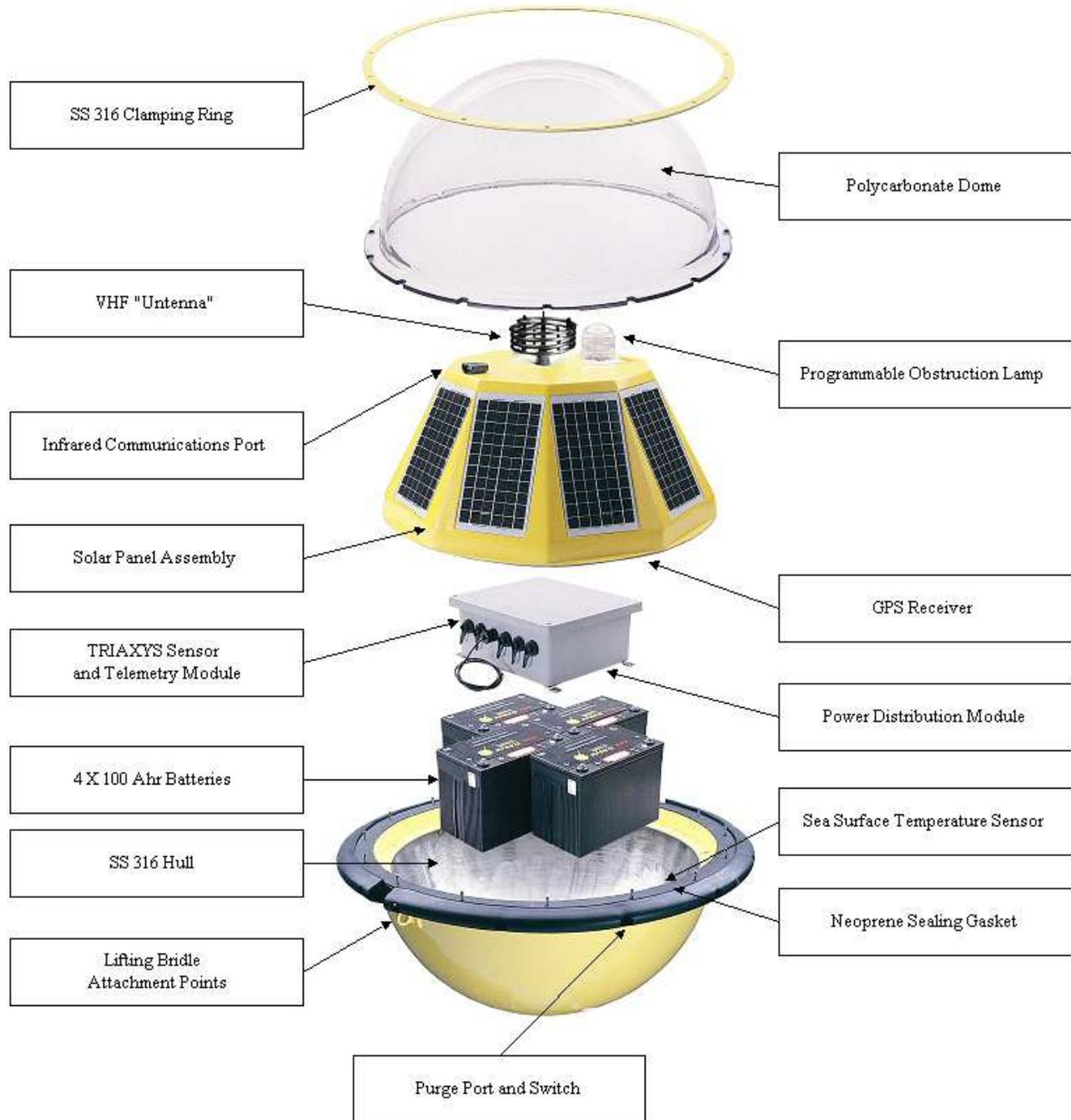


Table 1.1 TRIAXYS™ Directional Wave Buoy System Specifications

Item	Specification		
<b>Physical Description</b>			
Diameter:	1.10m (43.5 inches) Outside bumper		
	0.91m (36 inches) SS hull		
Weight (including four batteries)	197 kg (435 lb)		
Weight (excluding batteries)	90 kg (199 lb)		
Obstruction Light	Amber LED source. Programmable flash sequence. Three mile visibility.		
Purge Port Plug	¾" 16 UNF torqued to 20 N-m (14.5 ft-lbs)		
<b>TORQUE SPECIFICATION:</b> Dome Retaining Nuts	<b>SS 316- M8 nylocks torqued to 18-22 N-m (13-16 ft-lbs)</b>		
<b>Materials</b>			
Hull	Stainless steel		
Dome	Polycarbonate Lexan Se (tested to ASTM D3763 and ISO 6603-2 impact specifications)		
Solar Panel Assembly	Fiberglass over foam		
Clamping Ring	Stainless steel		
<b>Sensors/Processor</b>			
Water Temperature	Thermilinear composite network		
Accelerometers	Flexure suspension servo (Range ±2g)		
Rate	Piezoelectric vibrating gyroscope (Maximum angular velocity ±80°/s)		
Compass	Microprocessor controlled fluxgate (Accuracy ±0.5°)		
A/D and sampling frequency	8 channel 14 bit at 4 Hz		
Microprocessor	PC104 and 80C552		
GPS	12 channel		
<b>Resolution/Accuracy</b>			
	Range	Resolution	Accuracy
Heave	±20m	0.01m	Better than 2%
Period	1.6 to 33.3 seconds		
Direction	0 to 360°		±1°
Water Temperature	-5 to +50 °C	±0.1°C	±0.5°C
<b>Power System</b>			
Operational system voltage	11.0 to 14.1 VDC		
Batteries	4 @ GNB SunLyte 5000X 12 volt, 100 amp hr/battery		
Solar Panels	10 @ 6 watt Siemens SM6		
Smart Charger	Sunsaver-6		
External on/off switch	<b>Turns buoy on when Magnetic Key is removed</b>		
<b>Telemetry</b>			
29 to 50 MHz	Synthesised VHF transmitter (standard)		
Effective radiated output	0.5 watts		
Data format	Binary transmission		
Transmission rate	1200 Baud		
Maximum Range (VHF line of sight)	26 km (14 nautical miles) over water (less over land)		
Other Telemetry	Inmarsat D+, Iridium, Orbcmm, ARGOS, GSM, CDMA		
WatchCircle Beacon	Inmarsat D+ or ARGOS		



**Figure 2: Exploded View of TRIAXYS™ Directional Wave Buoy**  
**1.2. Polycarbonate Dome - Part #1439**

One of the unique features of the TRIAXYS™ Directional Wave Buoy is the polycarbonate dome. This dome is manufactured from a polycarbonate known as Lexan SE. It is extremely strong and resistant to impact (see specifications). It allows the TRIAXYS™ Directional Wave Buoy to be solar powered as well as providing access to the processing unit in the Sensor and Telemetry Module via the Infrared port. The dome must be removed in order to connect the main batteries prior to setup procedures. After the initial

connection, the buoy need not be reopened unless for service or shipping and can be shut off with the magnetic switch.

\*Note: TRIAXYS should not be left "ON" with the batteries connected and dome 'cap' on while awaiting deployment, as batteries will be run down.

Prior to removal of the polycarbonate dome, users should test the internal atmosphere of the buoy with a Hydrogen gas detector inserted into the external purge port on the side of the buoy. Because of the rechargeable lead-acid batteries used to power the system, there is a risk that there may be small quantities of hydrogen gas in the buoy. If any Hydrogen gas is detected, procedures should be followed to neutralize the hazard as outlined in Section 7.1. The removal of the polycarbonate dome of the TRIAXYS™ Directional Wave Buoy from the hull must be carried out carefully in a well-ventilated space away from any sources of flame or sparks.



**Figure 3: Purge port and switch**

When the polycarbonate dome is replaced it is very important that the dome nuts are tightened to the correct torque specification and that a pressure test is performed to ensure a seal between the dome and hull is established prior to deployment, as listed in Table 1.1.

### **1.3. Stainless Steel (AISI 316) Hull - Part #1522**

The stainless steel (SS) hull of the TRIAXYS™ Directional Wave Buoy provides a strong base for the mooring attachment, as well as resistance to wear and tear while in transit, storage and operation. Stainless steel brackets are welded into the hull to ensure strong securing points for the batteries, the Sensor and Telemetry Module and the Solar Panel Assembly. Any material attached to the hull (e.g., shackles, etc.) should be made of 316 SS to prevent galvanic corrosion.

#### **1.3.1 Purge Port**

The purge port on the TRIAXYS™ Directional Wave Buoy is located just below the rubber bumper 90° from the lifting tabs. It defines the "buoy North" direction. If you look downward on the buoy, with the purge port oriented directly opposite your body, you are facing "buoy North". The purge port consists of a 1/2 - 16 UNF nut welded onto the hull, pre-pared to receive a sealed plug. The plug used is a stainless steel 316 Swagelok Hollow Hex Plug, type 8-HPST with an O-Ring.

The purpose of the purge port is twofold. Firstly, a dry gas can be injected into the hull to remove any water vapor that may exist in the air in the buoy (that may condense upon cooling). Secondly, since the batteries used in the buoy are lead-acid, it is possible for hydrogen gas to be released from the batteries if they are overcharged. The buoy should be purged with air or better with an inert gas prior to removal of the polycarbonate dome. Purging of the buoy is imperative especially in the cases where the buoy has been damaged and or flooded.

#### **1.3.2 DeOxo™ Hydrogen Catalyst**

On the inside of the buoy under the Solar Panel Assembly a flat disk container containing DeOxo™ Hydrogen Catalyst is mounted. The DeOxo™ catalyst along with oxygen from air in the buoy will convert free Hydrogen gas to water vapour (H<sub>2</sub>O). The DeOxo™ is a catalyst and is not consumed therefore there is no need to replace it unless it becomes contaminated with seawater if the buoy is flooded. A bag of dessicantis also placed inside the buoy to remove any water vapour. A new bag of dessicant should be replaced at each servicing of the buoy.

## 1.4. Rechargeable Batteries

The TRIAXYS™ Directional Wave Buoy is supplied with four 100 Amp-hour rechargeable, non-spillable, lead-acid batteries that provide sufficient power reserve to operate the buoy indefinitely using a 25-minute sample once-an-hour sampling regime in areas where sunlight hours are 1200 hours per year or more. The batteries are normally recharged through the solar panels. When shipping buoys by air, disconnect the battery leads from the power distribution module. As with any rechargeable batteries, hydrogen gas can be generated under certain conditions. Operators should assume the presence of hydrogen gas and follow purge procedures defined in this manual.

### 1.4.1. 1.4.1 Power Budget

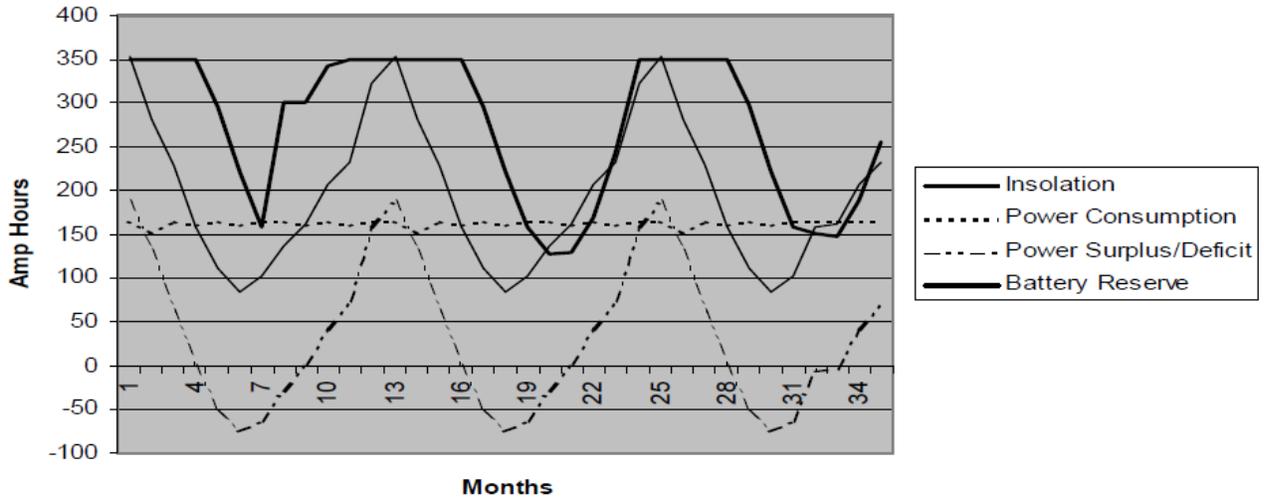
The following table indicates approximate power usage, including transmission of data once per hour. Assuming an hourly 25-minute sample period, with VHF transmission once per hour, then in 75 days the total power usage would be:

$$75 \times 24 \times 0.182 = 327.6 \text{ Ahr}$$

If the light were operating on average eight hours per day, then the power usage of the light in 75 days would be  $75 \times 8 \times 0.120 = 72.0$  amp hours. This would give a total power usage of  $327.6 + 72.0 = 399.6$  amp hours. The battery capacity in the buoy is 400 amp hours. Thus without any solar input, the batteries will last approximately 75 days with hourly transmissions.

Sample Duration (min/hr)	Power Usage (Amp hr/hr)
5	0.93
10	0.116
15	0.137
20	0.160
25	0.182
Obstruction Light	
GpF1 5 (20)s	0.06

The following graph shows a typical charge-discharge curve for a TRIAXYS™ Buoy deployed in latitudes North or South of 40°. This shows the importance of ensuring the buoy is fully charged prior to any new deployments. As a general rule, operators should de-rate the total reserve battery capacity to 350Ahrs to take into account a number of factors such as cold temperatures, age of the batteries, cloudier conditions, and incomplete charging, to name a few.



**Figure 4: Typical TRIAXYS Power Charge-Discharge Curves**

**1.4.2. 1.4.2 Power Regulation and Monitoring**

The TRIAXYS™ Buoy uses an advanced temperature compensated solar charge control module which features accurate pulse width charge modulation, full overload and reverse current protection. They include field adjustments for either sealed or flooded batteries, and the "L" models feature a low battery load disconnect. LEDs indicate charging and low battery. SunSaver controllers (SG-4) excluded are Class 1, Div. 2 certified for hazardous locations.

Note: When the green light on the SunSaver 6 module is lit, this indicates voltage input from the solar panels. This may or may not be sufficient to charge the batteries depending on the present charge of the batteries and amount of solar radiation present.

**1.5. Solar Panel Assembly (SPA)**

The solar panel assembly is bolted to the flange on the inside of the SS hull. It holds the ten 6-watt solar panels as well as the obstruction light, the antenna, the infrared (IR) port, and the INMARSAT D+ transceiver (if ARGOS is chosen as the telemetry option, the INMARSAT D+ transceiver will be replaced with the GPS receiver). The solar panel power junction module is located on the underside of the assembly.



**Figure 5: Solar Power Assembly**

This unit is insulated to reduce excess thermal heat trapped in the air space above the SPA from transferring to the main electronics compartment.

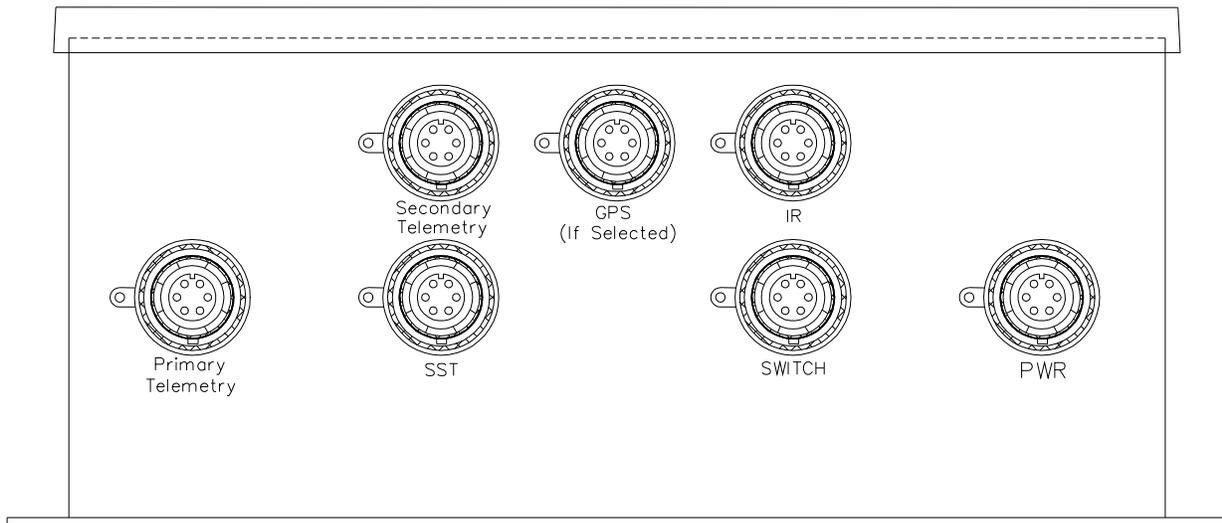
**1.6. TRIAXYS™ Sensor and Telemetry Module (TAS)**

The TRIAXYS™ Sensor and Telemetry Module contains the telemetry system (e.g., VHF transmitter), data logging system, as well as the sensors (accelerometers, rate sensors and compass) and the processing unit. The processing unit samples and analyses the data and controls all the systems in the TRIAXYS™ Directional Wave Buoy. The processing unit is set up through a series of interactive menus. For details of these menus and their operation see Chapter 2. For details of data sampling and analysis software and how the data are handled see Chapter 4.

This unit is an NMEA 4x sealed enclosure. The upper lid has a gasket that face-seals to the lower box when secured with the screws. Users typically only access this enclosure to remove the flash RAM data card (see Section 1.6.2). An

ESD shield covers the electronics and sensors. If the warranty seals are broken without prior authorization or instruction from Axys, future warranty entitlements will be voided.

The connections to the Sensor and Telemetry Module are as indicated in the drawing above. The actual layout of the connections in your buoy may be different to that shown. The TRIAXYS™ Buoy may be configured with either INMARSAT D+ transceiver or ARGOS satellite transmitter, but not both (note: if ARGOS is selected a separate GPS unit is required). The connection for this optional device will be in the upper middle Bulgin connector (as shown in Figure 1.4 as Secondary Telemetry). VHF, Cellular Phone, Iridium or Orbcomm telemetry package, the transmitter will be connected to the port identified as Primary Telemetry in the adjacent figure.



**Figure 6: Side elevation of TRIAXYS Sensor and Telemetry Module.**

Table XX TRIAXYS™ TAS Connector Descriptions

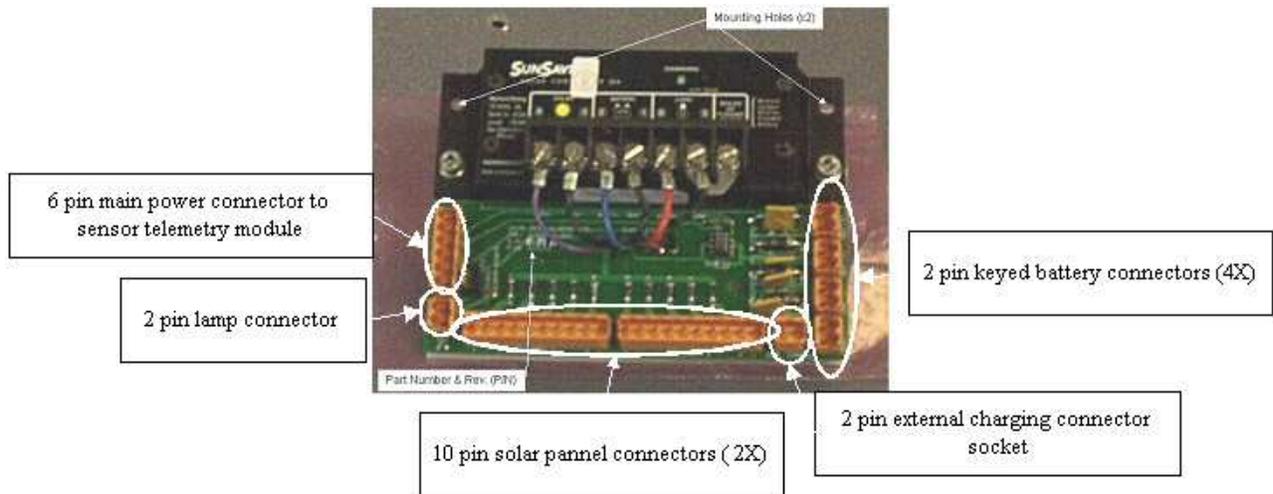
Plug Label	Connector	Description
Primary Telemetry: VHF/GSM/Iridium	RF Bulgin / 6 pin female Bulgin	Coax cable connection to the VHF Antenna or signal/power to the external GSM/Iridium module
GPS	6 pin female Bulgin	Signal-Power connection to the GPS Receiver. Only required with ARGOS.
Secondary Telemetry: INMARSAT D+ or ARGOS	RF Bulgin / 6 pin female Bulgin	Signal-Power connection to the INMARSAT D+ Transceiver or coax cable to the ARGOS Antenna
SST	6 pin female Bulgin	Signal-Power connection to the Infrared Communications Port of Direct Communications Port connection on a PC.
IR Port	6 pin female Bulgin	Signal-Power connection to the Infrared Communications Port or Direct Communications Port connection on a PC
SWITCH	6 pin female Bulgin	Signal connection to the on/off Magnetic Switch
PWR	6 pin male Bulgin	12 VDC Power Input and Current Monitoring connection to the Power Distribution Module

### 1.6.1. 1.6.1 Power Distribution Module

The TRIAXYS™ Buoy uses an advanced temperature compensated solar charge control module which features accurate pulse width charge modulation, full overload and reverse current protection. They include field adjustments for either sealed or flooded batteries, and the "L" models feature a low battery load disconnect. LEDs indicate charging and low battery. SunSaver controllers (SG-4) excluded are Class 1, Div. 2 certified for hazardous locations.

Note: When the green light on the SunSaver 6 module is lit, this indicates voltage input from the solar panels. This may or may not be sufficient to charge the batteries depending on the present charge of the batteries and amount of solar radiation present.

The power distribution module is mounted on the lower mounting bracket of the Sensor-Telemetry module. This allows for easy access when connecting all power leads in the hull. There is an 2 pin connector that allows for charging of the batteries. **However, when using this connector the TAS unit connector and Obstruction Lamp connector should be disconnected.** Having these connected during charging could lead to damage of the the Power distribution module circuit. The charging Voltage through this connector should not exceed 13.5 volts and the applied current should not exceed 5 amperes. **Damage to the Diodes may occur if the current is greater than 6 Amps.** The Diodes are nominally rated at 5 amps.



**Figure 7: Power Distribution Module**

Batteries may also be charged at a higher current individually or as a block if a parallel circuit is rigged. That is to say that all the Positive connectors are connected together and all of the Negative connectors are connected together. **However, since the wires to the batteries are 14 AWG the current should not exceed 15 amps.** To rig this, 5 Weidmuller 2 pin sockets (Axys Part Number 50105020) and 1 Weidmuller 2 pin plug (Axys Part Number 50207015) are needed. Positive contact points and Negative contact points are wired together in parallel. The 4 battery plugs would be inserted into the parallel system. The Weidmuller 2 pin plug would be wired to the battery charger and then connected to the remaining socket.

Batteries may also be charged directly and individually. The maximum specified current is 30 amps. **This is not recommended because charging at this rate would probably damage or degrade the battery.**

### 1.6.2. 1.6.2 Internal Data Logging

The TRIAXYS™ Buoy comes with an internal data logging capability which can be used either as a back-up system in the event of marginal telemetry conditions or as a stand-alone feature. At present, the processed wave data and 4Hz RAW data files can be logged onto a 1 Gbyte PCMCIA Flash RAM card in a format as per Section 4.3 of this manual. The card can be removed from the Sensor-Telemetry Module by opening the lid on the enclosure. Prior to removing the card, ensure that the Magnetic Key has been installed to turn off the buoy power. Once the enclosure lid is opened, depress the release button to eject the Flash Card. The data can then be copied to a PC for archival and/or further processing.

Installation of the card is completed by inserting into the slot (ensure that the alignment and orientation are correct), then seat fully. The diagnostic menu will verify the correct installation. Erase the card using the TRIAXYS™ setup menu. If the RAM card does not have enough free space sufficient for the deployment, data will be not logged after the card is full. The active drive designation for the data flash card is drive "D". If the RAM card ever requires reformatting ensure

FAT 16 protocol is used, not FAT 32 protocol. Data is stored in a directory as follows:

D:\TRIAXYS for processed data  
 D:\TRIAXYS\Raw for unprocessed sensor readings

The following table indicates the approximate storage required on the buoy for processed wave data files at some typical sampling regimes.

Sampling Regime	Processed Standard Files	Raw Data Files
AC INT = 60AC DUR = 25	32 MB/year	692 MB/year
AC INT = 30AC DUR = 20	65 MB/year	1156 MB/year

NOTE: If the card fills up completely, no further data will be recorded.

## 1.7. Water Temperature Sensor

The water temperature sensor is a YSI model 44203 linearized thermistor composite network. The thermistor is mounted on a short length of connectorized cable and potted in a hollow 2\_" long, \_" diameter stainless steel bolt that is screwed into a nut welded at the lowest point of the hull's inner surface. This provides a direct contact thermal connection to the external sea surface.

## 1.8. Telemetry Options

Described below are some of the types of telemetry presently available with the TRIAXYS™ Buoy. The VHF, Orbcomm, Iridium and ARGOS modules are installed within the Sensor-Telemetry enclosure. The GSM and INMARSAT D+ modules are mounted externally to the Sensor-Telemetry enclosure.

### 1.8.1. VHF Transmitter

The VHF Transmitter can be factory pre-set in the 29 to 50 MHz range. Given the transmitter configuration with the small internal antenna, the effective radiated output power is in the order of 0.5 watts. Separate radios are required for the 29 to 38 MHz range and for the 38 to 50 MHz range (some overlap is present). The factory can select any one of the pre-set frequencies. Preset Frequencies are generally ñ0.2 MHz from the chosen centre channel, as this will ensure the radio is completely tuned on any of the up to 16 channels. Typical ranges for VHF transmission are line-of-sight, and depend on the height and type of the receiving antenna and the wave conditions. Under normal circumstances the TRIAXYS™ Directional Wave Buoy will be able to transmit up to 14 nautical miles. Radio propagation over land can significantly reduce the effective radio range. For most jurisdictions, a RF radio license is required for the operation of this type of telemetry.

A new VHF antenna, called the "Untenna" (see Figure 1.3), has been incorporated into the TRIAXYS™ buoy resulting in improved radio performance and increasing the transmit range to a maximum of 14 nautical miles. This antenna is mounted on the upper surface of the Solar Panel Assembly. Care should be taken not to use this antenna as a handle or hit it against other surfaces when servicing, as this will change the tuned characteristics of the unit.

A high gain omni directional Proline Ringo-Ranger antenna is shipped with the TDR. This antenna has been tuned to the factory set frequency. YAGI directional antennae are available as an optional item.

### 1.8.2. GSM Transmitter

The GSM Cellular modem option for the TRIAXYS™ Directional Wave Buoy utilizes a Tri-band GSM cellular module activated on a Circuit Switched Data (CSD) network on either the 900, 1800 or 1900 MHz bands.

The cell phone communication is a one-way data transfer, whereby the Cellular Module on the TRIAXYS™ Buoy will dial a number, obtain a connection and begin to download the data. At the completion of the data transfer, the TRIAXYS™ Buoy Cellular Module will terminate the call. On receipt of the buoy the client is required to install a SIM (Subscriber Identity Module) card for account activation. Refer to Section 2.3.1.2 for set-up procedures, testing and operation.



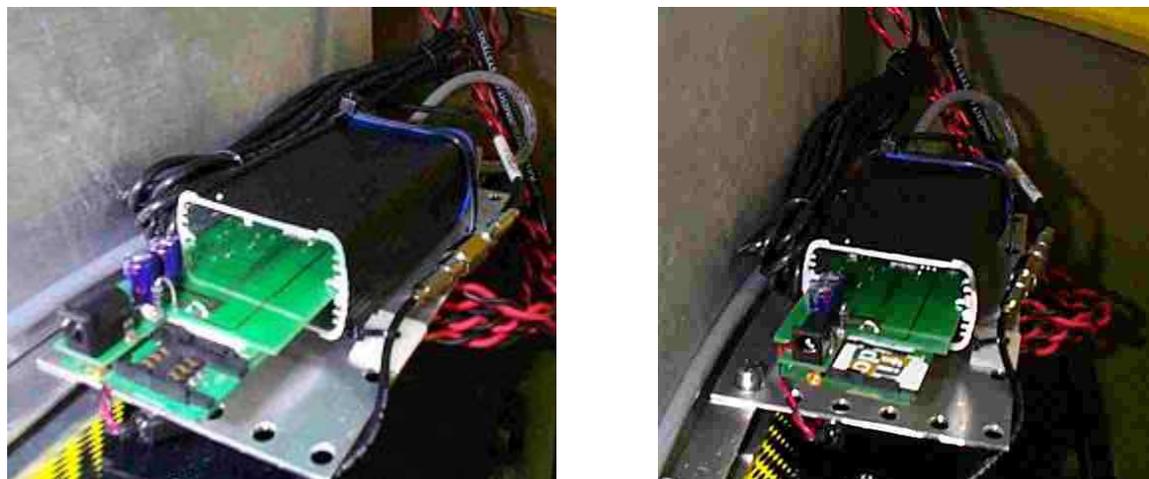
**Figure 8: Cell phone module installed in TRIAXYS Directional Wave Buoy**

#### *1.8.2.1. Cellular Module Activation*

Ensure the TRIAXYS™ Buoy is switched OFF (Magnetic Switch is installed) before continuing!

This module requires a SIM card activated for outgoing data transfer on a CSD network. Remove the cellular module from the TRIAXYS™ Buoy and insert the SIM card as described below:

1. The cellular module is located inside the TRIAXYS™ Buoy, mounted beside the TRIAXYS™ Sensor and Telemetry Module. To gain access to the SIM card slot, disconnect the power, serial DB9 and antenna connectors.
2. Remove screws from one end as shown and carefully slide the circuit board out as shown below. The SIM card is inserted, with the contacts facing into the cellular module and downwards, as shown below.
3. Once the SIM card is installed, slide the circuit board back into the cellular module enclosure and replace the end cap and two screws.
4. Replace the DB9 serial connector, the antenna connector and finally the power connector.



**Figure 9: GSM Cell Phone SIM Card Installation**

### **1.8.3. IRIDIUM**

Iridium is now available as a telemetry solution for the TRIAXYS™ Directional Wave Buoy. Iridium offers a true global service, capable of providing real-time data directly to your computer. With this telemetry, complete wave spectral data can be transmitted in less than two minutes of airtime (2400bps). Iridium's two-way service gives the potential for power savings over VHF since the Iridium system acknowledges that data has been received avoiding multiple redundant transmissions.

Iridium functions in the same way as the GSM option and the appropriate SIM card is required.

### **1.8.4. INMARSAT D+ Satellite Transceiver**

The INMARSAT D+ telemetry option for the TRIAXYS™ Directional Wave Buoy utilizes a SkyWave DMR-200 unit to provide buoy position, wave data, and buoy configuration/remote set-up. The buoy can be configured for GPS position-only data as a WatchCircle beacon, or can be configured to contain both position and wave data.

The INMARSAT communication is a two-way data transfer device, allowing communications between the TRIAXYS™ Buoy and a land earth station providing global coverage. The data is forwarded to a control station, operated by Axys (a registered solution provider), performing all communications with the buoy and providing the data to the user, via secure web page access, a secure FTP account, or by email, in near real-time (please refer to data format information below). The data is sent in packets, and one packet is required for each message: Poll9 (position), optional wave data, and configuration/set-up. INMARSAT communications fees are charged on a usage basis. Please contact Axys for more information regarding INMARSAT D+ transmission costs.

The SkyWave DMR-200 unit is installed at AXYS and can be remotely activated or deactivated as required. The INMARSAT system can fill the role of either the primary or secondary telemetry option.

#### ***1.8.4.1. FTP INMARSAT D+ Data***

FTP data is uploaded hourly to a secure FTP site hosted by AXYS Technologies Inc., and includes all data collected during the hour. Nomenclature for the uploaded files consists of the INMARSAT identifier, the data type, and a date code (i.e. 5941 6558\_Poll9\_06020 1 for position data and 5941 6558\_TRIAXYS Wave\_06020 1 for wave data). The data format within these files is shown below:

Poll 9 file data format:

Datatype, Date, Time (UTC), Inmarsat ID, Latitude, Longitude, Altitude, Temperature,

Battery Voltage. Example Data:

Poll 9,20040602,012205,59416558,48.654444,-123.415833,0,20,14.0

Wave data format:

Datatype, Date, Time (UTC), Inmarsat ID, TAS #, Sample Start Time, Hmax, Hm0, Havg, Tp, T13, Tavg, Mdir, Spread, Pos. Status Flag (1=On WatchCircle, 0=Off WatchCircle), Boot Times.

Example Data:

TRIAXYSWave,20040602,01241

5,59416558,330,01:00,0.0,0.0,0.0,28.5,0.0,15.5,231,75,1,0,0

Configuration data format:

-Datatype, Date, Time (UTC), Serial No., Acquisition Interval, Acquisition Duration,

Offset, Files to transmit (status/wave/nondir/dir/HNE 0=off, 1=on), # of retries, Wave

Threshold, High Pass Filter, WatchCircle Radius, WatchCircle Reset, WatchCircle Check-in, D+ Data, Log Data, Reset, Valid Time, Message ID (A for configuration state,

F for configuration change request)

Example Data:

TRIAXYSConfig,14791,59417744,4,20050105,0314,1.00,5.00,3.00,9.00,TAS040,180.00,20.00,0.00,50.00,1.00,0.

10,0.00,1000.00,1.00,never check-in,0.00,3.00,1.00,1.00,0.00,170.00

#### ***1.8.4.2. Email INMARSAT D+ Data***

Emailed data is formatted identically to FTP data. The subject line of the email messages are formatted as follows:

Poll9: Buoy Serial Number, DataType, Date Received, Time Received (UTC), DataType,

Date, Time(UTC), Inmarsat ID, Message Type, Inmarsat Destination ID, Latitude, Longitude, Boot Times, Temperature, Battery Voltage.

Example:

TAS01200 Poll 9 200501061726 Poll

9,20050106,172616,59417437,137,33,39.853333,50.077778,0,12, 12.20

Wave: Buoy Serial Number, DataType, Date Received, Time Received (UTC), Datatype,

Date, Time (UTC), Inmarsat ID, TAS #, Sample Start Time, Hmax, Hm0, Havg, Tp, T13,

Tavg, Mdir, Spread, Pos. Status Flag (1=On WatchCircle, 0=Off WatchCircle), Boot Times.

Example:

TAS01200 TRIAXYS Wave 200501061729

TRIAXYSWave,20050 106,172956,59417437,1200,17:00,0.4,0.6,1.0,3.5,4.0,3.0,0,30,0,4,0

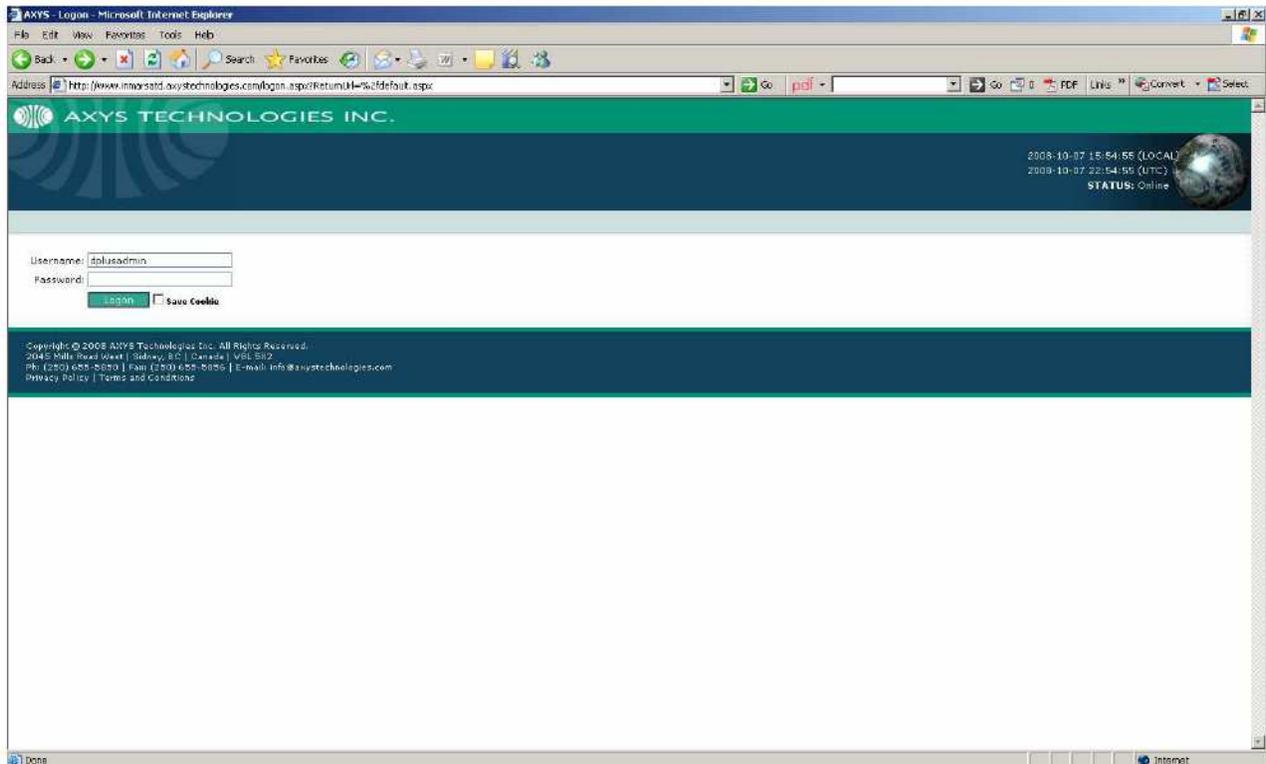
Configuration: Buoy Serial Number, DataType, Date Received, Time Received (UTC), Datatype, Date, Time (UTC), Serial No., Acquisition Interval, Acquisition Duration,

Offset, Files to transmit (status/wave/nondir/ dir/HNE 0=off, 1=on), # of retries, Wave Threshold, High Pass Filter, WatchCircle Radius, WatchCircle Reset, WatchCircle Check-in, D+ Data, Log Data, Reset, Valid Time, Message ID (A for configuration state, F for configuration change request)  
 Example:  
 TAS00040 TRIAXYSConfig 14791 59417744 4 2005-01-05 03:14:46  
 TRIAXYSConfig,14791,59417744,4,20050105,0314,1.00,5.00,3.00,9.00,TAS040,180.00,2  
 0.00,0.00,50.00,1.00,0.  
 10,0.00,1000.00,1.00,never check-in,0.00,3 .00,1.00,1.00,0.00,170.00

**1.8.4.3. Web Interface**

The Web Interface is a real-time interactive application, enabling the user to directly access the AXYS Technologies Inc. data server to view INMARSAT position or wave data collected over any given period, by selecting from a calendar interface near the top of the screen, and to modify selected buoy operating parameters.

To log onto the Web Interface application, enter [www.inmarsatd.axystechnologies.com](http://www.inmarsatd.axystechnologies.com) into the address line of your web browser. The username is your four-digit AXYS Customer ID, and a password will be provided by AXYS. Further instructions can be found in the Inmarsat D+ Web Interface User Manual.



**Figure 10: Inmarsat D+ Web Interface Login Screen**

**1.8.5. Orbcomm Satellite Transceiver**

The Orbcomm transceiver option for the TRIAXYS™ Directional Wave Buoy transmits selected wave data to low earth polar orbiting satellites.

The Orbcomm communication is a one-way data transfer, whereby the transceiver establishes a hand-shake link with the satellite in view prior to the transmittal of data. At the completion of the data transfer, the TRIAXYS™ Buoy Orbcomm transceiver will terminate the call. This transceiver requires a client account to be setup prior to use.

### **1.8.6. ARGOS Satellite Transmitter**

The ARGOS Transmitter is used to transmit a 20 or 28 byte data message and/or a buoy position beacon to a network of Polar orbiting satellites. This is a very low power transmitter that can be activated continuously or only when the buoy has moved from its moored position. The transmitter is programmed to send the data string every 90 to 200 seconds (ID specific), with message updates dependent on the buoy's programmed configuration. Both wave and position data can be transmitted via this telemetry. Additionally, position of the transmitter can be derived from the service provider through successive transmissions. This transmission medium requires that the client get a transmitter ID issued from Service ARGOS or CLS. Rates will vary depending on the registration country of origin and level of service selected.

## **1.9. Obstruction Light**

The amber obstruction light is set for a standard IALA Ocean Data Acquisition System (ODAS) light sequence, namely a group flash 5 every 20 seconds (see Appendix B for interpretation of flash sequences). The light uses a series of amber LEDs which, when lit during a flash sequence, are on for a full second. Any one of 250 other flash sequences can be programmed into the light (see Appendix B for details of how to adjust the light for different flash sequences and light intensities). These adjustments are made on the electronics board that is housed on the light. The light has a visibility range of up to three miles.

## **1.10. Infrared Port and Communications Set-up**

Normal communication with the TRIAXYS™ Directional Wave Buoy is through the Dome via the infra-red serial port using an external PC with an IR port. There is no need to remove the Dome to communicate with the buoy. All the set-up parameters can be adjusted/monitored using this port, which is linked to the processing unit. During sampling, processing and transmission, data are sent out the IR port. These can be monitored to check for correct operation of the buoy (see Section 2.0). To avoid stray signals affecting the TRIAXYS™ Directional Wave Buoy during operation, the receive circuit of the IR port is automatically shut down as soon as the "run" command is initiated (Section 2.7). Reactivation of the receive circuit on the IR port can only occur by re-setting the TRIAXYS™ Directional Wave Buoy (see Section 1.12). The communications setting for programming the buoy are:

```
19,200 baud
8 bits
1 stop bit no parity
no flow control
```

## **1.11. Magnetic On/Off Switch**

The TRIAXYS™ Directional Wave Buoy has a magnetic on/off switch mounted on the inside of the buoy hull under the rubber fender above the purge port (Section 1.3). Using the Magnetic Key (see Section 1.12.1) activates the switch. When the Magnetic Key is in place (looped over the two lugs on either side of the purge

port), the buoy is switched off. Removing the Magnetic Key will cause the processing unit in the buoy to switch on and the infrared port to be activated.

**NOTE:** The TRIAXYS™ Directional Wave Buoy is turned ON when the external Magnetic Key is removed. If the buoy is in Run mode, only resetting the buoy will allow access to the Main Programming Menu via the IR Communications Port. Positioning the Magnetic Key and removing it again resets the buoy. Hold the magnet in the switch location for at least 15 seconds to effect the reset.

It is advisable to make sure that the Magnetic Key is stored safely during deployment so that when the buoy is recovered it can be switched off. If the WatchCircle is activated (Section 2.2.5), and the buoy is left on, then the Beacon will start transmitting as soon as the buoy is outside the WatchCircle.

**NOTE:** The buoy batteries can still be charged if the Magnetic Key is installed and the shipping cover is removed. For air shipment of the assembled buoy, the batteries must be disconnected from the Power Distribution Module, since having the Magnetic Key in place does not meet shipping regulations.

### 1.11.1. Magnetic Key

The Magnetic Key is an orange-coloured plastic rectangular ring. There is a large black spot on the top edge of the long side of the rectangle, this is the location of the embedded magnet. **IT IS IMPORTANT THAT THE LONG SIDE WITH THE BLACK SPOT IS UPPERMOST WHEN THE MAGNETIC KEY IS ATTACHED TO THE BUOY.** The holes in the lugs on either side of the purge port are used for tie-wraps to keep the Magnetic Key attached to the buoy during shipment or storage.



**Figure 11: Magnetic key**

### 1.12. Cover and Shipping Palette

The TRIAXYS™ Directional Wave Buoy is supplied with a shipping palette and storage cover. It is recommended that the buoy remain on the shipping palette with the storage cover on when not in use. The cover should be removed when recharging with Solar (sunlight).

### 1.13. TRIAXYS™ Digital Receiver - (TDR)

The TRIAXYS™ Digital Receiver (TDR) is used to receive the VHF transmitted data from the TRIAXYS™ Directional Wave Buoy. The TDR comprises a VHF receiver and modem, power supply, signal strength meter and loudspeaker, and on/off switch. The TDR needs to be connected to a computer that is running the WaveView™ software. The transmissions are one-way only from the TRIAXYS™ Directional Wave Buoy to the TDR (see Section 5.2).



**Figure 12: TDR**

## 2. TRIAXYS™ PROGRAMMING, OPERATION AND TEST MENUS

When the Magnetic Key is removed from the hull, the TRIAXYS™ Directional Wave Buoy is turned on, and the infrared port is activated. Using a PC with an infrared serial device and configured to the specifications listed in Section 1.11 for serial communications, the operator will be able to configure and program the buoy through the Lexan Dome without disassembling the buoy. The programming and setup menus are described in the following section. Refer to Section 9 for details of Pre-deployment Setup and Checkout Procedures and Section 10 for Glossary of Terms for a more complete description of the setup parameters. If the buoy has been left unattended for a period of time after removing the Magnetic Key, the buoy will likely be in "Run" mode and need to be reset with the Magnetic Key to activate the programming and setup menus. Please note: When programming the TRIAXYS™ buoy, if the programming terminal is left inactive for longer than one (1) minute, the TRIAXYS™ operating system will automatically back up to the previous menu. This process will continue back through the menu tree until the main menu is displayed. If there is no activity on the main menu for more than one minute, then the buoy will automatically enter the "RUN mode".

The TRIAXYS™ Buoys are available with a number of telemetry configurations. As such there will be variations in the firmware that configures and controls each of the different telemetry options. Table 2.1 lists the currently developed telemetry options and the firmware variant that will be installed in the system. Note that the firmware versions referenced in the buoy will have numbers such as ver. 3.32 and will increment periodically with new updates. We use the variants 1 to 6 in the following table merely to indicate that there are different versions of firmware applicable to that telemetry pairing. The firmware differences only affect Menu Item #2, Telemetry Options.

Table 1.3 Firmware Variations and Telemetry Pairing

		Secondary Telemetry	
	None	INMARSAT D+	ARGOS
Primary Telemetry			
None	1	2	1
VHF	1	2	1
IRIDIUM			
GSM	3	4	3
ORBCOMM	5	6	5

### 1. Communications Setup

The TRIAXYS™ buoy can be accessed in a number of ways for programming. This procedure addresses communications using the JetEye IR port and cable provided with the TRIAXYS™ buoy. No special software is needed (most commercial communications software will work) as the buoy firmware provide a menu-driven interface that can be accessed by almost any terminal program. This procedure demonstrates the process using the Windows Hyperterminal program.

What you will need:

- TRIAXYS™ buoy
- JetEye IR port and cable (in spares and accessories kit)
- HyperTerminal program installed on your PC (you may need your Windows CDROM if HyperTerminal is not already installed). If HyperTerminal is not installed on your machine and you don't have access to your Windows CDROM, you can download and install a free version of HyperTerminal Private Edition (HPTE) from <http://www.hilgraeve.com>

Note: PDA's with IR Ports can be used if terminal software has been configured.

### 2.1.1. Installing the JetEye IR device

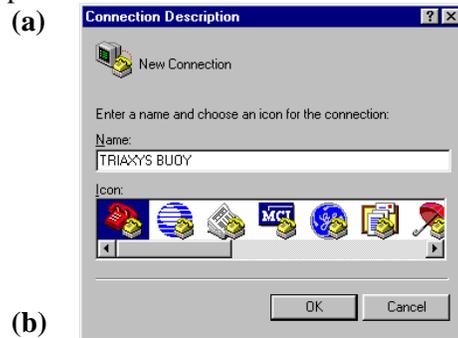
Plug the JETEYE into an available 9-pin Serial COM port on the computer.

Make a note of the COM port number used (1,2,3,4...).

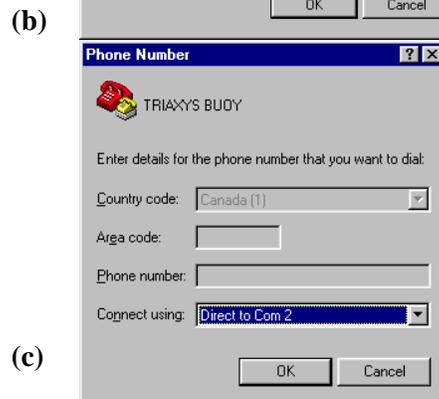
Secure with the strap provided (or hold) the JetEye about 1550cm from the IR port on TRIAXYS™.

### 2.1.2. 2.1.1 Starting Hyperterminal

1. In Windows, click Start Button | Programs | Accessories | Communications |
  - a. HyperTerminal to open the HyperTerminal window.
  - b. Double click on the Hyperterm.exe to run HyperTerminal.
2. In the Connection Description window (Figure 13a), enter TRIAXYS Buoy in the Name field and click OK to continue.



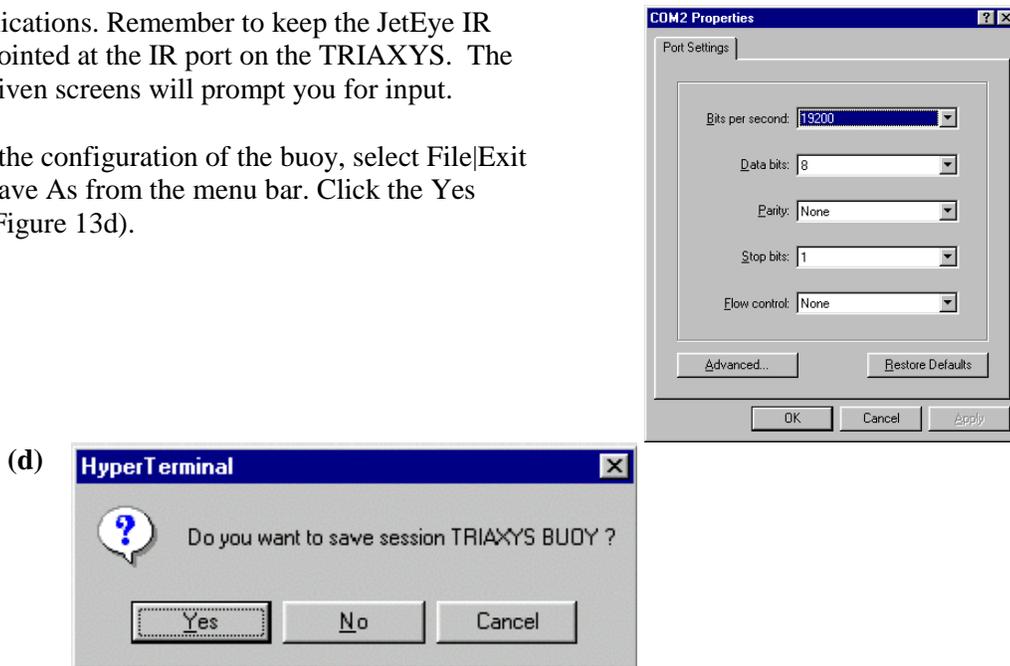
3. In the Connect To window (Figure 13b), click on the down arrow for the Connect using: drop-down menu selections and select the COM Port to which the cable is connected. In this example the cable is connected to COM2:
4. The other fields in the window will gray out and the Direct to COM2 is now set. Click OK to continue.



5. The COM2 Properties window (Figure 13c) will appear. Set the Bits per second to 19200, Data Bits to 8, Parity to None, Stop Bits to 1, and Flow control to None, then click OK to continue.
6. The Terminal Window will now be displayed and you can now begin programming the TRIAXYS™ buoy. Remove the magnetic switch to activate the buoy

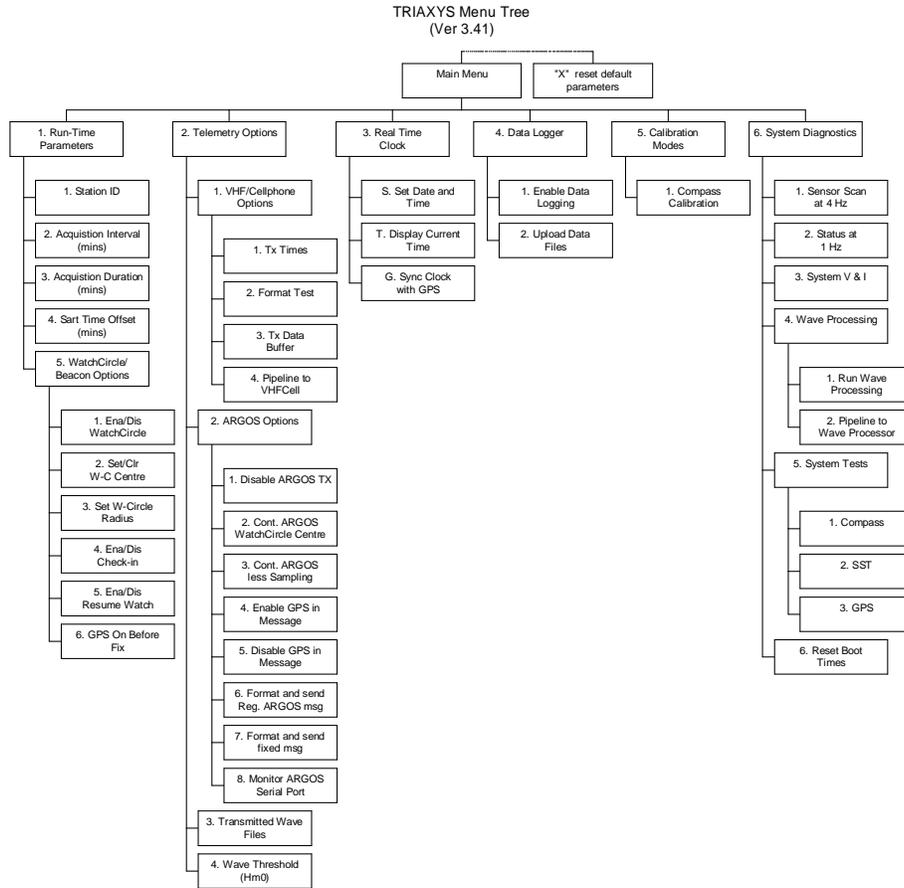
communications. Remember to keep the JetEye IR device pointed at the IR port on the TRIAXYS. The menu-driven screens will prompt you for input.

7. To save the configuration of the buoy, select File|Exit or File|Save As from the menu bar. Click the Yes button (Figure 13d).

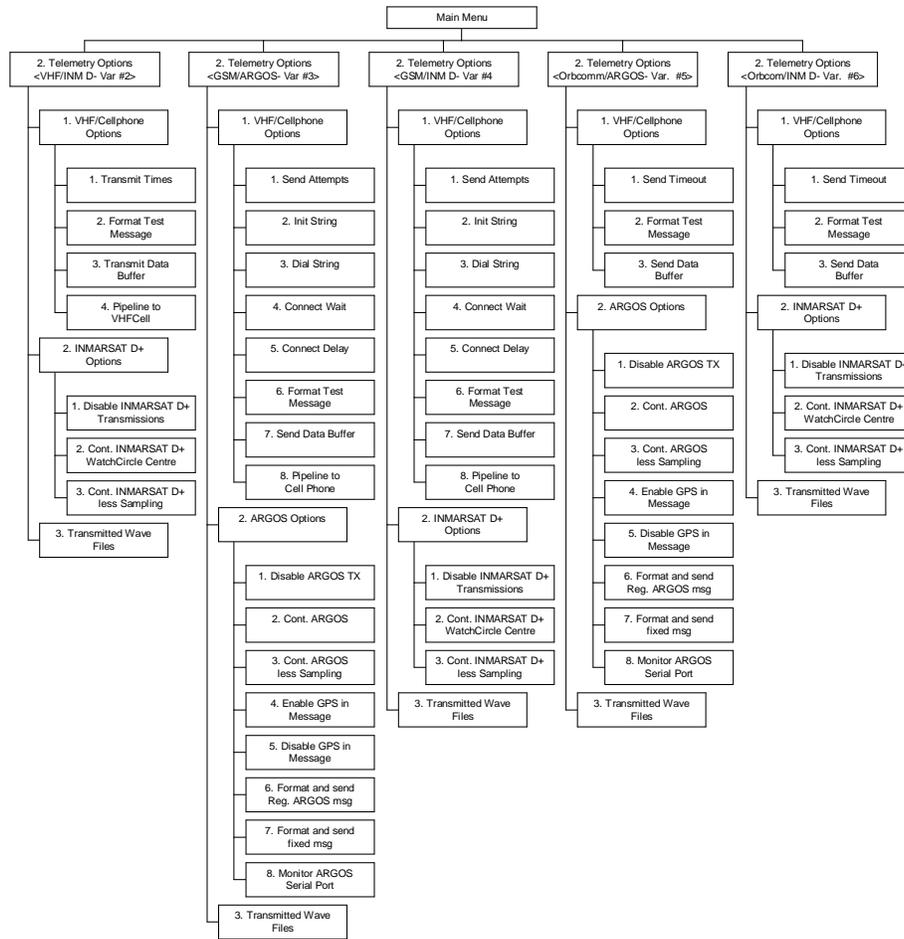


**Figure 13: Hyperterminal windows including a) Connection Description, b) Connect To, c) COM2 Properties, and d) Save confirmation.**

The following menu tree is specific for buoys configured with a VHF and ARGOS transmitter and is identified as a type 1 firmware variant as listed in Table 2.1.



This basic structure is valid for all firmware releases with the exception of the differences noted in the Main Menu Item #2 "Telemetry Options". The following table summarizes variants #2-6 of the applicable telemetry configurations. The setup of these parameters will be discussed more extensively later in this chapter.



The following sections will describe each of the menu items in hierarchical flow. This is not necessarily the sequence that an operator would follow when testing and configuring a buoy for deployment.

## 2.2. Main Menu

To reach the Main Menu, the user is required to reset the buoy with the magnetic key. After removal of the magnetic key, the reset of the system can take up to 10 to 15 seconds before the following menu should appear. It is from this point, that all other menus are accessible. See Section 10 Glossary for definitions for all acronyms and contractions used within the programming menus.

--- Axys Environmental Systems ---  
 TRIAXYS Directional Wave Buoy Ver 3.41

### MAIN MENU

- 1 Run-Time Parameters
- 2 Telemetry Options
- 3 Real Time Clock
- 4 Data Logger
- 5 Calibration Modes
- 6 System Diagnostics

R Run

Select an option.. R

Not listed in the options under this menu is a command that will reset all settings on the buoy to the factory defaults. You should do this when you receive your buoy from Axys or when you want to globally reset all the settings. Axys technical support may instruct you to do this when trouble shooting a buoy problem. When in this menu, type an "X". The user will be prompted with a dialogue box confirming that you want to proceed with a system reset. To continue enter a "Y" to complete the acceptance of factory defaults. If you do not wish to proceed, then enter an "N".

## 2.3. Run-Time Parameters Menu

By selecting 1 from the Main Menu, the user can access the Run-Time Parameters Menu, where the buoy ID, sampling parameters and WatchCircle can be set.

Run-Time Parameters

```

1 Station ID                : TAB00801
2 Acquisition Interval (mins) : 0060
3 Acquisition Duration (mins) : 20
4 Start Time Offset (mins)   : 0000
5 WatchCircle/Beacon Options : Disabled
    
```

M Return to Main Menu

### 2.3.1. Station ID

By selecting 1 at the Run-Time Parameters Menu, the user can enter an Identification string for the specific system. Note: The string is limited to 12 characters long. The default factory setting is set to the buoy serial number, i.e. TAB00781.

### 2.3.2. Acquisition Interval (AC INT)

By selecting 2 at the Run-Time Parameters Menu, the user can set the Acquisition Interval (AC INT) in minutes. The value must divide into 24 hours (1440 minutes) evenly, with the lowest allowable value being 5 minutes. The default factory setting is set to 60 minutes.

Note: This means that only the following Acquisition Intervals (in minutes) are valid: 5, 6, 8, 9, 10, 12, 15, 16, 18, 20, 24, 30, 32, 36, 40, 45, 48, 60, 72, 80, 90, 96, 120, 144, 160, 180, 240, 288, 360, 480, 720, 1440. The AC INT must be longer than the AC Dur.

### 2.3.3. Acquisition Duration (AC DUR)

By selecting 3 at the Run-Time Parameters Menu, the user can set the Acquisition Duration (AC DUR) in minutes. This value must be a whole number in the range of 1 to 35 minutes. If 35 minutes is entered, the value for the Acquisition Duration will default to the maximum allowable of 34.14 minutes. The default factory setting is set to 20 minutes.

Note: The AC DUR must be at least 3 minutes shorter than the AC INT when logging data on board the buoy. More time should be allowed if multiple transmissions are to be sent from the buoy via VHF or GSM. This will also depend on the file types transmitted.

### 2.3.4. Start Time Offset

By selecting 4 at the Run-Time Parameters Menu, the user can offset the sample start time from the top of the hour. The default factory setting is set to 0.

### 2.3.5. WatchCircle/Beacon Options

By selecting 5 at the Run-Time Parameters Menu, the user is directed to the WatchCircle/Beacon Parameters Menu. This will allow the user to configure a secondary location beacon satellite transmitter if installed on the buoy. The benefit of this feature allows for the secondary transmitter only to be active when either the buoy has moved off of a programmed moored location or when checking in on a set schedule. Typically the users pay only for when the secondary transmitter beacon is active.

**NOTE:** The user should be aware that many of the features in this menu are automatic. For example if you are establishing a WatchCircle centre and have removed the key, the buoy will be locking onto the GPS signal to obtain a valid location. If you are delayed in the deployment or in a fast moving current, the established centre may be set prior to the buoy being deployed resulting in the buoy being outside the WatchCircle radius and activating the beacon. If you are only using Inmarsat D+ or ARGOS during WatchCircle alarm events or during its check-in schedule, disable the Inmarsat D+/ARGOS transmitter in the telemetry menu.

#### WatchCircle/Beacon Parameters

```

1 Enable/Disable WatchCircle      : Enabled
2 Set/Clear WatchCircle Centre    : None
3 Set WatchCircle Radius          : 1000 meters
4 Enable/Disable Check-In        : Enabled (14 day) for (30 mins)
5 Enable/Disable Resume Watch    : Enabled
6 GPS On before Fix Delay        : 5 mins
M Return to the Previous Menu
  Select an option..
    
```

#### 2.3.5.1. Enable/disable WatchCircle

By selecting 1 at the WatchCircle/Beacon Parameters Menu, the user is able to toggle the WatchCircle status (Enabled/Disabled). This option must be enabled for the WatchCircle (Inmarsat D+/ARGOS) beacon to be active. If the buoy GPS receiver reports a position outside of the WatchCircle radius or does not get a GPS position, the buoy will activate the WatchCircle transmitter beacon. The default factory setting is set to Enabled.

#### 2.3.5.2. Set/Clear WatchCircle Centre

By selecting 2 at the WatchCircle/Beacon Parameters Menu, the user is able to manually enter a latitude and longitude position for the buoy. If no position is set, it will be indicated by the word "NONE". If a position is present, but you would like to change it, selecting 2 will also prompt you through clearing the centre.

If the WatchCircle is enabled and a position is not entered (i.e., NONE), the buoy will acquire a GPS position just after entering the RUN mode (see 2.1.5.6), and then continue in the Normal RUN mode. If the WatchCircle is Disabled, then a Position is not applicable and option 6 will not be performed. The default factory setting is set to none.

If the deployment location is not known, the Clear WatchCircle Centre command is selected. Once this command has been initiated the buoy can be left to run or restarted (attach Magnetic Key and remove at any later time), resulting in the buoy waiting for a default of 20 minutes, at which time the position acquired by the GPS will be saved as the WatchCircle Centre. The 20 minute default time can be changed, see Menu Item #6 below.

```
Enter up to 10 characters for Latitude eg: 4839.2676N
[deg][minutes.decimalminutes][N (or)S] : ////.////N

Enter up to 11 characters for Longitude eg: 12324.9691W
[deg][minutes.decimalminutes][E (or)W] : /////.////W
WatchCircle Centre ////.////N, /////.////W; Diameter 1000m
```

If, for whatever reason, the buoy cannot establish a WatchCircle centre, the transmitter Beacon is turned on and transmits until a WatchCircle centre can be found or until the buoy is recovered and reset (on the initial deployment).

### ***2.3.5.3. Set WatchCircle Radius***

By selecting 3 at the WatchCircle/Beacon Parameters Menu, the user may enter (in metres) the distance limit for the WatchCircle Radius. The acceptable range is from 100m to 5,000m. The default factory setting is set to 1000m.

### ***2.3.5.4. Enable/Disable check-in***

By selecting 4 at the WatchCircle/Beacon Parameters Menu, the user may Enable or Disable the WatchCircle Check-In routine. If enabled, the buoy will transmit messages using the WatchCircle Transmitter beacon at the specified check-in time interval. This provides a means of checking for proper operation of the beacon, as the beacon will normally be turned off as long as the buoy stays within the WatchCircle radius. The default factory setting is set to 14 days, 30 minutes.

### ***2.3.5.5. Enable/Disable Resume Watch***

By selecting 5 at the WatchCircle/Beacon Parameters Menu, the user may Enable or Disable the Resume Watch function. If enabled, and the buoy re-enters the WatchCircle, the beacon will turn off. If disabled, once the buoy leaves the WatchCircle for the first time, the beacon will continue to transmit regardless of whether the buoy subsequently re-enters the WatchCircle. The default factory setting is set to enabled.

```
Do you want to change WatchCircle Check-In? (Y/N)..N

Enter Check-In Time Interval in days (max 250) : 14

Enter Check-In Time Duration in Minutes (max 120) : 30
```

### ***2.3.5.6. GPS On Before Fix Delay***

By selecting 6 at the WatchCircle/Beacon Parameters Menu, the user may enter the time (in minutes) the GPS will be On before a fix is established. If the WatchCircle is enabled and there is NO defined WatchCircle centre, the GPS will acquire a position for the amount of time set in the "GPS on Before Fix Delay" field. This will occur before the first sample interval starts. If the WatchCircle is disabled, this option is not applicable. The default factory setting is set to 20 minutes.

NOTE: If no WatchCircle centre has been entered when the Buoy starts up, the GPS will be turned on for this specified time. At the end of the time period, the buoy will obtain a GPS fix, and use the fix as the WatchCircle Centre. If a centre was not obtained (due to GPS not functioning, the buoy will automatically turn on the WatchCircle Beacon, and attempt to obtain a WatchCircle centre again. The buoy will repeat this process until a centre is obtained, or the buoy is manually reset. A time of less than 5 minutes may not allow sufficient time for the GPS receiver to obtain a 'lock' and may result in no WatchCircle centre being acquired).

## 2.4. Telemetry Options

By selecting 2 at the Main Menu, the user can access the various telemetry settings and configurations. These settings apply to the transfer wave data and do not affect the WatchCircle Beacon satellite transmitter operation. Buoys can be configured with no transmitters, 1 transmitter or 2 transmitters. When two transmitters are installed, one will be the Primary and one the Secondary transmitter as defined in the following sections.

### 2.4.1. Primary Telemetry Options

By selecting 1 at the Telemetry Menu, the user can access the Primary Data telemetry transmitter settings. These include the following transmitters: VHF 29 to 50 MHz), GSM Cell Phone and Orbcomm. Each of these transmitters will have a specific set of parameters that need to be set to ensure proper operation. The following dialogue boxes will list each of the setup parameters for the transmitters listed above and in Table 2.1.

```

Telemetry

1 VHF Options
2 Inmarsat Options
3 Transmitted Files
4 Wave Threshold (Hm0) = 0.00 metres

M Return to Main Menu

Select an option..
    
```

#### 2.4.1.1. Transmitted Wave Files

By selecting Option # 3 from the Telemetry Options Menu the operator can select which files to transmit via the Primary Telemetry transmitters. By selecting the menu number next to the data type will toggle whether it is transmitted or not. The files to be transmitted are shown in the window below. The files transmitted are also shown in the Run Mode Summary as shown in Section 2.7.

```

1 Status      : 1
2 Wave Stat   : 1
3 Non-Dir     : 1
4 Dir Spec    : 1
5 Mean Dir    : 0
6 HNE        : 0
7 Auxillary   : 0

M Return to Previous Menu
    
```

### ***2.4.1.2. VHF Settings***

If your buoy is configured with a VHF transmitter, the following menu will be displayed when selecting Option 1 at the Telemetry Menu. The user can access the Primary Data telemetry transmitter settings.

#### **2.4.1.2.1. Radio Transmit Times**

By selecting 1 at the VHF Menu, the user can define how many times the radio will transmit the current message. Transmitting more than once may be required due to environmental noise conditions, or other uncontrollable factors. The default is 1. Increasing this parameter will consume more power.

#### **2.4.1.2.2. Format Test Message**

By selecting 2 at the VHF Menu, the user can have the buoy format a test radio message of 6000 "A" characters. The user can then use the "Transmit Radio Buffer" to send this message.

```
VHF
1 Tx Times : 1
2 Format Test
3 Tx Buffer
4 Pipeline

M Return to Previous Menu

Select an option..
```

#### **2.4.1.2.3. Transmit Radio Buffer**

By selecting 3 at the VHF Menu, the user can transmit the data which is currently in the transmit buffer. If there is nothing in the buffer, the user can load a test message as stated above. This is a diagnostic tool, and WaveView will not decode this message. This data will be logged into the RX folder of the WaveView data archive.

#### **2.4.1.2.4. Pipeline Through VHF**

By selecting 4 at the VHF Menu, the user has direct access to the radio and may send individual characters to test the RF link. Hit CTRL <C> to exit this option. This is a diagnostic tool, and WaveView will not decode these characters

### ***2.4.1.3. GSM Cell Phone Settings***

If your buoy is configured with a GSM Cell Phone transmitter-modem, the following menu will be displayed when selecting Option 1 at the Telemetry Menu. The user can access the transmitter settings.

Typically, the only setting that will need to be modified is the phone number to be dialed for the data transfer (3 Dial String:). All other settings are factory Default and should not be changed without a clear understanding of the system.

```
Cell Phone

1 Send Attempts : 3
2 Init String   : AT&F&C1&D2X0S0=0E0V0&Q6&K3S7=99S95=47
```

```

3 Dial String      : 2506555818
4 CONNECT wait    : 30
5 CONNECT delay   : 20
6 Format Test Message
7 Send Data Buffer
8 Pipeline to Cell Phone

```

M Return to the Previous Menu

Select an option.. 3

#### **2.4.1.3.1. Send Attempts**

By selecting 1 at the GSM Menu, the user can define how many times the GSM Cell Phone will call and transfer the current message. Transmitting more than once may be required due to local area conditions such as environmental noise, traffic or other uncontrollable factors. The factory default setting is 3 times. This will have financial costs associated with this setting, as the buoy will always connect 3 times for each data record as well as consume more power.

#### **2.4.1.3.2. Init String**

By selecting 2 at the GSM Menu, the user can configure the modem setup and operation. The factory default string should not be modified without instruction from Axys.

```

*Note* 15 chars max
Modem x Dial $ : 011445678901

```

#### **2.4.1.3.3. Dial String**

By selecting 3 at the GSM Menu, the user can enter the number that the Cell Phone will call to transmit the data. This will require that the receiving phone be setup with a PC and a running copy of WaveViewT configured to receive the GSM transmitted data. The factory default string is set to zero.

#### **2.4.1.3.4. Connect Wait**

By selecting 4 at the GSM Menu, the user can modify how long the GSM Cell Phone will wait for a valid connection prior to timing out and disconnecting. This parameter may need to be changed depending on the specific network that the system is operating, but only on the recommendation from AXYS Technical Support. The factory default setting is 30 seconds.

#### **2.4.1.3.5. Connect Delay**

By selecting 5 at the GSM Menu, the user can modify how long the GSM Cell Phone will delay prior to negotiating a valid connection. The factory default setting is 20 seconds.

#### **2.4.1.3.6. Format a Test Message**

By selecting 6 at the GSM Menu, the user can have the buoy format a test radio message of 900 "A" characters. The user can then use the "Transmit Radio Buffer" to send this message.

#### **2.4.1.3.7. Send Data Buffer**

By selecting 7 at the VHF Menu, the user can transmit the data which is currently in the transmit buffer. If there is nothing in the buffer, the user can load a test message as stated above. This is a diagnostic tool, and WaveViewT will not decode this message. This data will be logged into the RX folder of the WaveViewT data archive.

```

ph init: AT&F&C1&D2X0S0=0E0V0&Q6&K3S7=99S95=47
hit ^C to exit

AT&F <CR>
AT <CR>
OK

AT+CSQ <CR>
+CSQ: 031, 099
OK

AT+COPS? <CR>
+COPS: 000,000,"Microcell"
OK

AT+CBAND? <CR>
+CBAND: 3
OK

AT+CNUM? <CR>
+CNUM: "FIDO","12508858201",129

+CNUM: "", "", 0
+CNUM: "", "", 0
OK
    
```

#### 2.4.1.3.8. Pipeline to Cell Phone

To test the Cell Phone and the network connection, use Menu 8 Pipeline to Cell Phone and perform the following commands (this allows typical AT commands directly to the cell phone module) Below is a sample session, which checks the phone and the network connection.

NOTE: <CR> signifies pressing the ENTER key on the keyboard, anything before the <CR> is entered by the user, whereas anything after the <CR> is the response from the Cellular Modem.

Note: (1&2 provided network info, whereas 3&4 provided cell module info).

1. AT+CSQ gives the Network Signal Strength. The first number should be above 20 for a data connection.
2. AT+COPS? gets the service Provider (in the sample case, Microcell).
3. AT+CBAND? gets the frequency band setting. Set using AT+CBAND =# where # is 3 or 4 as appropriate.
  - a. CBAND: 3 is for the 1900MHz North American Network.
  - b. CBAND: 4 is for the European 900/1800 MHz Networks.
4. AT+CNUM? provides the numbers programmed on the SIM card.

To perform a test call, while still in the pipeline mode, perform the following:

```

AT <CR>
OK
ATDT2506555872 <CR>
    
```

```
CONNECT 9600
+++ <CR>
AT+CHUP <CR>
NO CARRIER
```

After dialing, the phone will connect to the receiving modem and respond with a CONNECT 9600, at which point data can be transferred or any keystrokes pressed on the keyboard will be transferred to the receiving modem. When complete, issue a +++<CR> (all within 1 second) and then hang-up with the AT+CHUP<CR>, at which point the modem should respond with a NO CARRIER message.

To exit the pipeline, press <ctrl>C and you will be returned to the Cell Phone Menu.

```
Shut off VHF/Cell? (Y/N)..Y
```

#### **2.4.1.4. 2.4.1.4 Iridium**

Iridium functions in much the same way as GSM Cell Phone, see section 2.4.1.3 for details.

Telemetry

```
1 Iridium Options
2 Inmarsat Options
3 Transmitted Files
4 Wave Threshold (Hm0) = 0.00 metres
```

M Return to Main Menu

Iridium

```
1 Send Attempts : 3
2 Init String   : AT&D0&K0V0+CBST=6,0,1
3 Dial String   : ATD006972506555821
4 CONNECT wait  : 40
5 CONNECT delay : 5
6 Format Test Message
7 Send Data Buffer
8 Pipeline to Cell Phone
```

M Return to Previous Menu

Orbcomm

```
1 Send Timeout (min)      : 35
2 Format Test Message
3 Send Data Buffer
4 Pipeline to Orbcomm Modem
```

M Return to the Previous Menu

Select an option..

#### **2.4.1.5. Orbcomm Settings**

If your buoy is configured with an Orbcomm satellite transmitter, the following menu will be displayed when selecting Option 1 at the Telemetry Menu, the user can access the Primary Data telemetry transmitter settings.

#### **2.4.1.5.1. Send Timeout**

By selecting 1 at the Orbcomm menu, the user can define how long the SC will remain powered on and attempting to upload the data messages to the Satellite. If all the messages are successfully uploaded to the satellite prior to the 35 minute time window, the SC is powered down to conserve power. (There are no retries.)

#### **2.4.1.5.2. Format a Test Message**

By selecting 2 at the Orbcomm Menu, the user can have the buoy format a test message that includes WST (wave statistics), STA (status) and MND (mean direction) files. These files do not actually contain real wave data, but instead contain text indicating the type of test file represented. The user can then use the "Transmit Radio Buffer" to send this message. This is a diagnostic tool, and WaveView will not decode these messages, but will save it too the RX log file for viewing.

#### **2.4.1.5.3. Transmit Radio Buffer**

By selecting 3 at the VHF Menu, the user can transmit the data which is currently in the transmit buffer. If there is nothing in the buffer, the user can load a test message as stated in 2 above.

#### **2.4.1.5.4. Receiving Messages**

The data sent via the Orbcomm SC is delivered to an email account as setup by the Orbcomm Service Provider. The data is automatically forwarded to the account setup as Speed Dial # 1. WaveView retrieves this data automatically as long as there is a MS Windows connection to an Internet service provider or LAN. WaveView uses the default MS Windows connection to access the mail server as explained in the TRIAXYS™ User's Manual Addendum.

#### **2.4.1.5.5. Orbcomm Transmitted Data Format**

Data is transmitted via Orbcomm satellite telemetry from the TRIAXYS™ Directional Wave Buoy as per the setup instructions of the Buoy User Manual. The WaveView software builds complete data files from the email received messages. It does not archive redundant data.

The TRIAXYS™ Directional Wave Buoy transmits the data in binary format. The data files are transmitted as separate blocks with CRC error checking. On being received at the base station, WaveView first verifies that the data was received from a registered platform, then will process the data into the various files listed below. The received data will also be stored as a raw RX file. The data is automatically converted into standard comma delimited files and archived by the WaveView software in daily directories, which are in turn archived in monthly and yearly directories. The archived data is separated into three standard files, which are named as follows:

```
YYYYMMDD.WAVE  
YYYYMMDD.STAT  
YYYYMMDD.Meandir
```

The YYYYMMDD format is used as the file name, and the extension describes the type of file. These will be stored in monthly folders.

## 2.4.2. Secondary Telemetry Options

By selecting Option #2 at the Telemetry Menu, the user can access the Secondary telemetry transmitter settings. These include the following transmitters: INMARSAT D+ and ARGOS. Each of these transmitters will have a specific set of parameters that must be set to ensure proper operation. The following dialogue boxes will list each of the setup parameters for the transmitters listed. INMARSAT D+ can be used for position and wave statistics as well as remote configuration of the buoy. ARGOS can be used both for limited data (when compared to VHF and GSM) and position telemetry.

### 2.4.2.1. INMARSAT D+

If the buoy has been configured with an INMARSAT D+ Transmitter, the following INMARSAT D+ Options will be displayed.

The second header line indicates the current state of the transmitter (Enabled or Disabled), as used for a position beacon. This can be "Disabled", but will still be activated if the WatchCircle mode has been "Enabled" (section 2.1.5.1) and the buoy moves off station.

This transmitter can be used as a Beacon reporting Date, Time, and Position information or for transmitting limited wave data (Sample Start Time, Hmax, Hm0, Havg, Tp, T13, Tavg, Mdir, Spread).

```
Inmarsat Transmitter

Inmarsat State: Enabled with 64 bit Wave Data

1 Disable Inmarsat Transmissions
2 Request Beacon Mode Only
3 Request 64 bit Wave Data

M Return to Previous Menu

Select an option..
```

#### 2.4.2.1.1. Disable INMARSAT D+ Transmissions

By selecting 1 at the INMARSAT D+ Options Menu, the user can enable or disable the INMARSAT D+ Transceiver for transmitting. The default factory setting is set to disabled if installed.

#### 2.4.2.1.2. Request Beacon Mode Only

By selecting 2 at the INMARSAT D+ Options Menu, the user can enable the INMARSAT D+ Transceiver to

#### 2.4.2.1.3. Request 64 bit Wave Data

By selecting 3 at the INMARSAT D+ Options Menu, the user can enable the INMARSAT D+ Transceiver to

### 2.4.2.2. ARGOS Transmitter

If the buoy has been configured with an ARGOS Transmitter, the following ARGOS Options should appear when selecting Option 2 from the Telemetry Menu. The second header line indicates the current state of the

transmitter (Enabled or Disabled), as used for a position and data transmitter. This can be "Disabled", but will still be activated if the WatchCircle mode has been "Enabled" (Section 2.1.5.1) and the buoy moves off station. This transmitter can be used to transmit wave data as well as Date, Time, and Position information.

ARGOS Transmitter

ARGOS State: Disabled

- 1 Disable ARGOS Tx
- 2 Request Continuous ARGOS
- 3 Request ARGOS but not during Data Acquisition (DEFAULT setting)
- 4 Enable GPS Data in ARGOS Message
- 5 Disable GPS Data in ARGOS Message
- 6 Format and Send Regular ARGOS Message
- 7 Format Fixed Message and Send
- 8 Monitor ARGOS Serial Port

Select an option..

#### **2.4.2.2.1. Disable ARGOS Tx**

By selecting 1 at the ARGOS Options Menu, the user can enable/disable the operation of the ARGOS transmitter while the buoy is deployed. The state of the activation is shown just above the menu listings.

#### **2.4.2.2.2. Request Continuous ARGOS**

By selecting 2 at the ARGOS Options Menu, the user can request that the ARGOS be powered ON continuously. It is only possible for power to be applied to the transmitter when the buoy is turned ON. The transmitter will transmit the data buffer at the programmed repetition rate (typically 110 seconds).

#### **2.4.2.2.3. Request ARGOS Not during Data Acquisition**

By selecting 3 at the ARGOS Options Menu, the user can request that the ARGOS be powered ON, only when the buoy is not sampling. This is the factory default setting.

#### **2.4.2.2.4. Enable GPS Data In ARGOS Message**

By selecting 4 at the ARGOS Options Menu, the user can include the Buoy's last known GPS position in the tail end of the ARGOS message. If this option is enabled, the message replaces the T=-3hr fields in the regular ARGOS message (see section 4.5). This is the factory default setting.

#### **2.4.2.2.5. Disable GPS Data in ARGOS Message**

By selecting 5 at the ARGOS Options Menu, the user can exclude the Buoy's last known GPS position in the end of the ARGOS message. If this option is disabled, the regular ARGOS message is used.

#### **2.4.2.2.6. Format and Send Regular ARGOS Message**

By selecting 6 at the ARGOS Options Menu, the buoy will automatically load a fixed message into the ARGOS transmit buffer, and send when ready. The message consists of 32 bytes of data.

#### **2.4.2.2.7. Format Fixed Message and Send**

By selecting 7 at the ARGOS S Options Menu, the user can load a specific message into the ARGOS transmit buffer, and send when ready. The message consists of 32 bytes of data, ranging from 000 to 062, in steps of 2. An example is shown below;

```
ARGOS:000 002 004 006 008 010 012 014 016 018 020 022 024 026 028 030
      032 034 036 038 040 042 044 046 048 050 052 054 056 058 060 062
```

```
Set RTS, wait for CTS, CTS lo, sending message, clr RTS
Monitoring ARGOS Serial (Debug) port
Typical...   State = 4
              Starting a transmission window for 7200 seconds
              Sleeping for  xx seconds (at yy)....and so on
```

Hit any key to continue...

#### **2.4.2.2.8. Monitor ARGOS Serial Port**

By selecting 8 at the ARGOS Options Menu, the user can monitor the serial output from the ARGOS transmitter. This is not the actual sent data, but is the diagnostics used to monitor the progress of the transmitter. An example is shown below;

Note: Users should be aware of both time requirements and power implications when selecting the types of data to transmit. The more data the longer the transmission and increase in power consumption.

```
Monitoring ARGOS Serial (Debug) port
```

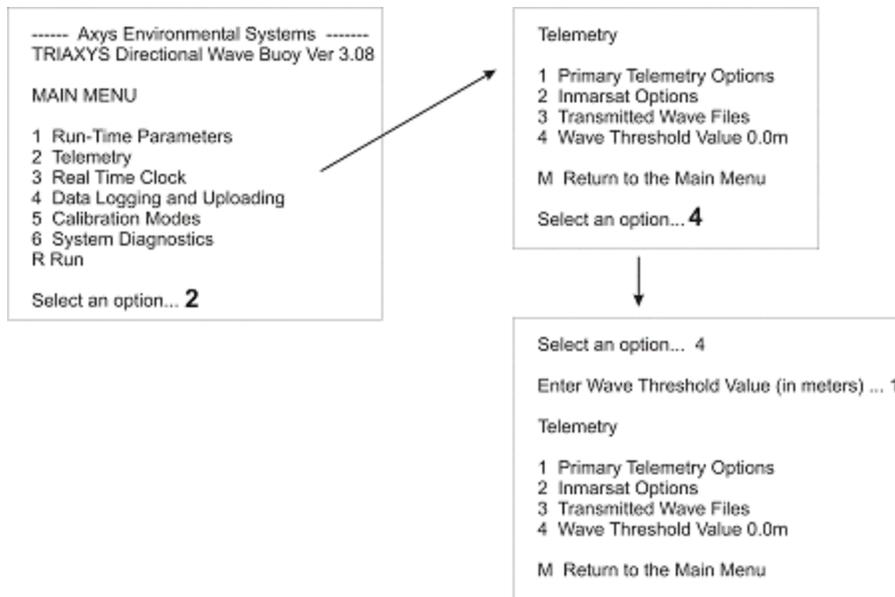
Hit any key to continue...

```
Typical...   State = 4
              Starting a transmission window for 7200 seconds
              Sleeping for  xx seconds (at yy)....and so on
```

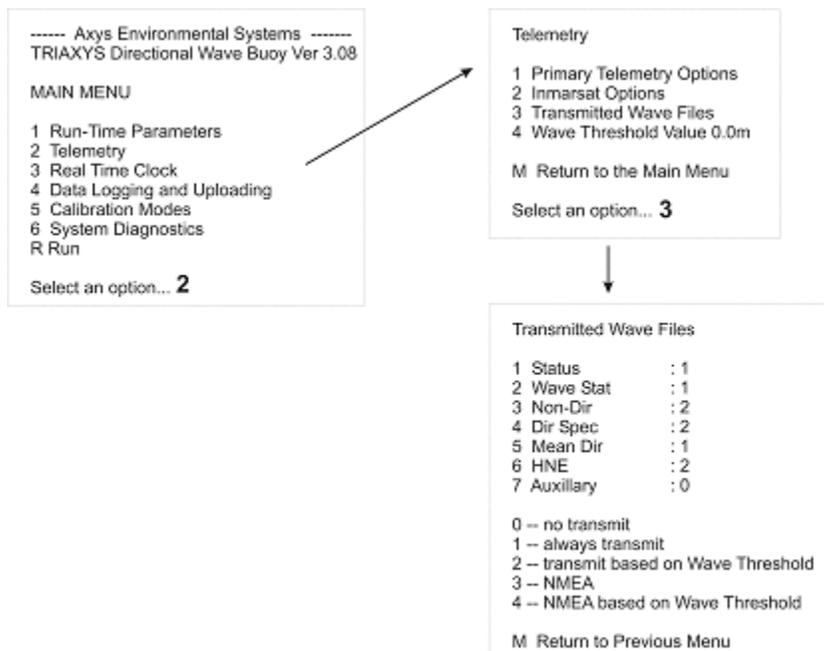
#### **2.4.2.3. Wave Threshold**

Wave Threshold is a power conservation protocol, intended to extend deployment durations in areas of low isolation or programs with high sample rates. It enables the user to transmit specific files when the significant wave height measured during the sampling interval meets or exceeds a user-specified wave height. As transmission of the larger files consumes more power, up to 30% power savings could be gained by transmitting fewer of these large data files. The data that is not transmitted will still be logged on the internal data logger and is available for further analysis when the buoy is recovered and serviced.

The Wave Threshold is a mechanism unique to the TRIAXYS™ Directional Wave Buoy that allows all transmitted data to only be transmitted when the wave threshold is met or exceeded. Each individual file can be independently associated with the wave threshold.



**Figure 14: Setting the wave threshold**



**Figure 15: Enabling data transmission based on wave threshold setting**

Note: Settings 3 and 4 are for use by Axys technical personnel for advanced diagnostic purposes. Do Not Use Settings 3 and 4. Settings 3 and 4 will not be decoded by WaveView.

AXYS recommends setting the Status and Wave Stat to 1 (Always Transmit), as these files are small and contain important system and basic wave information. The largest files, HNE and Dir Spec, should be set to 2 (Transmit based on Wave Threshold), as they are likely to be of interest for waves over a certain height.

Please note that all files available for transmission are logged to the on-board data logger, irrespective of transmission or threshold settings.

#### 2.4.2.4. NMEA Data Format

There is now the option to transmit Status, Wave Statistics, Non Directional and Mean Directional data from the TRIAXYS buoy in National Marine Electronics Association (NMEA) format. TRIAXYS NMEA messages use the NMEA 0183 standard of two Talker Identifier characters and three Sentence Identifier characters, as follows:

```
$TSmma,df1, df2, ..*cs<cr><lf>
```

Where 'TS' is the two-character talker identifier, indicating that the message is being sent from a TRIAXYS buoy, and 'mma' is the sentence identifier: 'mm' indicates the message format, and 'a' is the minor revision of the buoy software.

**The NMEA messages are as follows:**

**Mean Dir (PM)**

```
$TSPMA, Date, Time, Serial, BuoyID, Latitude, Longitude, Number of Bands,
Initial Frequency, Frequency Spacing, Mean Average Direction, Spread Direction,
Energy 1, Mean Direction 1, Direction Spread 1, Energy N***, Mean Direction
N***, Direction Spread N***, *cs<cr><lf> Non Dir (PN)$TSPNA, Date, Time, Serial,
BuoyID, Latitude, Longitude, Number of Bands, Initial Frequency, Frequency
Spacing, Energy 1, Energy 2, Energy 3, Energy N***,
*cs<cr><lf>
```

**Buoy Status (PS)**

```
$TSPSA, Date, Time, Serial, BuoyID, Latitude, Longitude, Sea Surface
Temperature, Battery Voltage, Sample Rate, Samples, Acquisition Interval,
Transmission Interval, Radio Transmissions, Serial No., GPuC Firmware Version,
PC 104 Firmware Version, Boot Times, Status, Solar Current, Magnetic Variation,
Acquisition Duration,
*cs<cr><lf>
```

**Wave Statistics (PW)**

```
$TSPWA, Date, Time, Serial, BuoyID, Latitude, Longitude, Number of Zero
Crossings, Havg (Average Wave Height), Tz (Mean Spectral Period), Hmax (Maximum
Wave Height), Hsig (Significant Wave Height), Tsig (Significant Period), H10
(average height of highest tenth of waves), T10 (average period of H10 waves),
Tavg (Mean Wave Period), TP (Peak Period), TP5, HMO, Mean Direction, Mean
Spread, *cs<cr><lf>
```

\*\*\*for up to 123 bands

Note: <cr> and <lf> are computer codes for 'carriage return' and 'line feed' respectively.

#### 2.4.2.5. Data Transmit Duration

This table shows the amount of time required to transmit the data files from the TRIAXYS™ buoy using a 1200 baud configuration and binary format, based on an ACDUR of a 25 Minute Sample Record. It is important to realize that each data type will be additive in terms of total transmit duration and that enough time needs to be allowed prior to the beginning of the next acquisition period to complete either a single or multiple transmission of the data selected.

Parameter	File Size	Time
-----------	-----------	------

Stat	0.120K	1 second
Wave	0.110K	1 second
Fourier	8.0K	66 seconds
NonDireSpec	2.0K	16 seconds
HNE	0K	100 seconds
MeanDir	0/75K	6 seconds

## 2.5. Real Time Clock

By selecting 3 at the Main Menu, the user can configure the system time of the buoy.

```
Real Time Clock 01-08-21 08:46:32
```

```
S Set the Date and Time
T Display the Current Time
G Sync Clock with GPS
```

```
M Return to the Main Menu
```

Select an option..

### 2.5.1. Set the Date and Time

By selecting 1 at the Real Time Clock Menu, the user can enter the current UTC date and time. This is the system time for the buoy, and should always be entered in UTC.

### 2.5.2. Display the Current Time

By selecting 2 at the Real Time Clock Menu, the user can display the current buoy date and time.

### 2.5.3. Sync Clock With GPS

By selecting 3 at the Real Time Clock Menu, the user can set the buoy date and time via a received GPS signal. The buoy will wait for a valid GPS signal (up to 8 minutes), at which time the system date and time will be updated. Hit any key to exit after the update is completed.

NOTE: The buoy will also automatically update the system date and time every day at 0000hr UTC

## 2.6. Data Logging and Upload

By selecting 4 at the Main Menu, the user can access the data logging features of the buoy. The buoy can log both raw sensor data and processed data. By default, the buoy is configured to record raw data all the time.

```
Data Logging/Uploading
```

```
1 Logging of Processed Data : Disabled
2 Upload Data Files
M Return to the Main Menu
```

Select an option..

### 2.6.1. Logging of Processed Data

By selecting 1 at the Data Logging/Upload Menu, the user can enable or disable the logging of the processed wave files on the internal PCMCIA flash RAM card installed into drive "D" of the TRIAXYST<sup>TM</sup> Sensor Module. Ensure there is sufficient space on the RAM card for the deployment duration (see Section 1.15). No further data will be recorded if the card becomes full during the course of deployment, however, the buoy will still continue to operate and transmit the data over any installed telemetry. The default factory setting is set to Enabled if the option is installed.

The 1G flash cards on the TRIAXYST<sup>TM</sup> Wave Buoy data logger are formatted FAT 16 on a computer running Windows 9 5/98 Operating System for use by the TRIAXYST<sup>TM</sup> "Internal Data Logger". The flash cards supplied with the TRIAXYST<sup>TM</sup> Wave Buoy have been correctly formatted and tested.

If the flash cards are incorrectly formatted, data will be written to the card five or six times before the data logger ceases to function. The buoy will continue to operate normally, collecting and sending data through the primary telemetry system, but there will be no data backup if any transmissions are lost. It is recommended that you test the flash card for a minimum of ten write cycles to ensure correct format. You can also purchase formatted and tested flash cards from AXYS.

On recovery from the buoy the flash card data needs to be processed using a registered AXYS Post Processing Software application. This will automatically create the final wave products (Wave Summary, Dir Spec, Non-Dir Spec, UVH, HNE (if raw processed)) and set up archived data folders by year and month for the respective data sets.

### 2.6.2. Upload Data Files

By selecting 2 at the Data Logging/Upload Menu, the user can access the Data Logger file retrieval system. This feature will allow the user to list and upload any internally logged processed wave data file(s) via the IR port, rather than opening the buoy and recovering the RAM card.

The user is guided through each step of the process, indicating which drive letter is available for querying. To upload the data, the user selects either U or S. This will use a Z modem protocol and automatically upload the file(s) to the default directory of whatever terminal program the operator is using to communicate with the TRIAXYST<sup>TM</sup> Buoy (e.g., HyperTerminal or ProComm).

NOTE: Users should only attempt to upload the processed wave (\*.w03) data via this menu due to the size of the files and the speed of the IR connection. Logged 4 Hz RAW data files, may be acquired by opening the buoy and removing the appropriate internal memory card. This will need to be run through the post processing software suite available from AXYS.

To complete the analysis and archival of data to appropriate folders, the data recovered via this upload feature or by copying the Flash Card data directly to a PC must be processed using the Post Processing Software Suite available from AXYS. This utility does not list the ".R0\*" files (refer to Section 2.6.4.2).

```
-TRIAXYSTTM DATA LOGGER RETRIEVAL SYSTEM
```

```

          Press 'D' to see a list of files on the D:
                Press 'E' to see a list of files on the E:
                    Press 'Q' to quitD is      valid
E is      invalidSelect an option....D

```

```
the choices for the D are:
```

L to see a L)ist of files on the drive  
 U to U)pload all of the files from the drive  
 S to upload a S)ingle file from the drive  
 P to go to the P)revious menu

Select an option....L

- 1. JA061923.W01 888
- 2. JA062023.W01....888

End of file list...

Select an option..

### 2.6.3. Erasing Logged Data without Opening the Buoy

To erase information from the data logger flash card without opening up the buoy, set up IR communications with the buoy as described in the TRIAXYSTM User Manual, section 1.11. Reset the buoy using the magnetic key so that the buoy main menu is displayed on the terminal screen, and follow the steps illustrated below to access the data logger.

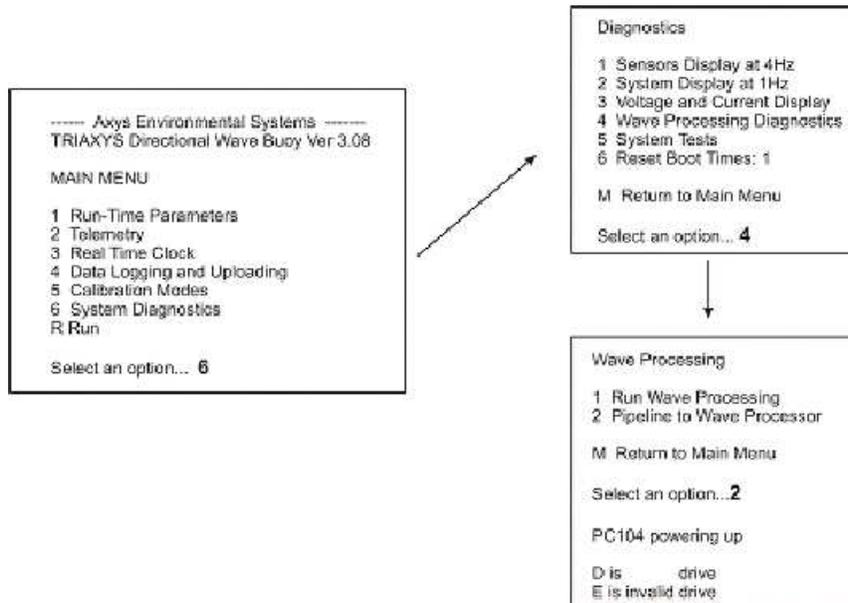


Figure 16: Accessing the datalogger

The DOS prompt C. should be displayed. Type the following commands to access and delete the files on the data logger flash card.

Prompt	Type	Description
C:\>	D:	Moves to 'D' drive (the flashcard drive).
D:\>	Dir	Directory listing of files and folders on 'D'. There should be a folder called 'triaxys'
d:\>	Cd triaxys	Moves to 'triaxys' subdirectory
d:\ triaxys>	Dir	Lists of files and folders inside 'triaxys' should be two folders, called 'rawdata' and 'wfiles'

```

d:\triaxys> Cd rawdata           Moves to 'rawdata' subdirectory
d:\triaxys\rawdata> Dir         Lists the raw data files. They should be of the format
                                "MR010200.R04" as described in
                                the Triaxys™ Users Manual,
                                section 4.3, logged data format.
d:\triaxys\rawdata> Del *.*     Deletes contents of 'rawdata'
d:\triaxys\rawdata> cd..       Move up to parent directory
d:\triaxys> Cd wfiles          Move to 'wfiles' directory
d:\triaxys\wfiles> Dir         Lists the processed data files. They should be of the
format                          listed in the Triaxys™ Users
Manual, section 4.2 Triaxys data
                                formats.
d:\triaxys\wfiles> Del *.*     Deletes contents of 'wfiles'

```

## 2.7. Calibration Mode - Service Technicians Only

By selecting 5 at the Main Menu, the user can access the calibration mode routines for the buoy.

Warning: These calibration routines are to be used by service technicians trained in advanced TRIAXYS™ operation procedures. Unauthorized use of these commands may affect the performance of the TRIAXYS™ system. Any operators requiring information on the implementation of these menu items can contact Axys for assistance.

```
--Calibrate Modes Menu --
```

```
Note *** The following Modes allow access to calibration
routines. Proceed only with advice from AXYS, as Re-Cal
may affect wave measurement calculations and results.
```

```
1 Compass Calibration
M Return to the Main Menu
Select an option..
```

### 2.7.1. Compass Calibration

By selecting 1 at the Calibration Mode Menu, the user can calibrate the buoy compass.

```
Compass Calibration Mode
Motion Sensors powered up. PC104 powered up P/U
COM2CO
```

The user is now communicating directly with the compass. The commands that can be used are those for the KVH C100 compass (see Appendix F). Hit <esc> key to exit compass pipeline and type <ctrl> C to return to the Calibration Mode menu.

## 2.8. System Diagnostics Menu

By selecting 6 at the Main Menu, the user can access the various diagnostic tools for the buoy.

Diagnostics

- 1 Sensors Scan at 4 Hz
- 2 Status at 1 Hz
- 3 System V & I
- 4 Wave Processing
- 5 System Tests
- 6 Reset Boot Times : 5

M Return to Main Menu

Select an option..

### 2.8.1. Sensor Display at 4Hz

By selecting 1 at the System Diagnostics Menu, the user can observe the seven sensor outputs (three accelerometers, three rate gyros, and the compass) at a sample rate of 4Hz.

```
Line, Comp, AccX, AccY, AccZ, RGyX, RGyY, RGyZ<crLf>
00000, 54.5,+0.0115,-0.0565,-0.9953, +0.42, +0.08, -0.23
00001, 53.9,+0.0115,-0.0564,-0.9953, +1.14, -0.80, +0.53
00002, 54.0,+0.0114,-0.0567,-0.9952, +1.18, -0.70, +0.49
00003, 54.1,+0.0114,-0.0566,-0.9952, +1.04, -0.53, +0.28
00004, 54.1,+0.0116,-0.0567,-0.9950, +1.05, -0.54, +0.35
00005, 54.0,+0.0114,-0.0565,-0.9952, +1.07, -0.54, +0.35
```

NOTE: Accelerometer values are in "g's" and Rate Gyro values are in deg/sec. Hit the

### 2.8.2. System Display at 1Hz

By selecting 2 at the System Diagnostics Menu, the user can observe various system parameters being sampled at a 1 Hz rate.

```
-----Sensor Outputs-----
Compass Heading 113.7

Accelerometer Y -0.015 Rate Gyro Y +02.71
Accelerometer Z -1.044 Rate Gyro Z +01.63
System Voltage 14.1 Sys Current 0.151
Battery Current +0.474 Solar Current 0.625
Water Temp +23.1

Hit <esc> to exit
```

NOTE: Battery Current = Solar Current - System Current. If the battery current sign is positive, the batteries are charging.

### 2.8.3. Voltage and Current Display

By selecting 3 at the System Diagnostics Menu, the user can observe the system voltage and current parameter being sampled at a 1 Hz rate. The user is able to observe the effects of turning ON the PC 104, Motion Sensors, and Radio. The status of each is displayed in the header line, and toggling is achieved by pressing the P, M, or R keys. Hit the <esc> key to exit.

```
-- System V & I --
```

```

PC-104 off Motion Sensors off Radio off
SysV 13.27 SysI 0.143
BatI -0.146 Chrg 0.000
Hit P to toggle PC-104 power
      M for Motion Sensors
      R for Radio
<ESC> to exit
    
```

## 2.8.4. Wave Processing Diagnostics

By selecting 4 at the System Diagnostics Menu, the user can access the Wave Processor (PC 104) or simulate a sample.

```

Wave Processing

1 Run Wave Processing
2 Pipeline to Wave Processor

M Return to the Previous Menu

Select an option..
    
```

### 2.8.4.1. Run Wave Processing

By selecting 1 at the Wave Processing Diagnostics Menu, the user is required to enter the amplitude and period for a simulated wave sample. The number of samples loaded will depend on the sample duration set from the Run Time Parameters Menu (see section 2.1.1.3). Once the PC 104 has powered up, the user will need to wait preset sine wave with defaults of period = 10 seconds, amplitude = 500 a/d units (0.34m). This will test the PC-104 processor independently of the sensor suite.

```

Enter an Amplitude (in a/d units).. 500___

Enter a Period (in seconds).. 10___
Loading 240 sample Ampl= 500.00(a/d units) Period=10.00(sec)
Compass 0deg, Ax 0.01x, Ay 2x -90deg, Az 1x 0deg, Rx 0.1x, Ry 0.01x, Rz
0.01x
...
mem load complete
Start PC-104 P/U
0108210851,AXYS,+000.0,,00.00,4.0,240,5,5,3,00350,3.23,1.19,2,0,0.000,+00.
0
Xfer Stat.txt
TRIXXFER
ø,,€,,x,,?,,T,F,A,L,R,N,I,V,O,C,M,W,S,Q,0,1,2,3,4,5,6,X,
PROCESS
PC104 proc
C:\>C0(6) = .8236000E+02 CC0(7) = -.8236000E+02 CC1(1) =
.1000000E+03 CC1(2) = .4883000E+00 CC1(3) = .4883000E+00 CC1(4) =
-.4883000E+00 CC1(5) = .4118430E+02 CC1(6) = -.4118430E+02 CC1(7) =
.4118430E+02 Stop - Program terminated. C:\>ANALYSE2 No. of zero-
crossing waves = 4 HAV = .000 m, TAV = .000 s HMAX =
.000 m H13 = .000 m, T_H13 = .000 s SZT = .1567954E+00
m**2/Hz Hmo = 4.576 m, Tp = 9.584 s Mean Theta = 269.322 deg,
Sigma_Theta = 6.877 deg Stop - Program terminated
    
```

```
.
.
.
Got Hs=0.000 Tp=9.50 Hmx=0.000 MnDir=269.0 MnSprd=7.0
Vers.txt is 1.19,16AUG2001
```

### 2.8.4.2. Pipeline to Wave Processor

By selecting 2 at the Wave Processing Diagnostics Menu, the user can access the Wave Processor (PC 104) and perform general DOS based commands.

```
@ pipe_pc104 Hit ^C to exit
PC-104 powered upC>
C>dirVolume in drive C is MS - RAMDRIVE
Directory of C:\
TEMP <Dir>          05-10-00
DATA <Dir>          05-10-00
                2 file(s)      0 bytes
                2889728 bytes free
```

NOTE: When communicating directly with the PC-104, the operator should be knowledgeable in the use of DOS commands. The potential exists to loose data logged on the data logger through the use of inappropriate commands.

Table: Procedure for checking on internally logged data

2.12.2	Menu	Keystroke Description	Enter
1	Main	System Diagnostic Menu	6
2	System Diagnostic	Wave Processing Diagnostic Menu	4
3	Wave Processing	Pipeline to Wave Processor	2
4	C>	Change Drive to Flash RAM	D:
5	D>	Change Directory	cd triaxys
6	D:\Triaxys	Check Directory for processed data files	dir /p
7	D:\Triaxys\RAW	Change Directory to Raw (from Triaxys Root Directory)	cd raw
8	D:\Triaxys\RAW	Check Directory for Raw data files	dir /p
9	D:\Triaxys\RAW	Exit Pipeling to Wave Processor	<ctrl>c
10		Confirm the request to exit	Y
11		PC104 powered down	

This opens a console window into the PC 104 wave processing computer. From the console window, DOS commands are permitted, such as DIR<enter> which displays the current directory. If the data logging option is installed, follow the instructions below to view the logged data.

## 2.8.5. System Tests

By selecting 5 at the System Diagnostics Menu, the user can access the test mode for various sensors.

Tests

- 1 Compass
- 2 SST
- 3 GPS

M Return to the Previous Menu

Select an option..

### 2.8.5.1. Compass

By selecting 1 at the Tests Menu, the user can observe the output from the compass. The converted field is the compass reading in degrees magnetic. Hit <esc> key to exit.

Compass Display

Hit <ESC> to exit.. AutoCAL

A/D Counts: 10098	Voltage= 2.5245	Converted= 232.5
A/D Counts: 10097	Voltage= 2.5243	Converted= 232.4
A/D Counts: 10106	Voltage= 2.5265	Converted= 232.7
A/D Counts: 10103	Voltage= 2.5258	Converted= 232.6

Do you want to shut off the Compass? (Y/N)..N\_ \_Y  
powered down\_

### 2.8.5.2. SST

By selecting 2 at the Tests Menu, the user can observe the output from the Sea Surface Temperature sensor.

Sea Surface Temperature

Hit <ESC> to exit.. AutoCAL

A/D: 8345 Volts: 2.0863	Temp: 20.85 deg C
A/D: 8344 Volts: 2.0860	Temp: 20.86 deg C
A/D: 8343 Volts: 2.0858	Temp: 20.87 deg C

### 2.8.5.3. GPS

By selecting 3 at the Tests Menu, the user can observe the output from the GPS receiver.

GPS Sensor Display

Hit <ESC> to exit..

```
$GPRMC,162451,A,2503.7068,N,12138.4143,E,000.0,000.0,210801,003.4,W*7D
$GPRMC,162452,A,2503.7068,N,12138.4143,E,000.0,000.0,210801,003.4,W*7E
$GPRMC,162453,A,2503.7068,N,12138.4143,E,000.0,000.0,210801,003.4,W*7F
```

Call the GPS Decode routine ? (Y/N)..Y

```

Waiting for GPS (10) ..
Found: GPRMC,162504,A,2503.7068,N,12138.4143,E,000.0,000.0,210801,003.4,W*

GPS   UDC:210801 UTC:162453 LAT:2503.7068N LON:12138.4143W MVAR:003.4

Shut off the GPS Reciever ? (Y/N)..Y
GPS powered down
    
```

The operator will be able to determine if the GPS data being reported is valid by observing whether a "V" or an "A" is being displayed in the \$GPRMC NMEA string. If an "A" is displayed, the GPS receiver is reporting good data. If a "V" is displayed this indicates a validity error and should not be used to set the time or position. This will automatically switch when the receiver locks onto enough satellites. If no valid GPS position is available or the buoy is outside the WatchCircle radius, the WatchCircle Alarm is activated if installed.

### 2.8.6. Reset Boot Times

By selecting 6 at the System Diagnostics Menu, the user can reset the system boot times. This diagnostic feature is used to monitor the operational status of the buoy. If the number changes during the course of a standard deployment, please report the condition to AXYS. Please note that the Boot Time number will increment each time the user interrupts the normal run mode of the buoy.

## 2.9. Run

By selecting R at the Main Menu, the user has instructed the buoy to enter the RUN mode. If the buoy is left unattended during a programming session, it will also automatically enter into the RUN mode.

```

DTs =18
start inm_d
64 bit D+: 34 C3 A1 9E 8F 10 3F 80
Sending Cnfg Msg
INM Cnfg: C5 C2 00 00 30 00 00 00 00 00 00 00 00 00 00 00 00 00 67 AA
08 34 C3 A1 9E 8F 10 3F 80
Inm Sleep
Parameters Summary:
Station ID  TAB00801
ACQ INT(mins) 0060  ACQ DUR(mins) 20  ACQ START OFFSET(mins) 0000
Compass      -2.000E+01  1.000E+02
Accelerom X  -1.000E+00  4.883E-01
Accelerom Y  -1.000E+00  4.883E-01
Accelerom Z   0.000E+00 -4.883E-01
Rate Gyro X  -8.236E+01  4.118E+01
Rate Gyro Y   8.236E+01 -4.118E+01
Rate Gyro Z  -8.236E+01  4.118E+01
Water Temp   9.579E+01 -3.592E+01
Sys Voltage   0.000E+00  5.857E+00
Sys Current   0.000E+00  4.000E-01
Battery Chg   0.000E+00  1.000E+00
MTN_F1        3.000E-02
MTN_MAG_VAR   0.000E+00
MTN_X,Y,Z     0.000E+00  0.000E+00  0.000E+00
MTN_HPF       0
WVN_DF        5.000E-03
    
```

```

WVN_F1,F2      3.000E-02  6.400E-01
WVN_STR        1.000E-02
RS_FREQ        1.280E+00
UID            01030
TxFiles        1 1 1 1 0 0 Aux="" Hm0_th= 0.00
Boottimes      5

Inmarsat On
Inmarsat state= Enabled with 64 bit Wave Data
Inmarsat Check-In Disabled
Logging Waves
05-03-09 16:58:03 Next @ 17:00:00 zzz
05-03-09 16:59:00 Next @ 17:00:00 zzz

```

NOTE: The operator will observe all the programmed options and loaded buoy coefficients. Some text may not be present, depending on the buoy configuration. The "zzz" means that the buoy is asleep. It will wake up every minute to check if it is time to start the next acquisition/processing sequence. This will be output every minute.

A wave sample sequence can be seen via the IR port. The sequence starts at the time the buoy starts the sample and ends when the buoy is sleeping again. The data that comes out of the IR port documents the processes being carried out in the buoy including position identification, data analysis, processing, message formatting etc. The output is cryptic and indicates that the buoy is functioning properly. Within this data collection and processing it can be normal to see commentary stating problem getting information.

```

0000
0004
0008
.
.
4796
4800...
T/O DMR
Start PC-104 P/U
0810211900,TAB00000,+022.2,,14.03,4.0,4800,60,60,1,00000,3.58,2.03
,3,0,0.000,+00.0
Xfer Stat.txt
TRIXFER
?,T,F,A,L,R,N,I,V,O,C,M,H,W,S,Q,0,1,2,3,4,5,6,X,
PROCESS
PC104 proc
C:\>z
Stop - Program terminated.
C:\>MOTION6A
N1 = 4800
DT1 = .2500000E+00
NCH = 7
DV = .2500000E-03
DATE = 10212008190000
CC0(1) = -.2000000E+02
CC0(2) = -.1000000E+01
CC0(3) = -.1000000E+01
CC0(4) = .0000000E+00
CC0(5) = -.1525900E+03
CC0(6) = -.1525900E+03
CC0(7) = -.1525900E+03

```

```

CC1(1) = .1000000E+03
CC1(2) = .4883000E+00
CC1(3) = .4883000E+00
CC1(4) = -.4883000E+00
CC1(5) = .7629400E+02
CC1(6) = .7629400E+02
CC1(7) = .7629400E+02
SUB. RPW2: WRMS = .1007790E-02
Iteration Residual Error
1 .7420894E-05
2 .2077080E-07
Stop - Program terminated.
C:\>ANALYSE2
No. of zero-crossing waves = 172
HAV = .001 m, TAV = 6.248 s
HMAX = .002 m
H13 = .001 m, T_H13 = 10.757 s
SZT = .1698011E-08 m**2/Hz
Hmo = .001 m, Tp = 28.676 s
Mean Theta = 280.521 deg, Sigma_Theta = 75.120 deg
Stop - Program terminated.
C:\>MAKEMSGE
C:\>cd \temp
C:\TEMP>KVH7
Stop - Program terminated.
C:\TEMP>NDBC
C:\TEMP>copy SP1.hex SP2.hex
1 file(s) copied
C:\TEMP>if exist tspaa.nme frame tspaa.fra tspaa.nme 00000 0
C:\TEMP>if exist tsmbb.nme frame tsmbb.fra tsmbb.nme 00000 0
C:\TEMP>frame stat.fra stat.dat 00000 0
Output file: stat.fra, size = 115 byte(s)
Input file: stat.dat, size = 104 byte(s)
crc= 1c66e0ee
C:\TEMP>frame waves.fra waves.dat 00000 0
Output file: waves.fra, size = 103 byte(s)
Input file: waves.dat, size = 92 byte(s)
crc= 641c798e
C:\TEMP>frame ndirspec.fra ndirspec.dat 00000 0
Output file: ndirspec.fra, size = 535 byte(s)
Input file: ndirspec.dat, size = 524 byte(s)
crc= 5957d24a
C:\TEMP>frame dirspec.fra dirspec.dat 00000 0
Output file: dirspec.fra, size = 2630 byte(s)
Input file: dirspec.dat, size = 2619 byte(s)
crc= 84e02e2b
C:\TEMP>frame meandir.fra meandir.dat 00000 0
Output file: meandir.fra, size = 1166 byte(s)
Input file: meandir.dat, size = 1155 byte(s)
crc= 13e33afa
C:\TEMP>frame block1.fra rs_hne1.dat 00000 0
Output file: block1.fra, size = 1589 byte(s)
Input file: rs_hne1.dat, size = 1578 byte(s)
crc= ee4d38f7
C:\TEMP>if exist rs_hne2.dat frame block2.fra rs_hne2.dat 00000 0
Output file: block2.fra, size = 1589 byte(s)
Input file: rs_hne2.dat, size = 1578 byte(s)
crc= bdd0e14b

```

```

C:\TEMP>if exist rs_hne3.dat frame block3.fra rs_hne3.dat 00000 0
Output file: block3.fra, size = 1589 byte(s)
Input file: rs_hne3.dat, size = 1578 byte(s)
crc= 6def52bf
C:\TEMP>if exist rs_hne4.dat frame block4.fra rs_hne4.dat 00000 0
Output file: block4.fra, size = 1589 byte(s)
Input file: rs_hne4.dat, size = 1578 byte(s)
crc= 446a3f35
C:\TEMP>if exist rs_hne5.dat frame block5.fra rs_hne5.dat 00000 0
Output file: block5.fra, size = 1589 byte(s)
Input file: rs_hne5.dat, size = 1578 byte(s)
crc= 0463bdf
C:\TEMP>if exist rs_hne6.dat frame block6.fra rs_hne6.dat 00000 0
Output file: block6.fra, size = 665 byte(s)
Input file: rs_hne6.dat, size = 654 byte(s)
crc= 75aa23e3
C:\TEMP>if exist rs_hne7.dat frame block7.fra rs_hne7.dat 00000 0
C:\TEMP>if exist rs_hne8.dat frame block8.fra rs_hne8.dat 00000 0
C:\TEMP>if exist rs_hne9.dat frame block9.fra rs_hne9.dat 00000 0
C:\TEMP>copy /b block*.fra rs_hne.fra
BLOCK1.FRA
BLOCK2.FRA
BLOCK3.FRA
BLOCK4.FRA
BLOCK5.FRA
BLOCK6.FRA
1 file(s) copied
C:\TEMP>NDRDCODE
123,0.03,0.005,3.990229e-06,6.096187e-06,3.727493e-06,1.688931e-
06,5.603599e-07,6.845587e-07,8.264598e-07,1.424418e-06,3.215337e-
07,2.01934e-07,9.193437e-08,8.135889e-08,1.104068e-07,8.380336e-
08,8.352097e-08,9.223591e-08,4.404182e-08,2.132797e-08,1.840367e-
08,1.689936e-08,1.4062e-08,2.563592e-08,2.337962e-08,1.426935e-
08,1.971659e-08,1.739989e-08,1.78053e-08,1.241542e-08,2.504897e-
08,1.018573e-08,9.159624e-09,4.387362e-09,4.00661e-09,5.14297e-
08,2.122799e-07,4.260767e-07,3.906723e-07,4.598546e-07,2.917922e-
07,4.384993e-07,4.049003e-07,2.55778e-07,1.937076e-07,1.882834e-
07,1.183095e-07,1.080176e-07,1.090221e-07,8.417457e-08,1.074761e-
07,3.416869e-07,1.720988e-07,1.067213e-07,1.172473e-07,1.428086e-
07,1.114529e-07,8.765196e-08,6.979388e-08,5.531919e-08,6.897097e-
08,5.678879e-08,6.266443e-08,6.229575e-08,5.615079e-08,5.921465e-
08,6.876179e-08,5.740159e-08,6.32564e-08,4.766214e-08,2.948778e-
08,3.94187e-08,2.324044e-08,1.134423e-07,4.334713e-08,4.274118e-
08,3.775052e-08,3.464073e-08,2.516078e-08,2.539625e-08,1.846158e-
08,1.747038e-08,9.124461e-09,9.058364e-09,1.889379e-08,2.470705e-
08,2.292085e-08,1.795032e-08,2.283044e-08,1.959177e-08,1.467705e-
08,1.233413e-08,1.352956e-08,1.321126e-08,1.7185e-08,1.885396e-
08,9.507775e-09,9.5302e-09,1.763401e-08,2.004245e-08,1.071797e-
08,6.875464e-09,1.035214e-08,1.156693e-08,1.141999e-08,1.134835e-
08,9.525682e-09,6.907751e-09,6.896608e-09,1.605435e-08,6.767613e-
09,5.807389e-09,6.236799e-09,5.324894e-09,5.64379e-09,5.325191e-
09,5.636183e-09,5.80933e-09,8.55119e-09,8.823619e-09,5.486271e-
09,7.024141e-09,2.137601e-08,4.827722e-09,3.93184e-09
C:\TEMP>dir /oe
Volume in drive C has no label
Volume Serial Number is 2BA3-2F9C
Directory of C:\TEMP
. <DIR> 01-01-02 12:00a

```

```

.. <DIR> 01-01-02 12:00a
TEMP_WAV BIN 2556 10-21-08 7:21p
V_NORTH DAT 31074 10-21-08 7:21p
V_WEST DAT 31074 10-21-08 7:21p
ETA DAT 31074 10-21-08 7:21p
D_NORTH DAT 31074 10-21-08 7:21p
D_EAST DAT 31074 10-21-08 7:21p
RS_HNE DAT 8322 10-21-08 7:21p
RS_HNE1 DAT 1578 10-21-08 7:21p
RS_HNE2 DAT 1578 10-21-08 7:21p
RS_HNE3 DAT 1578 10-21-08 7:21p
RS_HNE4 DAT 1578 10-21-08 7:21p
RS_HNE5 DAT 1578 10-21-08 7:21p
RS_HNE6 DAT 654 10-21-08 7:21p
RS_ETA DAT 2794 10-21-08 7:21p
RS_D_NOR DAT 2794 10-21-08 7:21p
RS_D_EST DAT 2794 10-21-08 7:21p
WAVES DAT 92 10-21-08 7:21p
NDIRSPEC DAT 524 10-21-08 7:21p
DIRSPEC DAT 2619 10-21-08 7:21p
STAT DAT 104 10-21-08 7:21p
MEANDIR DAT 1155 10-21-08 7:21p
STAT FRA 115 10-21-08 7:21p
WAVES FRA 103 10-21-08 7:21p
NDIRSPEC FRA 535 10-21-08 7:21p
DIRSPEC FRA 2630 10-21-08 7:21p
MEANDIR FRA 1166 10-21-08 7:21p
BLOCK1 FRA 1589 10-21-08 7:21p
BLOCK2 FRA 1589 10-21-08 7:21p
BLOCK3 FRA 1589 10-21-08 7:21p
BLOCK4 FRA 1589 10-21-08 7:21p
BLOCK5 FRA 1589 10-21-08 7:21p
BLOCK6 FRA 665 10-21-08 7:21p
RS_HNE FRA 8610 10-21-08 7:21p
WAVES HEX 184 10-21-08 7:21p
NDIRSPEC HEX 1048 10-21-08 7:21p
DIRSPEC HEX 5238 10-21-08 7:21p
STAT HEX 208 10-21-08 7:21p
SP1 HEX 1601 10-21-08 7:21p
SP2 HEX 717 10-21-08 7:21p
TSPSA NME 110 10-21-08 7:21p
TSPWA NME 108 10-21-08 7:21p
TSPNA NME 1289 10-21-08 7:21p
TSPMA NME 1607 10-21-08 7:21p
TEMP4 RAW 67282 10-21-08 7:20p
STAT TXT 84 10-21-08 7:20p
RS_HNE TXT 33243 10-21-08 7:21p
RS_ETA TXT 19423 10-21-08 7:21p
RS_D_NOR TXT 19423 10-21-08 7:21p
RS_D_EST TXT 19423 10-21-08 7:21p
ARGOS TXT 32 10-21-08 7:21p
MEANDIR TXT 3744 10-21-08 7:21p
NDBC TXT 4188 10-21-08 7:21p
AXYS TXT 12080 10-21-08 7:21p
TSPSA TXT 432 10-21-08 7:21p
TSPWA TXT 201 10-21-08 7:21p
TSPNA TXT 1587 10-21-08 7:21p
TSPMA TXT 3483 10-21-08 7:21p

```

```

TEMP4 WAV 2126 10-21-08 7:21p
60 file(s) 408298 bytes
14043136 bytes free
C:\TEMP>cd \
C:\>echo QQQ
QQQ
C:\>
C:\>
C:\>
C:\>
C:\>
PC WST NMEA
TSPWA.NME is
$TSPWA,20081021,190000,00000,TAB00000,,,172,.00,6.2,.00,.00,10.8,.
00,15.4,6.5,28.6,28.7,.00,280.5,75.1*3F
Thresh Active stat.fra[115] waves.fra[103] ndirspec.fra[535]
dirspec.fra[2630] VERS
LOGWAV
C:\>c:
C:\>cd \
C:\>log4w2
Stop - Program terminated.
C:\>mkdir d:\triaxys
Directory already exists
C:\>if exist c:\temp\tspaa.nme copy /b c:\data\*.w?? +
c:\temp\tspaa.nme c:\data\*.
C:\>if exist c:\temp\tsmbb.nme copy /b c:\data\*.w?? +
c:\temp\tsmbb.nme c:\data\*.
C:\>copy c:\data\*.w?? d:\triaxys
C:\DATA\OC211900.W08
1 file(s) copied
C:\>echo QQQ
QQQ
C:\>
C:\>
C:\>
C:\>
C:\>
LOGRAW
C:\>e copy /b c:\data\*.r?? + c:\temp\tspaa.nme c:\data\*.
C:\>if exist c:\temp\tsmbb.nme copy /b c:\data\*.r?? +
c:\temp\tsmbb.nme c:\data\*.
C:\>copy c:\data\*.r?? d:\triaxys\rawdata
C:\DATA\OC211900.R08
1 file(s) copied
C:\>echo QQQ
QQQ
C:\>
C:\>
C:\>
C:\>
C:\>
C:\>
C:\>
C:\>2.03,08JUL2008
Files:
Ack=1 Fn=stat.fra Fs=115

```

```

Ack=1 Fn=waves.fra Fs=103
Ack=1 Fn=ndirspec.fra Fs=535
Ack=1 Fn=dirspec.fra Fs=2630
Ack=0 Fn=none Fs=0
Ack=0 Fn=none Fs=0
Ack=0 Fn=none Fs=0
TX #1 Radio on.. 5s delay.. TXing.. Bin stat.fra[115]
waves.fra[103] ndirspec.fra[535] dirspec.fra[2630]post tx 2s
delay.. Radio off...
T/O DMR ...
T/O DMR ...
T/O DMR ...
T/O DMR
D+ Sleep
WDTs =9
08-10-21 19:22:26 Next @ 20:00:00 zzz
08-10-21 19:23:00 Next @ 20:00:00 zzz
08-10-21 19:24:00 Next @ 20:00:00 zzz
08-10-21 19:25:00 Next @ 20:00:00 zzz
08-10-21 19:26:00 Next @ 20:00:00 zzz
08-10-21 19:27:00 Next @ 20:00:00 zzz
08-10-21 19:28:00 Next @ 20:00:00 zzz
08-10-21 19:29:00 Next @ 20:00:00 zzz
08-10-21 19:30:00 Next @ 20:00:00 zzz
08-10-21 19:31:00 Next @ 20:00:00 zzz
08-10-21 19:32:00 Next @ 20:00:00 zzz
08-10-21 19:33:00 Next @ 20:00:00 zzz
08-10-21 19:34:00 Next @ 20:00:00 zzz
08-10-21 19:35:00 Next @ 20:00:00 zzz
08-10-21 19:36:00 Next @ 20:00:00 zzz
08-10-21 19:37:00 Next @ 20:00:00 zzz
08-10-21 19:38:00 Next @ 20:00:00 zzz
08-10-21 19:39:00 Next @ 20:00:00 zzz
08-10-21 19:40:00 Next @ 20:00:00 zzz
08-10-21 19:41:00 Next @ 20:00:00 zzz
08-10-21 19:42:00 Next @ 20:00:00 zzz
08-10-21 19:43:00 Next @ 20:00:00 zzz
08-10-21 19:44:00 Next @ 20:00:00 zzz
08-10-21 19:45:00 Next @ 20:00:00 zzz
08-10-21 19:46:00 Next @ 20:00:00 zzz
08-10-21 19:47:00 Next @ 20:00:00 zzz
08-10-21 19:48:00 Next @ 20:00:00 zzz
08-10-21 19:49:00 Next @ 20:00:00 zzz
08-10-21 19:50:00 Next @ 20:00:00 zzz
08-10-21 19:51:00 Next @ 20:00:00 zzz
08-10-21 19:52:00 Next @ 20:00:00 zzz
08-10-21 19:53:00 Next @ 20:00:00 zzz
08-10-21 19:54:00 Next @ 20:00:00 zzz
08-10-21 19:55:00 Next @ 20:00:00 zzz
08-10-21 19:56:00 Next @ 20:00:00 zzz
08-10-21 19:57:00 Next @ 20:00:00 zzz
08-10-21 19:58:00 Next @ 20:00:00 zzz
08-10-21 19:59:00 Next @ 20:00:00 zzz
08-10-21 20:00:00

```

After the completion of the transmission of the data, the TRIAXYS™ buoy will go into "sleep" mode prior to the start of the next data acquisition period. The previous sample collection period can be monitored on

the IR communications port, but cannot be interrupted during this cycle as the RX lines on this serial device are disabled while the buoy is in run mode.

### 3. MOORINGS

The TRIAXYS™ Directional Wave Buoy has certain mooring requirements, which need to be observed to achieve maximum performance. The key feature required in all surface wave-monitoring systems is the need to de-couple the mooring from the buoy to allow unrestricted buoy motions in wave fields.

The de-coupling is accomplished either by operating the TRIAXYS™ Buoy in an untethered free-floating configuration, or by integrating a compliant section into the mooring. The compliant mooring section is composed of an extruded 32mm (1.25") bunaN rubber cord, 1.5m in length, terminated with stainless steel compression fittings. The elastic nature of the compliant component allows the TRIAXYS™ Buoy to follow waves in an unrestricted fashion. The compliant section is usually attached directly to the buoy.

There are no requirements for external ballast as the buoy's internal batteries provide the proper dynamic stability for the operation of the buoy.

In any moored deployment the connection to the buoy should be made with a 12mm stainless steel swivel. The swivel reduces the chance that the mooring will become fouled in the presence of rotary tidal currents.

The design and fabrication of the mooring for most shallow water (20-50m) applications can follow the basic design shown in Figure 3.1. This mooring typically has a scope of 2:1, with the length of the individual components adjusted according to the depth. This mooring configuration is applicable for deployments where current velocities do not exceed 1.5m/second and for depths between 1.5m and 30 m. A simple means to calculate the component lengths is as follows:

$$\text{Mooring Depth (m)} \times 2 = \text{total mooring length (TML)}$$

$$\text{TML - compliant mooring segment (1.5 m)} = \text{residual mooring length (RML)}$$

$$\text{RML} / 2 = \text{length of each polypropylene line and SpacelayT components}$$

(Note: SpacelayT is an anti-torque plastic coated wire rope.)

The polypropylene line is lifted off the bottom to prevent any accelerated wear, using auxiliary floatation on the lower segment of the mooring. By virtue of the neutrally buoyant compliant section and the positively buoyant polypropylene line, the design of this mooring will not add any residual weight to the buoy. The only vertical weight component added to the buoy is from current drag on the buoy and mooring.

The mooring can be deployed without the polypropylene line segment, using the same 2:1 scope design criteria for depths 15-30 m.

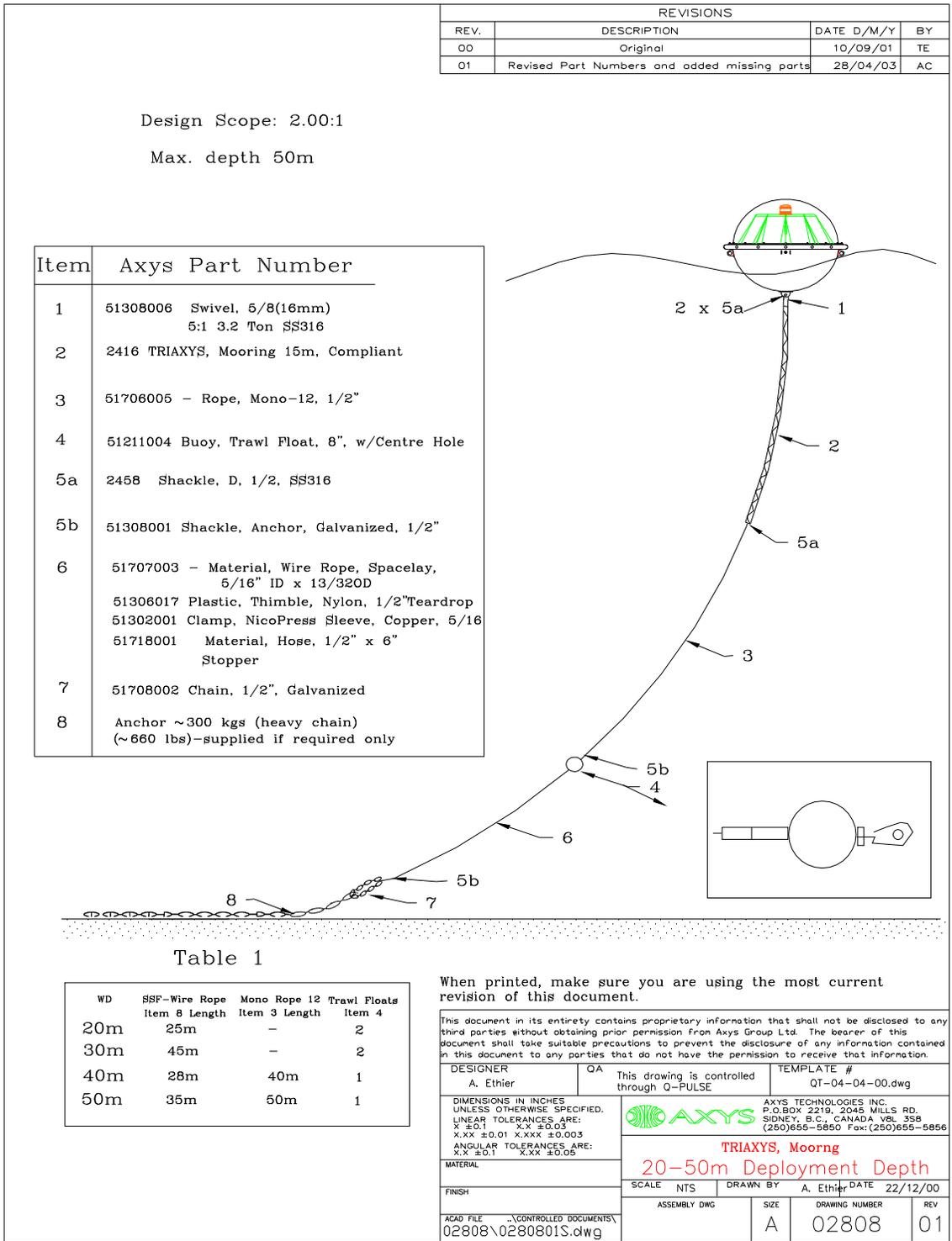
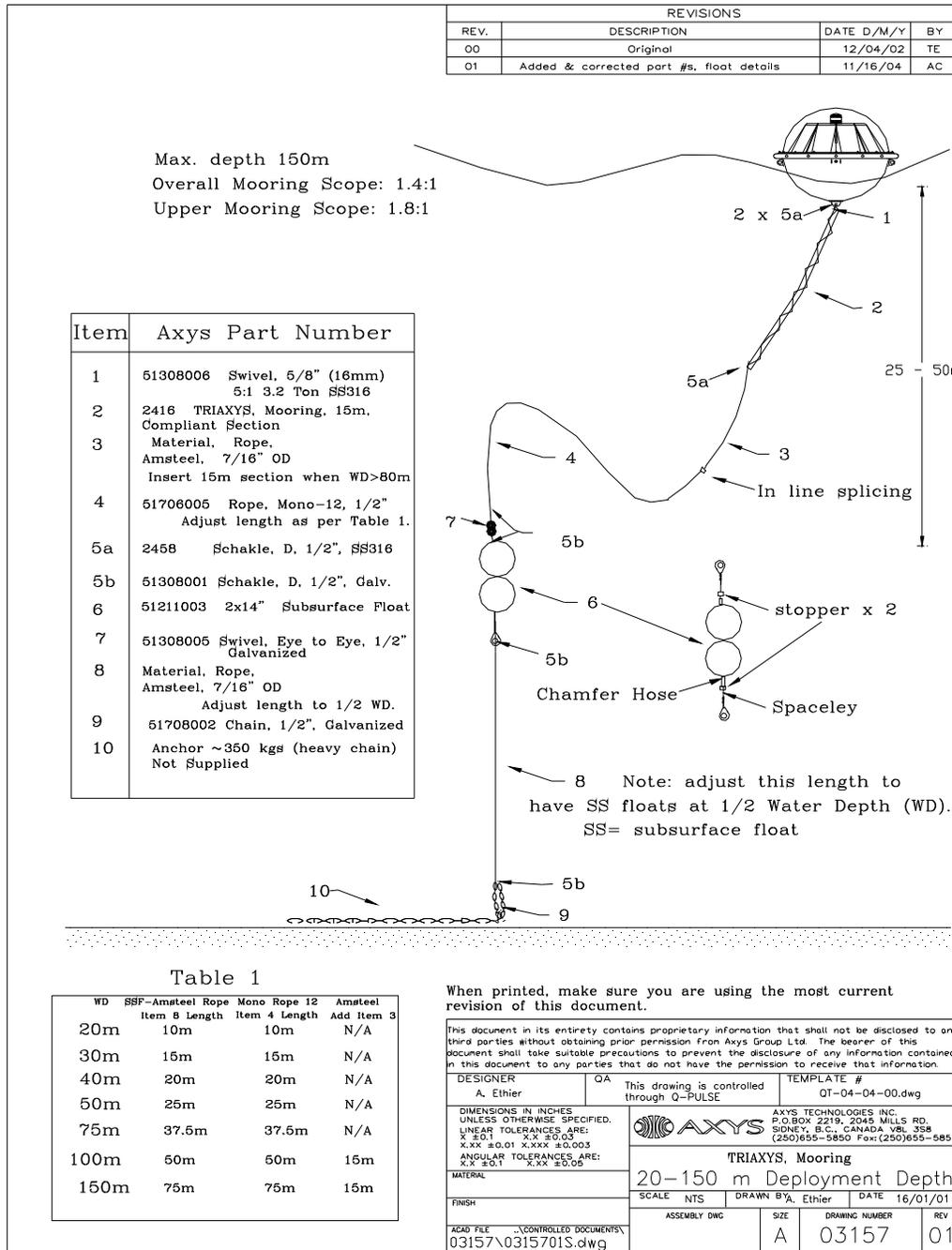


Figure 17: Standard 20 to 50 m TRIAXYS Mooring Configuration



**Figure 18: Standard 20 to 150 m TRIAXYS Mooring Configuration**

There are several mooring designs that can be used to deploy the buoy in deeper water or faster currents. These include false-bottom moorings and inverse catenary moorings. There are many references in oceanographic literature documenting alternative mooring strategies as well as commercial mooring design programs available. These programs will model the loading placed on the buoy for different mooring designs, components and current regimes. The user must take adequate precautions when designing a mooring to ensure that vertical drag and weight on the buoy are minimized so that the hull has unrestricted motion. Vertical loading of up to 45 kg is acceptable.

Another consideration that must be taken into account is that mooring components must be selected to ensure they are electrolytically and mechanically compatible. Isolation of dissimilar metals is imperative to prevent galvanic corrosion that will cause premature mooring failure. This can be accomplished by using "like materials" (e.g., SS 316 with SS 316) or isolation bushings (e.g., nylon thimbles) to prevent contact of dissimilar materials. For long-term deployments the use of anodes on metal components is recommended. Shackle sizes should be chosen so that safe working loads are not exceeded during deployment and recovery operations, as well as for wear factors during deployment.

### **3.1. Deployment Procedures**

The procedures to deploy a moored TRIAXYS™ Buoy are as follows:

1. Lay out all the mooring components in the correct order that will allow for a free run during pay out (either flaked, in parallel lines or in a figure eight).
2. Ensure the lifting bridle (3/4" polypropylene) on the buoy is in good condition. This bridle is left on the buoy for the duration of the deployment.
3. Ensure that all sections of the mooring are connected and the shackles are seized with cotter pins of stainless steel wire.
4. Ensure the magnetic key has been removed to turn the buoy on. Keep the magnetic key in a safe place for use on recovery.
5. Lift the buoy by its rope bridle and either place in the water or drop from a maximum height of 2 metres. Ensure that the buoy does not strike the side of the vessel during release. Pay out the mooring line with the vessel motoring away.
6. Release the anchor once the complete mooring is run out and the vessel is on station.

It is important to always follow the "buoy first then anchor last" sequence.

### **3.2. Recovery Procedures**

The procedures to recover a moored TRIAXYS™ Buoy are as follows:

1. Lift the buoy onto the recovery vessel using the lifting bridle.
2. Recover the compliant cord. **DO NOT LIFT THE ANCHOR USING THE COMPLIANT CORD.** It is extremely dangerous if the full weight of the anchor comes to bear on this section. If the mooring cannot be recovered without putting tension on the compliant cord, the line should be cut for safety considerations.
3. Once the compliant cord had been recovered, the balance of the mooring and anchor can be winched aboard using standard procedures.
4. Switch the buoy off by replacing the Magnetic Key.

### **3.3. General Deployment/Recovery Notes**

There are no extraordinary procedures that need to be followed to prevent damage to any of the payload components or sensors. The TRIAXYS™ Buoy is a rugged instrument designed to take minor bumps anticipated through the course of routine field operations. There are no limitations associated with spinning or freezing.

## 4. SOFTWARE AND DATA FORMATS

### 4.1. Software

All data processing is performed in the buoy. A unique proprietary iterative algorithm developed by the Canadian Hydraulics Centre (CHC) of the National Research Council of Canada (NRC) is used to solve the full non-linear equations of motion that define the buoy motions relative to a fixed reference frame in terms of the raw data from the six motion sensors and compass. See Section 11 References for relevant published papers on these algorithms. Any updates can be downloaded from the Axys Technologies Inc. web site: [www.axystechnologies.com](http://www.axystechnologies.com). The wave processing algorithms reside both in the buoy firmware and WaveViewT base station software for VHF and GSM transmitted data. The TRIAXYS™ Post Processing Software will take raw logged TRIAXYS™ Buoy data and perform all wave analysis and archive the data into various data products.

Motion analysis is performed in the frequency domain using specialized Fast Fourier Transform (FFT) integration techniques. This complete motion analysis procedure, including all six degrees of freedom, allows the vertical displacement and the north and east velocities of the buoy to be measured with very high accuracy because no simplifying approximations have to be made regarding earth gravity terms, cross-coupling terms or other spurious effects.

A practice commonly used in spectral analysis is to taper the data record over the first and last 5% or 10% of its length to avoid producing any spurious Gibbs oscillations due to cyclic discontinuities. In the processing unit a cyclic merging process is carried out. The brief details of this process are described below.

#### 4.1.1. Cyclic Merging

The first 5% of the record is defined as the merging zone. The original record is multiplied by a ramp function that goes linearly from 0 to 1 over the merging zone. The last 5% of the original record is removed and multiplied by another linear ramp function that goes from 1 to 0 over its length. This segment is then added to the original record in the merging zone. Since one ramp is going up while the other is going down, the average energy in the merging zone is preserved. The resulting cyclic-merged record is 95% as long as the original record and is cyclic over its own length because the beginning of it has the same amplitude and slope as the end of it. The data in the merging zone is artificial because it is a linear combination of the first and last 5% sections of the original record. After all FFT operations have been completed, the software removes the data in the merging zone and only outputs motion time series for the remainder of the cyclic merged records. This ensures that the computed motions apply only to the time interval where the input signals were not modified by the cyclic merging process.

CHC has found from simulations that cyclic merging produces more accurate motions than tapering because it preserves the average energy of each signal in the merging zone. It is because of the cyclic merging process that the data record is 10% shorter than the Acquisition Duration (AC DUR) (see Section 10 Glossary).

#### 4.1.2. Data Sampling and Re-sampling

The data from the accelerometers, angular rate sensors and compass are sampled at 4 Hz. To enable the Acquisition Duration (AC DUR) length to be variable between 1 and 35 minutes, the software re-samples the record length to get  $2n$  points where  $n$  is the smallest integer such that the new number of points is greater than or equal to the cyclic merged record length (AC DUR minus 5%).

#### Example

Original Record Length (AC DUR)  $L1 = 25$  minutes = 1500 seconds.

Original Number of Data Points  $N1 = 6000$  with  $dT1 = 0.25$ . The cyclic merging zone corresponds to the first 300 data points (5%).

Cyclic-merged Record Length  $L1C = (N1C * dT1) = 1425$  seconds. where the cyclic-merged number of data points  $N1C = 5700$  (corresponds in time to the first 5700 points of the original record).

Re-sampling occurs after the removal of the last 5% of the original record in the cyclic merging process.

Cyclic-merged record is resampled to  $2n$  points such that  $2n$  is greater than or equal to 5700. With  $n = 13$ ,  $N2C = 8192$ , and the new sampling frequency  $dT2C = dT1 * N1C / N2C = 0.1736$  seconds.

### 4.1.3. Motion Analysis

Motion analysis is performed using the re-sampled, cyclic merged records. Because the first 5% of the record is artificial due to the cyclic merging, after all the FFT operations have been completed, the first 5% of the computed motions are also removed. Thus the record length of the final computed motions is 10% shorter than the original record length (AC DUR) for the measured raw sensor signals. The wave analysis includes: a zero crossing analysis of the wave elevation record to produce time domain wave statistics; a spectral analysis that computes the non-directional wave energy spectrum,  $S(f)$ , which defines the distribution of wave energy as a function of frequency; a directional spectral analysis, using the wave elevation and the north and east buoy velocity components, that computes the directional wave spectrum,  $S(f, \theta)$ , which defines the distribution of wave energy as a function of frequency and direction of propagation; calculation of the mean wave direction and the directional spreading width as functions of frequency.

### 4.1.4. Frequency Bands

The frequency bands range from 0.64 Hz (1.56 seconds) to 0.03 Hz (33.33 seconds). 0.005 Hz separates the bands. Thus the number of frequency bands is 123 with the first band centred at 0.03 Hz and the last band centred at 0.64 Hz. These are the frequency bands in the output file.

### 4.1.5. Low Frequency Energy

The Root Mean Square (RMS) noise value for the accelerometers in the TRIAXYS™ sensor is about 0.0005g. This noise is uniformly distributed over the nominal measurement bandwidth of 1 Hz so the vertical acceleration spectra have a fairly constant amplitude of approximately  $0.00001 \text{ (m}^2/\text{s}^4)/\text{Hz}$  at all frequencies. However the wave elevation displacement spectrum  $SD(f)$  is related to the vertical acceleration spectrum  $SA(f)$  as follows:

$$SD(f) = SA(f) / \omega^4$$

Where  $\omega = 2\pi f$ . Since  $SA(f)$  is constant for a given RMS noise level, the relative effects of the noise on the wave elevation spectrum become much larger at low frequencies because  $SD(f)$  is inversely proportional to  $f^4$ . This leads to the presence of low frequency energy peaks in the power spectrum.

Although these peaks represent only a very small amount of spurious wave energy in absolute terms, the following method is used to reduce the effects of accelerometer noise when the buoy is stationary or when the wave amplitude is small.

The wave elevation displacement spectrum corresponding to an RMS accelerometer noise level of 0.001g\* is given by (SN(f)). If, at a given frequency, the measured spectral density of the wave elevation displacement spectrum, SD(f), lies below the spectral density for SN(f), then it can be assumed that SD(f) is mostly due to noise rather than real wave energy. In this case the corresponding Fourier transform coefficients at the frequency f are multiplied by 0.1 to reduce the spurious wave amplitude by a factor of 10 and the spurious spectral density by a factor of 100. If the measured spectral density of SD(f) is above the spectral density for SN(f), then it is assumed to be mostly due to real wave energy and the amplitude is not reduced.

NOTE: The value of 0.001g is chosen as a compromise between adding a safety margin above the stationary accelerometer noise levels and not restricting the ability of the buoy to measure small amplitude waves.

#### 4.1.6. Directional Wave Analysis

The directional wave analysis is based on the cross spectra between the vertical and horizontal motions of the buoy. Consequently, the directional wave analysis results will not be meaningful when the buoy is stationary because there are no real vertical or horizontal motions but only random accelerometer noise. Reliable directional wave measurements can only be made when there is a reasonable amount of buoy motion in the horizontal and vertical planes. Based on test and simulation results carried out at the Canadian Hydraulics Centre of the National Research Council, the following approximate guidelines can be used:

- If  $T_p$  is less than 10 seconds, then  $H_{mo}$  must be at least 0.1m for reliable directional wave analysis
- If  $T_p$  is greater than 10 seconds, then  $H_{mo}$  must be at least  $(0.001 * T_p^2)m$  for reliable directional wave analysis. For example if  $T_p = 20$  seconds then  $H_{mo}$  must be at least 0.4m for reliable directional wave analysis.

The significant wave height required for reliable directional wave analysis increases at the lower frequencies because the accelerometer noise effects are relatively larger at lower frequencies.

## 4.2. TRIAXYS™ Data Formats

The data is transmitted from the TRIAXYS™ Directional Wave Buoy as per the set-up instructions of the Buoy User Manual via either VHF, GSM cell phone telemetry and email receipt of YYYYMMDD.RX data. The WaveView™ software builds complete data files from the repeated messages. It does not archive redundant data. The TRIAXYS™ Directional Wave Buoy transmits the data in binary (VHF) or hex (GSM) format. This file is transmitted as complete block with all files referenced below embedded with CRC error checking. On being received at the base station, WaveView™ first verifies that the data was received from a registered platform, then will process the data into the various files listed below. The received data will also be stored as a raw RX file. The data is automatically converted into standard comma delimited files and archived by the WaveView™ software in daily directories, which are in turn archived in monthly and yearly directories. The archived data is separated into eight standard files, which are named as follows:

```

YYYYMMDD.RX
YYYYMMDD.WAVE
YYYYMMDD.STAT
YYYYMMDD.FOURIER YYYYMMDD.NONDIRSPEC YYYYMMDD.DIRSPEC
YYYYMMDD.HNE
YYYYMMDD.Meandir
    
```

The YYYYMMDD format is used as the file name, and the extension describes the type of file. These will be stored in monthly folders.

#### 4.2.1. File YYYYMMDD.RX

The .RX data files are the complete Hexadecimal (Hex) converted transmitted data file from the TRIAXYS™ Directional Wave Buoy. This file will be created and appended whenever an incoming data stream is monitored on the output port from a TDR or Modem. VHF data is transmitted from the buoy in Binary format and converted by WaveViewT to Hex. If the operator is monitoring the TDR serial port for data using HyperTerminalT rather than WaveViewT, no identifiable data will be seen during reception because of the Binary nature of the data string.

NOTE: In areas where there is significant radio interference, the operator may see many extra data sets of random Hex values with a header time stamp. A valid TRIAXYS™ message should begin with "7F". The timing of the incoming data time stamps should correspond to the set-up parameters on the buoy, i.e., reception hourly at 27 minutes past the hour for a 25 minute sample starting at the top of the hour.

#### 4.2.2. File YYYYMMDD.WAVE

The .WAVE data files are comma delimited and include the wave statistics as calculated on the TRIAXYS™ Directional Wave Buoy. The statistics are calculated from both the zero crossing analysis as well as the FFT

Parameter	Formula/Units
Received Message Time (computer time)	YYMMDD HHMMSS
Year	YYYY
MonthDay	MMDD
Time	HHMMSS
Buoy ID	12 Characters Alphanumeric
Location (lat./long.)	DDMM.MMM/ DDDMM.MMMM
Number of Zero Crossings	0000
Average Wave Height (Hav)	00.00 metres
Mean Spectral Period (Tz)	0000 seconds
Maximum Wave Height (Hmax)	00.00 metres
Significant Wave Height (Hs)	00.00 metres
Significant Period (Ts)	0.0 seconds
H10	00.00 metres
T10	0.0 seconds
Mean Wave Period (Tav)	0.0 seconds
Peak Period (Tp)	0.0 seconds
Tp5	0.0 seconds
Hmo	00.00 metres
Mean Magnetic Direction	000 degrees
Mean Spread	000 degrees
Mean True Direction	000 degrees
Te	0.0 seconds
Wave Steepness	0.000 ratio

#### 4.2.3. File YYYYMMDD.STAT

The .STAT files are comma delimited housekeeping files. Also in this file are the sea surface temperature.

<b>Parameter</b>	<b>Formula/Units</b>
Received Message Time (computer time)	YYMMDD HHMMSS
Status Message Time (buoy time)	YYMMDDHHMM
Buoy ID	12 Characters Alphanumeric
Location (lat./long.)	DDMM.MMM/ DDDMM.MMMM
Water Temperature	0.0°C
Battery Voltage	0.0 VDC
Sample Rate (4 Hz)	4HZ.( Fixed)
Samples per channel	0000
Acquisition Interval	000 Minutes
Transmission Interval	000 Minutes
Number of Transmissions	00 counts
TRIAXYS™ Sensor Serial Number	00xxx
Gpuc EPROM Version	2.x
PC104 EPROM Version	1.xx.xx
Boot Times	00 Counts
Status Code	0 or 1
Solar Current	0.0 Amps
Magnetic Variation	±00.00 degrees
Acquisition Duration	00 Minutes
Mode Normal	

#### 4.2.4. File YYYYMMDD.FOURIER

The .FOURIER file contains the first four Fourier coefficients of the directional spectra for each of the frequency bands. The first row of data includes:

```
Date/time
Number of frequency bands (n) Centre of the initial frequency band Frequency
Separation
```

The second and subsequent rows of data (tab delimited) include:

```
Date/time
Band 1 of n Coefficient a1      Coefficient b1      Coefficient a2      Coefficient b2
Band 2 of n Coefficient a1      Coefficient b1      Coefficient a2      ...

21/08/2003 11:26:01
Band 0/123 123 0.03 0.005 0
Band 1/123 81 0.065 0.005 3
Band 2/123 0.6477922 -7.742236E-02 -1.890794E-15 0.2389527
Band 3/123 0.8034814 -0.1104481 1.478381E+32 0.2304547
Band 4/123 0.5321179 -0.1448039 -1.133521E-13 0.2087785
Band 5/123 0.6173671 -0.1721139 -1.347969E+15 0.1752085
.
.
Band 122/123 0.5648439 0.3674361 6.447199E-34 8.174629E-02
Band 123/123 0.5051991 0.3396116 -5.870703E-13 0.061837
```

#### 4.2.5. File YYYYMMDD.NONDIRSPEC

The .NONDIRSPEC file contains the power spectra for each of the frequency

bands. The first four lines of data include:

```
Date/time
Number of frequency bands (n)
Centre of the initial frequency band Frequency
Separation
```

The fifth and subsequent lines of data include the m2/Hz values for each frequency band, for example:

Value for band 1 of n Value for band 2 of n Value for band 3 of n

```
21/08/2003 11:26:00
123
0.03
0.005
7.228927E-05
1.812071E-04
.
.
.
4.30365E-03
3.626124E-03
3.837209E-03
```

#### 4.2.6. File YYYYMMDD.DIRSPEC

The Directional Spectrum output files are formatted as 8 energy values in each row resulting in a listing of sequential values from 1 to 14883. This resolves into a matrix with 121 columns of direction bins by 123 rows of frequency bands. There are 121 columns of direction bins with a spacing of 3.00 degrees starting at 0.00 Degrees. There are 123 rows of frequency bands with a spacing of 0.005 Hz starting at 0.000 Hz

The first 121 values, from Value 1 to Value 121, represent the energies from 0 to 360 degrees at an increment of 3 degrees per column /bin, of the first resolvable frequency band (i.e., 0Hz).

Then the second sets of 121 values, from Value 122 to Value 242, are the energies for the second resolvable frequency band (i.e., 0.005Hz).

Therefore, the nth set of 121 values, form Value (n-1)\* 121 to Value n\* 121, are the energies for the nth resolvable frequency band (i.e., (n-1) \* 0.005 Hz).

Values 1 - 121 Equals Frequency Band 1- 0Hz

```
Value 1 Value 2 Value 3 Value 4 Value 5 Value 6 Value 7 Value 8
Value 9 ... .. Value 121 Value 122 Value 123 Value 124 Value 125 Value 126
:
:
Value 239 Value 240 Value 241 Value 242 Value 245 ... ..
Value 14881 Value 14882 Value 14883
```

Values 14762-14883 Equals Frequency Band 123- 0.61Hz

```
20:00:00 20 August 2003
NUMBER OF FREQUENCIES = 123
NUMBER OF DIRECTIONS = 121
```

```

INITIAL FREQUENCY (HZ)           =      0.000
FREQUENCY SPACING (HZ)           =      0.005
DIRECTION SPACING (DEG)          =      3.000
ALL VALUES FOR DIR1(1..NFREQ) ARE GIVEN, THEN
ALL VALUES FOR DIR2(1..NFREQ) ETC (1..NDIR)
  0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00...
  0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00...
:
.
```

#### 4.2.7. YYYMMDD.HNE

The .HNE file (optional) contains the latest time series data. Its format is provided in the following sample file:

```

TRIAXYS BUOY DATA REPORT
VERSION = 5D
TYPE = HNE
DATE = 2001 Aug 18 10:00(UTC)
NUMBER OF POINTS = 1382
TIME OF FIRST POINT (s) = 60.1645
SAMPLE INTERVAL (s) = 0.7813571
COLUMN 1 = TIME (sec)
COLUMN 2 = HEAVE (m)
COLUMN 3 = DISP. NORTH (m)
COLUMN 4 = DISP. EAST (m)
60.16 -0.6 -0.53 0
60.95 -0.72 -0.4 -0.01
61.73 -0.82 -0.26 -0.02
62.51 -0.89 -0.11 -0.04
.....and so on to 1382 points.
```

#### 4.2.8. YYYMMDD.Meandir

The Meandir file (optional) contains the latest mean direction and spreading width as a function of frequency. Its format is provided in the following sample file:

```

TRIAXYS BUOY DATA REPORT
VERSION = 5D
TYPE = MEAN DIRECTION
DATE = 2001 Aug 18 10:00(UTC)
NUMBER OF POINTS = 5
INITIAL FREQUENCY (Hz) = 0.03
FREQUENCY SPACING (Hz) = 0.005
RESOLVABLE FREQUENCY RANGE (Hz) = 0.03 TO 0.055
S(f) WEIGHTED MEAN WAVE DIRECTION = 355.72
S(f) WEIGHTED MEAN SPREADING WIDTH = 2.68
COLUMN 1 = FREQUENCY (Hz)
```

COLUMN 2 = SPECTRAL DENSITY (M<sup>2</sup>/Hz)  
 COLUMN 3 = MEAN WAVE DIRECTION(DEG)  
 COLUMN 4 = SPREADING WIDTH (DEG)

0.030	1.4119420E-01	355.69	5.09
0.035	1.4136670E+01	355.70	3.17
0.040	5.3730660E+01	355.71	2.62
0.045	3.0706180E+01	355.74	2.56
0.050	1.6008640E-01	355.76	2.79

### 4.3. Logged Data Format

Both Processed and Raw data can be recorded on the TRIAXYS™ Directional Wave Buoy onto a single PCMCIA Flash Ram card (1 Gbyte is the standard size; larger is optional). See section 1.6.1 for data capacities. This data is described in the following section as to file nomenclature. To review the logged data, the user must first run the logged data through the TRIAXYS™ Post Processing Software. The use of this application is described in Chapter 6 of the TRIAXYS™ Directional Wave Buoy Applications Software User's Manual.

#### 4.3.1. Processed Wave Data

Processed wave data (.WYY) can be logged onboard the buoy on a PCMCIA Flash RAM card. The Flash Ram card is accessed from inside the Sensor and Telemetry Module. When the Module lid is opened, the slot for the Flash RAM card is on the right hand side. The card is easily removed by pressing the release button. A new card can then be installed. Ensure the card is oriented correctly in the drive and firmly seated before closing up the lid of the Sensor and Telemetry Module.

The wave data on the Flash RAM card is logged to files with the filename representing the encoded date of the start time of the wave sampling. The files are named XXDDHHMM.WYY where:

XX = 2-letter month code (JA, FE, MR, AP, MY, JN, JL, AU, SE, OC, NO, DE)  
 DD = 2-digit day of the month (01-3 1)  
 HH = 2-digit hour code (00-23)  
 MM = 2-digit minute code (00-59) W = Constant  
 YY = 2-digit year code  
 e.g., AP120930.W99 = 09:30 a.m. 12-Apr-99

#### 4.3.2. 4 Hz Wave Data

4 Hz wave data (.RYY) can be logged onboard the buoy on a PCMCIA IBM Microdrive card. The card is accessed from inside the Sensor and Telemetry Module. When the Module lid is opened, the slot for the RAM card is on the right hand side (closest to the outside of the box). The card is easily removed by pressing the release button. A new card can then be installed. Ensure the card is presented the correct way round and firmly seated before closing up the lid of the Sensor and Telemetry Module.

The wave data on the card is logged to files with the filename representing the encoded date of the start time of the wave sampling. The files are named XXDDHHMM.RYY where:

XX = 2-letter month code (JA, FE, MR, AP, MY, JN, JL, AU, SE, OC, NO, DE)  
 DD = 2-digit day of the month (01-3 1)  
 HH = 2-digit hour code (00-23)  
 MM = 2-digit minute code (00-59)  
 R = Constant

YY = 2-digit year code  
e.g., AP120930.R99 = 09:30 a.m. 12-Apr-99

#### **4.4. Orbcomm Transmitted Data Format (Optional)**

The data is transmitted from the TRIAXYS™ Directional Wave Buoy (via Orbcomm satellite telemetry) as per the set-up instructions of the Buoy User Manual. The WaveView™ software builds complete data files from the email received messages. It does not archive redundant data.

The TRIAXYS™ Directional Wave Buoy transmits the data in binary format. The data files are transmitted as separate blocks with CRC error checking. On being received at the base station, WaveView™ first verifies that the data was received from a registered platform, then will process the data into the various files listed below. The received data will also be stored as a raw RX file. The data is automatically converted into standard comma delimited files and archived by the WaveView™ software in daily directories, which are in turn archived in monthly and yearly directories. The archived data is separated into six standard files, which are named as follows:

YYYYMMDD.WAVE  
YYYYMMDD.STAT  
YYYYMMDD.Meandir

The YYYYMMDD format is used as the file name, and the extension describes the type of file. These will be stored in monthly folders.

#### **4.5. INMARSAT D+ (Optional)**

The optional INMARSAT D+ Satellite Transceiver used in the TRIAXYS™ Buoy is a Skywave DMR-200 unit.

This option can provide buoy position, wave data and buoy configuration/remote set-up. The buoy can be configured for GPS position-only data as a WatchCircle beacon, or can be configured to contain both position and wave data. This data is available on a secure website, ftp or e-mail, as discussion of these formats can be found in section 1.8.4.

NOTE: This can only take place when the unit is powered up.

#### **4.6. Iridium and GSM (Optional)**

Data formats for Iridium and GSM are as per Section 4.2.

#### **4.7. ARGOS Transmission (Optional)**

The TRIAXYS™ Directional Wave Buoy can be fitted with an ARGOS transmitter for cases where the buoy is going to be out of range of a VHF receiver or for position verification. The ARGOS transmitter transmits a 32-byte binary data string every 90 to 200 seconds, depending on the transmission options. However, because of the passage of the satellites, the message does not always get through. The data are therefore repeated for the three previous hours. The limit of 32 bytes only allows the basic wave statistics to be transmitted. The ARGOS system can also provide location as well as wave statistics. Data is typically emailed to the end user from Service ARGOS or CLS.

NOTE: Service ARGOS has recently increased the number of valid PTT ID numbers. This has resulted in an increase of the PTT ID S/N's from a 20 bit to a 28 bit number. As the ARGOS message length is fixed, this has resulted in a decrease in the data message length by 8 bits. With our existing format, a 28 bit PTT ID will result in the truncation of the Decimal Minutes Latitude or T=-3 hr Mean Spread/Mean Dir values. A new data format will be released in the new year. Users can request that Service ARGOS issue 20 bit IDs for use with fixed format data messages. The current TRIAXYS™ Directional Wave Buoy ARGOS format is based on using the 28-bit ARGOS user ID found in Table 1.5.

NOTE: Decode of the ARGOS data can also be done using TRIAXYS™ ARGOS Decode Software. Refer to the TRIAXYS™ Application Software Manual for more information.

#### 4.7.1. Description of ARGOS Parameters

Julian Day

Time

Model #

Serial #

Water Temp.

System Voltage

Boot Times

From 1 to 365, or 366 in a leap year. Coded for years 1999 to 2098. Minute of the reported Sample Start time.

0 refers to TAB

XX refers to 00XX0

From 0 to 509, subtract 150 and divide by 10.

510 is above 35.9°C;

511 is below -15°C.

From 0 to 125, add 50 and divide by 10.

126 is above 17.5 volts;

127 is below 5 volts.

From 0 to 7. Number of times the system has been reset.

**Acquisition Interval** There are 32 possible Acquisition Intervals from 5 minutes to 1440 minutes that can be evenly divided into 1440 by 5 or greater. These are indicated as one of the following options listed in the following table. Although these options are available it is recommended that standard intervals of hours or simple divisions of an hour are used, e.g., a half (30 minutes), a third (20 minutes), a quarter (15 minutes) or a sixth (10 minutes)

**Acquisition Duration** There are 32 possible Acquisition Durations from 4 minutes to 35 minutes. These are calculated by adding 4 to the decimal number reported in minutes.

Acquisition Interval	ARGOS Reported AC INT		Acquisition Duration	ARGOS Reported AC DUR
5	00		4	0
6	01		5	1
8	02		6	2
9	03		7	3
10	04		8	4
12	05		9	5
15	06		10	6
16	07		11	7
18	08		12	8
20	09		13	9
24	10		14	10
30	11		15	11
32	12		16	12
36	13		17	13
40	14		18	14
45	15		19	15
48	16		20	16
60	17		21	17
72	18		22	18
80	19		23	19
90	20		24	20
96	21		25	21
120	22		26	22
144	23		27	23
160	24		28	24
180	25		29	25
240	26		30	26
288	27		31	27
360	28		32	28
480	29		33	29
720	30		34	30
1440	31		35	31

Data	Range	Bits
<b>XOR Checksum from next bit to end of message</b>		8
<b>Housekeeping (T=0)*</b>		0
Sample Start - Year	0 to 31	5
Sample Start - Month	01 to 12	4
Sample Start - Day	01 to 31	5
Sample Start - Time (hr)	0 to 23	5
Sample Start - Time (mins)	0 to 59	6
Buoy Serial ##### (ie TAS0###0)	1 to 512	9
Water Temperature (0.2 deg C resolution)	-15 to +35.8	8
System Voltage	5.0 to 17.5 V	7
Boot Times	0 to 7	3
Solar Current	0 to 1.5 (tenths amps)	4
GPS position included	0 or 1	1
<b>Present Data (T=0)</b>		
Hs (Significant wave)	0 – 4000 cm	12
Hmax (Maximum Wave)	0 – 4000 cm	12
T peak	0 to 350 tenths seconds	9
Mean Direction	0 to 357 (3 deg increments)	7
Mean Spread	0 to 345 (15 deg increments)	5
<b>Previous Data (T= -1hr)</b>		
Hs (Significant wave)	0 – 4000 cm	12
Hmax (Maximum Wave)	0 – 4000 cm	12
T peak	0 to 350 tenths seconds	9
Mean Direction	0 to 357 (3 deg increments)	7
Mean Spread	0 to 345 (15 deg increments)	5
<b>Previous Data (T= -2 hr)</b>		
Hs (Significant wave)	0 – 4000 cm	12
Hmax (Maximum Wave)	0 – 4000 cm	12
T peak	0 to 350 tenths seconds	9
Mean Direction	0 to 357 (3 deg increments)	7
Mean Spread	0 to 345 (15 deg increments)	5
<b>Previous Data (T= -3 hr) GPS position not incl.</b>		
Hs (Significant wave)	0 – 4000 cm	12
Hmax (Maximum Wave)	0 – 4000 cm	12
T peak	0 to 350 tenths seconds	9
Mean Direction	0 to 357 (3 deg increments)	7
Mean Spread	0 to 345 (15 deg increments)	5
<b>GPS position - if included, replaces T=-3hr Data</b>		
Degrees Latitude	000-099 deg	8
Minutes Latitude	000-059 min (add 100 for South)	8
Decimal Minutes Latitude	000-099 min	8
Deg Longitude	000-180 deg	8
Minutes Longitude	000-059 min (add 100 for East)	8
Decimal Minutes Longitude	000-099 min	8
* Extra bits in SST, batt, Hmax, Hs used for error flagging		
Batt	126 if <5.0 Volts, 127 if >17.5 volts	
SST	255 if < or > range	
Hmax and Hs	4094 if missing and 4095 if > 40.00 meters	

#### 4.7.2. Powering ARGOS ON and OFF

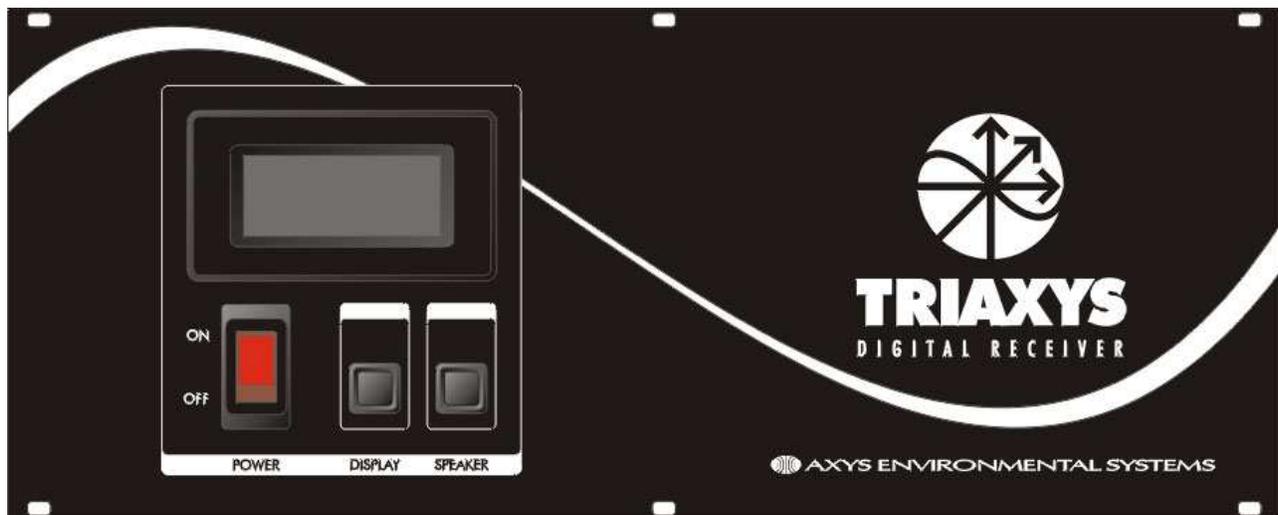
Both Processed and Raw data can be recorded on the TRIAXYS™ Directional Wave Buoy onto a single PCMCIA 1 Gbyte Flash Ram card. See section 1.6.1 for data capacities. This data is described in the following section as to file nomenclature. To review the logged data, the user must first run the logged data through the TRIAXYS™ Post Processing Software. The use of this application is described in Chapter 6 of the TRIAXYS™ Directional Wave Buoy Applications Software User's Manual.

## 5. Base Station System Configuration

The TRIAXYS™ Buoy is delivered with the variety of telemetry devices, which will have different hardware requirements for the on shore receiving and data processing facility. The following section will describe the different hardware configurations and system requirements. The basic requirements are a means to input the transmitted TRIAXYS™ data message into a PC running WaveView, either by direct VHF transmission, telephone modem or email. Each of these are described in the following section

### 5.1. TRIAXYS™ Digital Receiver (TDR)

A TRIAXYS™ VHF Base Station is comprised of the TRIAXYS™ Digital Receiver (TDR), antenna and cable. The TDR receiver is connected to a user supplied PC (running English windows) with an AXYS supplied serial cable. A registered copy of WaveView software must be installed and running on the PC to receive, decode, display and archive the wave data.



**Figure 19: TDR Face Plate**

The TDR is an integrated unit that contains a VHF receiver and radio modem and power supply. The unit has a number of diagnostic features to assist the user in gauging transmitted signal quality and includes a Received Signal Strength Meter and an Audible Speaker. The specifications are as follows:

Width: 34.3 cm (13.5 in)  
 Height: 14.0 cm (5.5 in)  
 Depth: 38.7 cm (15.25 in)  
 Weight: 4.0 kg (10 lb)  
 Power on/off switch  
 Received Signal Strength Meter

Speaker (audible strength indicator/quality) Power Supply AC 85V to 264V 50/60 Hz  
 DC 12V to 18V  
 Fuse 1A @ 250V  
 Modem: Indicator Lights, Power, Rx, Tx DB 9 serial connector

## 5.2. VHF Radio Receiver

Frequency Ranges: 29 to 38 MHz or 38 to 50 MHz

Number of channels: 16 preset channels. Set at the factory.

Received Signal Strength: 1.0 to 5.0 VDC linear over 60 dB input signal level

Change Operating Temperature: -30°C to +60°C, non condensing



**Figure 20: TRIAXYS Digital Receiver Back Plate**

The receiver is initially aligned at the factory for the frequency stamped on the "Factory Set Operating Frequency" label attached on the back of the radio in the top left-hand corner (see Figure 5.2). For a minor frequency change, a channel change is required. A major frequency change will require the complete

realignment of the radios. The frequency change is the accumulated frequency change in relation to the frequency stamped on the label. For a minor frequency change contact AXYS for a detailed work instruction.

### 5.2.1. Modem

This is configured at AXYS to the following setup:

Data rates: 1200 (default) bits per second.  
 Serial ports: RS 232 asynchronous serial interface configured as a DCE with a DB9 connector.  
 Data cable: Supplied to connect with the PC Serial Communications port.

#### 5.2.1.1. Modem Status LEDs

The modem has three LED indicators on the back panel that provide operational status of transmit (TX), receive (RX) and power (PWR) functions. Special combinations of these indicators are used to indicate operating modes and fault conditions.

Table 1.6 Modem LED Indicator States

State	LEDs	Indicator State
Normal Operation	PWR	On when the modem is powered.
	RX	A continuous irregular flash when the radio is powered and connected properly. On solid when the modem detects activity on the radio channel.
	TX	On when the modem is transmitting. Since the TDR is in Receive mode only, this LED does not light up on its own to indicate transmission.
Program Mode	RX, TX	Both on continuously
Reset	RX, TX	Flash together four times. Although the reset indication takes about four seconds to complete, the modem is fully operational when the flashing begins
Receive Buffer Overflow	RX	Flashes ten times for each occurrence.
Diagnostics Fault	PWR	Flashes for the duration of the fault. In this mode the modem has detected a fault but continues to operate. Operation may be unreliable due to the fault. The most common cause of this state is an out of range power source. The source of the fault can be diagnosed with the configuration program.
Catastrophic Fault	RX, TX	Alternately flash until the fault is cleared and the modem is reset. In this mode the modem has detected a catastrophic fault and is non-operational until the fault is corrected. The source of the fault can be diagnosed with the configuration program.

### 5.2.2. Antennae

Two omni-directional antennae are provided with each system delivered. Both antennae have been tuned at Axys to the frequency of the buoy system delivered. Exchanging tuned antennae between systems set on

different frequencies will result in a reduction of the received signal strength and may possibly lead to reception problems.

The small whip antenna provided can be used for testing or short-range deployments and is connected directly to the TDR. For most installations, use the externally mounted high gain Ringo Ranger antenna and provided coaxial antenna cable to complete the installation. See Appendix D for tuning and assembly instructions on the Ringo Ranger antenna. Care should be taken to mount the antenna away from other electrical devices such as transformers and other antennas. Optional YAGI directional antennae can be provided on re-quest.

### 5.2.3. Operation of the TDR

The base station TDR receiver is set up by connecting the serial data cable to the PC running WaveView and the VHF antenna or coaxial cable to the RF IN port on the TDR receiver. Once this has been done, switch the front power button to the "on" position. The operator can verify the operation of the unit by checking the "LED" status lights on the modem (see Section 5.2.2.1) and also by activating the TDR speaker. Turn the speaker on by moving the switch to the "on" position and depressing the squelch disable button. The operator should hear a static noise on the speaker (if not push the speaker button once more, repeat action). If the speaker is active, the operator will only hear a demodulated tone when the buoy transmits. Another diagnostic feature of the TDR is the signal strength meter on the front panel. When depressing the "display" button a value will be displayed which indicates radio signal levels at the tuned frequency. For good radio reception the differential strength between non-transmit to transmit should be >1.5. A non-transmit level of <2 is good, greater indicates a noisy RF environment. If the buoy is close to the receiving station, signals of over 5 will be reported on the display.

The operator can check that the radio speaker is operational by depressing the SQ Disable button on the back of the receiver. If the speaker is on, then you will hear a static signal output from the radio speaker. If it is off, then there will be no sound. Press the speaker button once then repeat.

## 5.3. GSM Base Station Hardware

When the TRIAXYS™ Buoy system is delivered with GSM telemetry, the Base Station is comprised of a telephone modem connected to a PC (either user supplied or a system option). A registered copy of WaveView software must be installed and running on the PC to receive, decode, display and archive the wave data. This modem is dedicated to the GSM telemetry system and cannot be shared with other applications or functions within WaveView.

If a Laptop Computer is supplied with the System, no setup is required. The internal modem of the laptop only needs to be connected to the phone line that the TRIAXYS™ Buoy has been configured to call.

NOTE: This must be an Analog phone line (NOT a digital line).

If a separate US Robotics modem (either user supplied or a system option) is supplied:

- 1 Connect the modem serial cable to the Computer running WaveView.
- 2 Ensure that the following switch settings on the back of the modem are set:  
3&8 set DOWN, all others set UP (as shipped)
- 3 Connect the phone line and modem power supply and turn the modem on.
- 4 Open the WaveView.ini file (located in the root directory of the WaveView install (usually c: \program files\ Wave View) and ensure the following text is in the file:  
[SETTINGS]  
.

HexMode, True

.

[End Settings]

[MODEM INIT]

ModemEnabled,True

String,AT&F 1E0&K0&M0&N6&R1 &S0&D0S0=1 Interval, 60

[END MODEM INIT]

5 Start WaveView and set the COM port (under Comms and Communications Setup) to the correct serial port (usually COM1 or COM2) and enter the following settings:

Parity = NONE

Data Bits = 8

Stop Bits = 1

Baud Rate = 9600

Then press OPEN PORT and OK!

## 5.4. Internet Reception of Buoy Data

With the release of the WaveView 3.07.000x or later there are a number of new Internet capabilities to receive data from Orbcomm transceivers as well as receiving data emailed from a primary base station. The remote PC running a registered copy of WaveView software and connected to either a LAN or dialup ISP can receive, decode, display and archive the emailed wave data. Further functionality of the email features are discussed in the TRIAXYS™ Applications Software User's Manual.

## **6. TRIAXYS™ APPLICATION SOFTWARE**

See the TRIAXYS™ Software User Manual Version 01

## 7. ASSEMBLY/DISASSEMBLY PROCEDURES

### 7.1. Purge Port

The purge port can be used to remove any moist air that remains in the buoy (if the desiccant packs are not new) once the Dome has been installed. It can also be used to sample for or remove any possible hazardous gases that may be present inside the buoy hull.

NOTE: Whenever handling this buoy, use proper hazardous gas ventilation procedures and/or an explosive gas detection apparatus if available. This product contains Sealed Lead Acid batteries, which when exposed to extreme temperatures (>40deg C) and/or overcharging, can result in the production of Hydrogen Gas in quantities sufficient to combust in the presence of an open flame or spark. Although the TRIAXYS Directional Wave Buoy carefully controls the battery voltage in order to prevent overcharging, it is recommended that proper handling procedures be followed. There is a purge port on the side of the buoy for forced ventilation of an inert gas (for example Nitrogen) to actively remove any potential hazardous gas build up.

NOTE: Another method of hydrogen generation is through electrolysis. If any electronic equipment is exposed to salt water, there is a potential to generate hydrogen and oxygen in sufficient quantities to support combustion. If a buoy is suspected of having water intrusion, it is very important that these procedures be followed. Always assume that the buoy contains hydrogen.

#### HYDROGEN SAMPLING PROCEDURE

Install the Dome Cover onto the buoy and let the buoy cool for as long as possible.

Install the Magnetic Key to turn the buoy off.

Remove the purge port plug.

If you have a Hydrogen gas detector (Industrial Scientific Model LTX3 12 or equivalent), insert the sample tube in through the purge port and sample the air. If no hydrogen gas is detected, proceed to Section 7.2.1. If gas is detected continue with the purging procedure to evacuate any residual Hydrogen gas from the hull.

If no gas detector is available, the hull should be purged as a matter of standard procedure.

#### PURGE PROCEDURE:

Loosen the dome nuts to aid in the ventilation of the buoy

Tip the buoy up so that the purge port is as high as possible.

Insert a loose-fitting tube through the purge port into the buoy.

Pump inert gas (for example Nitrogen) into the buoy for approximately ten minutes at a rate of 2 cfm or greater.

Turn off the gas and remove the tubing. Resample with the gas detector if available to verify a safe buoy atmosphere or proceed to Section 7.2.1.

### 7.2. Dome

The following procedures for removal and replacement of the Dome must be carried out if the Dome is being removed to replace the batteries or to access the other systems inside the TRIAXYS™ Buoy. Ensure that proper gas detection or purging procedures have been followed prior to the removal of the dome as described in Section 7.1.

#### 7.2.1. Dome Removal

Remove the nuts and washers, take off the Clamping Ring and remove the dome. The dome may be stuck to the flange gasket either through friction or negative pressure. Use a blunt prying bar to lift one edge of the dome to facilitate removal. Store the dome carefully to prevent damage to the flange-sealing surface. Scratches to this surface may prevent a seal.

### **7.2.2. Dome Installation**

When the polycarbonate dome of the TRIAXYS™ Directional Wave Buoy is installed onto the hull, it is essential that a proper seal be achieved between the dome and the hull. This is accomplished with the Flange Gasket (the silicone rubber seal fixed to the flange on the hull onto which the dome is seated).

Inspect the Flange Gasket for dirt and for any nicks or tears; remove to clean underneath.

Inspect the dome flange for scratches or damage. Dirt can be removed with a clean whisk brush and a damp cloth. Minor nicks and tears in the Flange Gasket can be repaired using Dow Corning 732 RTV silicon seal. The nick or tear is filled with the RTV sealant and then leveled off to the height of the surrounding gasket. The RTV must cure prior to the installation of the dome.

If the Flange Gasket is worn or damaged a new Flange Gasket must be installed.

Using a damp cloth, clean the Solar Panel Assembly of all dirt and grease marks (from handling). Wipe with dry cloth to remove any moisture.

Ensure that the inside of the Dome is clean and dry.

Ensure that there is no dirt between the inside edge of the rubber bumper and the studs.

Ensure that the studs are clean and free from dirt.

Place Dome onto hull with studs located in the machined notches. The Dome must sit freely on the Flange Gasket.

Place Clamping Ring over Polycarbonate Dome.

Fasten with M8 flat washers and M8 dome nuts (SS 316) per the torque specifications in Table 1.1.

Refer to Section 8.5 for vacuum test procedures.

### **7.2.3. Damaged Dome Studs**

In the event that the TRIAXYS™ hull dome studs are damaged and prevent the dome from being properly tightened as specified in Section 7.2.2, the studs can be replaced with an M8 x 45mm SS316 hex bolt by following the steps below:

Remove Dome and Clamping Ring

Remove damaged stud by pressing downwards out of hull flange. (when doing this, be sure not to deform the flange or damage the gasket seal)

Place a small bead of Silicon RTV around the new bolt shoulder and place into the flange from the bottom side.

Orient the bolt such that the bolt head fits into the head retainer on the bottom side of the flange and press into the head retainer.

The bolt should protrude from the top of the flange by 25.0 to 27.0 mm.

### **7.2.4. Solar Panel Assembly**

To gain access to either the batteries or the Sensor and Telemetry Module it is necessary to remove the Solar Panel Assembly.

#### ***7.2.4.1. Removal of the Solar Panel Assembly***

- Turn power off to the buoy by attaching the Magnetic Key.
- Remove Dome as per Section 7.2.1.

- Undo and remove the ten SS 316 nuts and washers holding the Solar Panel Assembly.
- Using the flip-up black handles lift up one edge of the Solar Panel Assembly and prop open.  
Note: lift from the edge with the IR Port as all connectors are on this side.
- Remove the two orange solar panel connectors from the power distribution module.
- Remove the Connectors for the IR Port, the Power and the Antenna(e) (VHF, ARGOS and GPS if they are installed) from the Sensor and Telemetry Module (see Section 1.6).
- Carefully remove the Solar Panel Assembly from the buoy.



SPA Handle

Prop open the SPA. Do not remove the SPA completely.

**CAUTION** Do not use the antenna as a handle as this may result in damage or detuning.

#### ***7.2.4.2. Replacement of the Solar Panel Assembly***

A completely assembled Solar Panel Assembly can be mounted onto the TRIAXYS™ Directional Wave Buoy hull as described below. Ensure that the Magnetic Key is in place so that the buoy is turned off. Align the Solar Panel Assembly such that the IR port is facing buoy North (directly above the purge port). This is required to ensure radio ground plane connection. Place on the buoy and prop up the Solar Panel Assembly on the IR Port edge. Connect the two orange solar panel terminal connectors to the power distribution module. Connect the IR Port, Power and Antenna connectors to the Sensor and Telemetry Module (see Section 1.6). Check that the other connectors (water temperature and magnetic switch) to the Sensor and Telemetry Module are correct (see Section 1.6), as well as the battery leads. Place two 16 unit desiccant packs into the pouch in the side of the hull to absorb any moisture in the enclosed air. N.B. To keep the desiccant packs effective, they must not to be exposed to ambient conditions for more time than is necessary to complete the installation of the dome. Lower assembly onto the ten studs and fasten using M6 flat washers and M6 dome nuts (SS 316). Tighten to 2 N-m (1.5 ft-lb).

### **7.3. TRIAXYS™ Sensor and Telemetry Module**

#### **7.3.1. Retrieving Data from the Sensor and Telemetry Module**

The TRIAXYS™ Sensor and Telemetry Module can be opened to remove the data storage RAM disk or, alternatively, upload the data using the instructions provided in Section 2.1.3 of this manual. To remove the flash RAM card:

Remove the dome and solar panel assembly per previous sections.

Loosen the two captive screws on the front of the top of the lid of the TRIAXYS™ Sensor Module.

Lift up the lid of the Module. It is hinged at the back.

Press the release button and remove the Flash Ram card.

**NOTE:** A Cover Plate protects the inside of the Module. Removal of this Cover Plate or tampering with the Cover Plate fastening bolts will void the manufacturer's warranty.

The data storage RAM disk can be accessed without removing the Cover Plate.

Place a new formatted\* Flash Ram storage disk in the slot being careful to align the card and ensure that it is seated properly. Carefully lower the Module lid and fasten the screws.

\*Formatted using FAT 16 protocol or erase the card in the direct pipeline mode per section 2.6.4.2.

### ***7.3.1.1. Removing the TRIAXYS™ Sensor and Telemetry Module***

If the TRIAXYS™ Sensor and Telemetry Module needs to be removed from the buoy to return to an authorized service depot, the following procedures should be carried out.

Carefully unplug all the Bulgin connectors from the outside of the Module, starting with the power connection.

Unscrew the four SS 316 M6 Nylock nuts.

Remove the Sensor and Telemetry Module.

Unbolt the Power Distribution Module unless the system is being returned to AXYS.

Care should be taken not to inadvertently short circuit any of the primary batteries.

### **7.3.2. Replacing the TRIAXYS™ Sensor and Telemetry Module**

To replace the Sensor and Telemetry Module the following procedures should be carried out.

Orient the Module such that the front, (side with the Bulgin connectors) is facing buoy

North, which is towards the purge port.

Place the Module on the rubber pads on the four upward pointing studs on the battery brackets.

Fasten the TRIAXYS™ Sensor and Telemetry Module using M6 flat washer and M6

Nylock nuts (SS 316). Tighten until rubber is slightly compressed, but not so tight that the feet are against the bottom nut.

Reconnect all the Bulgin Connectors.

Reattach the Power Distribution Module if it has been disconnected from the TAS module.

## **7.4. Batteries**

The TRIAXYS™ Directional Wave Buoy uses 4 lead acid batteries. These are fastened to the hull with bracket. The battery brackets serve two functions. The first function is to constrain the four batteries in the buoy hull. The second function is to mount the TRIAXYS™ Sensor and Telemetry Module.

A 110/240 VAC- 1 2VDC mains battery charger may also be used. The battery charger must be regulated to deliver between 13.5 and 14.10 volts (2.25 and 2.35 volts/cell) at a rate no greater than 6 amps. At full charge the batteries should be reading no less than 12.8 volts. The batteries must never be charged above 14.10 volts. Because the batteries are capable of supplying large currents over a short time span, great care should be taken to prevent short circuits when installing the batteries. Before the batteries are connected together it is important that they are all properly charged and do not differ in voltage by more than 0.3 volt. Each of the batteries has a current overload protection fuse on the power distribution module to prevent damage to the circuit boards. These poly fuses are temperature actuated (current overload) and can be reset by removing the cause of the overload or disconnecting the power. The operational voltage of the system is 11.0 to 14.1 volts. If the system voltage falls below 10 VDC then there will not be sufficient power to effectively operate the radio transmitter. The payload fails to operate properly when the system voltage falls below 7 VDC.

NOTE: Whenever handling this buoy, use proper gas ventilation precautions as described in Sections 7.1 and 7.2. This product contains Sealed Lead Acid batteries, which when exposed to extreme temperatures (>40deg C) and overcharging, can result in the production of Hydrogen Gas in quantities sufficient to combust in the presence of an open spark. Although the TRIAXYS™ Directional Wave Buoy carefully controls the battery voltage in order to prevent overcharging and has no spark generating components, it is recommended that proper handling procedures be followed.

### **7.4.1. Removal of Batteries**

Before the batteries can be removed, the Sensor and Telemetry Module has to be removed (see Section 8.2 above). Ensure that the orange battery connectors are unplugged from the Solar Panel Assembly.

Each battery is connected individually.

Undo the eight SS316 M6 Nylock nuts and flat washers holding down the batteries.

Remove the battery brackets.

Remove the batteries. Take care not to short circuit the batteries.

### **7.4.2. Replacement of Batteries**

Check the battery mounts and studs welded into the bottom of the hull are secure and undamaged. Place four fully charged GNB SunLyte 12-5000X Valve Regulated Lead Acid batteries into the battery mounts, and orient them such that all the terminals are facing inwards to each other. In this orientation, when the Sensor and Telemetry Module is installed, none of the terminals are exposed (i.e., they are all underneath the box). Place the battery brackets over the top of the batteries onto the studs located on the battery mounts. The two longer brackets mount lengthways (North-South) over the two outside batteries (Purge Port is North) and the two shorter brackets mount the other way (East-West) across the two inside batteries. Ensure that the two longer battery brackets are mounted such that the studs for the Sensor and Telemetry Module are on the outside edge of the bracket and pointing upwards. If these brackets are correctly placed the distance between them in the east-West direction will be 37.5 cm. Put Anti-Seize compatible with Stainless Steel on the studs. Fasten the battery Brackets to the studs on the battery mount using SS 316 M6 Nylock nuts and flat washers. Tighten until batteries are fastened rigidly.

## **8. CARE AND MAINTENANCE**

### **8.1. Dome**

Fine scratches can be removed from the dome by cleaning with a professional clear plastic polish such as Meguiar's Inc. Mirror Glaze #17 or Novus Plastic Polish #2. More abrasive cleaners are not recommended. The Dome can also be cleaned with Bleach (15% maximum concentration), followed by soap and water within 2 hours. For storage protection of the dome it is recommended that the shipping/storage cover be kept in place at all times when the TRIAXYS™ Directional Wave Buoy is not in use. Care should be taken not to scratch or damage the sealing flange surface.

### **8.2. Flange Gasket**

To ensure a watertight seal between the Dome and the Hull it is important that the Flange Gasket is kept in good condition. See Section 6.2.2 for procedures for checking the state of the Gasket. If a new Gasket has to be installed the following procedures should be followed.

Remove the old Gasket from the hull.

Check the SS flange surface for any imperfections and, if necessary, polish the surface of the flange with fine sandpaper (200 grade).

Clean the flange with solvent (acetone) to ensure that it is completely free from grease.

Carefully place the Gasket over the dome bolts on the flange and press down firmly ensuring a good seating of the new gasket to the flange.

### **8.3. Shipping/storage Cover**

The Shipping/Storage Cover is made from close weave polyester backed with polyurethane foam. This material is resistant to abrasion and is water repellent. Use soap and water to keep clean.

### **8.4. Paint Specification**

All external SS hull surfaces are powder coated. This can be touched up with marine grade epoxy paint. Please contact Axys with the manufacturer and product proposed to be used to top coating the buoy with anti-foul paint preparations for compatibility.

### **8.5. Hull Vacuum Test Procedure**

AXYS will provide a work instruction with the AXYS Vacuum Test Apparatus, part # 51202075, to complete a standard hull integrity test. All TRIAXYS™ buoy hulls must pass a vacuum test at -5 in. Hg for 24 hours without dropping more than 1 in. Hg prior to shipping from the factory.

## 9. SET-UP AND CHECK-OUT PROCEDURES

This section of the Manual summarizes the main procedures for buoy deployment and recovery. It can be used as a final check before the buoy is deployed. It repeats some of the details covered elsewhere in the manual. The Buoy should be assembled in a clean, dry environment

### 9.1. Inside the Buoy

Inspect batteries for any signs of corrosion.

Measure each battery voltage (can be done from the plug on the Power Distribution Module). Voltages should be within 0.3 V of each other. If not, place batteries on charge.

Ensure brackets are secure.

### 9.2. Sensor and Telemetry Module

The TRIAXYS™ Sensor and Telemetry Module is oriented with the front side (with electrical connectors) towards the purge port. The compass inside the buoy sets this orientation. The Module sits on rubber pads over the four upward pointing studs on the battery brackets. Fasten the TRIAXYS™ Sensor and Telemetry Module using M6 flat washer and M6 Nylock nuts (SS316). Tighten until rubber is slightly compressed, but not so tight that the feet are against the bottom nut. Place a 16-unit fresh desiccant pack in the mesh netting attached to the inside of the hull to absorb any moisture in the enclosed air. Ensure all the Bulgin connectors are plugged in and secured to the Sensor and Telemetry Module.

### 9.3. Solar Panel Assembly

The Solar Panel Assembly is oriented with the IR sensor facing North (directly above purge port). This will ensure the radio ground plane is connected to the hull. Prop up the assembly on one edge and connect all remaining connectors, including the battery power leads to the solar charger board. Verify operation of the IR port before completing the installation of the dome. Lower assembly onto the ten studs and fasten using custom yellow flat washers and M6 dome nuts (SS 316). Tighten to 2.0 N-m (1.5 ft-lb); see Table 1 for specification.

### 9.4. Dome Installation

Inspect gasket for dirt and for any nicks or tears. Dirt can be removed with a clean whisk brush and a damp cloth. Minor nicks and tears in the gasket can be repaired using Dow Corning 732 RTV silicon seal, which must be allowed to cure before installing the dome. Major damage to the gasket will require removing the gasket and applying a new one. Using a damp cloth, clean inside and outside of dome of all dirt and grease marks (from handling). Wipe inside with dry cloth to remove any moisture.

Place Dome onto hull with studs located in the machined notches.

Place Clamping Ring over Dome.

Coat studs with silicon grease.

Fasten with M8 flat washers and M8 dome nuts (SS 316). Tighten to 18-22 N-m (13-16 ft-lb see Table 1 for specification).

### 9.5. Once the Buoy is Assembled and Powered

Set up IR port parameters on the computer that will be reading the output from the buoy's IR port. Make sure to log all programming activity with the capture

feature. Complete a Checkout and Deployment Record as shown in Appendix C to set up and check out the buoy's operation prior to deployment. Remove the Magnetic Key and with the computer that will be reading the output from the buoy's IR port positioned to read from the IR port, check that the MAIN MENU is displayed.

Press 1 to check the Run-Time Parameters are programmed as required (i.e. ACINT, ACDUR, etc.) Press M to return to the MAIN MENU.

Press 2 to check the Telemetry Options are as required. Press M to return to the MAIN MENU.

Press 3 to set/check clock time and date are correct in TRIAXYS™ processing unit. Press M to return to the MAIN MENU.

Press 6 to check Diagnostics Menu.

Press 2 to access the 1 Hz display of real time sensors. The approximate values for the sensors if in a level, upright and still position should be as in the following table 8.1.

Press 3 to check the system power consumption; access the ability to toggle on and off the PC 104, the Motion Sensors and the Radio. (turn off after test!).

Press 5 to access real time data from the compass, the temperature sensor, and the GPS.

Press 6 to reset the boot times to zero. This indicates how many times the TRIAXYS™ processor has been reset. A reset occurs when the Magnetic Key is replaced and then removed. Press M to return to the MAIN MENU.

Press R to put the buoy into RUN mode

Watch the screen for a few minutes to check that:

the system indicates the correct "Next Acquisition" time;

the screen updates every minute with the current time; and,

the time of the "Next Acquisition" is correct and is followed by zzz.

The "zzz" indicates that the buoy is asleep. It wakes up every minute to check if it is time to start the next data acquisition. If not, it goes back to sleep again.

Upright), refer to checksheet in Appendix C

Sensor	Range	Check Procedure
Compass Heading	0 to 360	Check against hand held compass
Accelerometer X	Near 0 ± 0.06 g/s	x axis is north
Accelerometer Y	Near 0 ± 0.06 g/s	y axis is east
Accelerometer Z	Near -1 ± 0.06 g/s	z axis is positive downward
Water Temperature	-5°C to 50° C	Check with measured value of air temperature
System Voltage	11 to 14.1 volts	Measure before installing the dome.
System Current*	20 to 50 milliamps	PC104, Motion Sensors & Transmitter not powered (plus 100 ma if Inmarsat)
	550 to 750 milliamps	PC-104 only powered (plus 100 ma if Inmarsat powered)
	120 to 200 milliamps	Motion Sensors only powered (plus 100 ma if Inmarsat powered)
	100 to 200 milliamps	Transmitter only, powered on but not transmitting
Rate Gyro X	Near 0 ± 25°/sec	
Rate Gyro Y	Near 0 ± 25°/sec	
Rate Gyro Z	Near 0 ± 25°/sec	
Solar Current	1.1 to 1.5 amps	Bright Sunshine
	0.5 to 0.8 amps	Shade
	0.0 to 0.2 amps	Overcast
Battery Current*	-1.0 amps to +1.8 amps	Battery Current = Solar Current - System Current Check that the Battery Current is correct as per the above formula.

\*Note: System Current = Solar Current - Battery current. If there is no Solar Current then the Battery Current (negative) will approximately equal the System Current (positive). These values for currents assume daylight conditions and do not include any current draw that might be associated with the operation of the light. If the Inmarsat D+ unit is connected and powered the specification currents will read ~100 milliampere higher.

## 9.6. Moorings

There are no requirements for external ballast, as the buoys internal batteries provide the proper dynamic stability for the operation of the instrument.

In any moored deployment connection to the buoy should be made with a 12mm stainless steel swivel. The swivel will reduce the chances that the mooring becomes fouled in the presence of rotary tidal currents. A compliant mooring should be used as described in Section 3.0. Ensure that all shackles have been seized with SS wire.

### 9.6.1. Deployment Procedures

The procedures to deploy a moored TRIAXYS™ buoy are as follows:

Layout all mooring components in the correct order and in a fashion that will allow for a free run during pay out (either flaked in parallel lines or in a figure of eight).

Ensure the lifting bridle (3/4" polypropylene) on the buoy is in good condition. This bridle is left on the buoy for the duration of the deployment. Replace with a new bridle if necessary.

Ensure all sections of the mooring are connected and the shackles are seized with cotter pins or stainless steel wire.

ENSURE THE MAGNETIC KEY HAS BEEN REMOVED TO TURN THE BUOY ON. This will start the WatchCircle position acquisition .be sure to keep track of the time as new position will be entered after "x" minutes (user configurable) from activation

Lift the buoy by its rope bridle and either place in the water or drop from a maximum height of 2 m. Pay out the mooring line with the vessel motoring away.

Release the anchor once the complete mooring is run out and the vessel is on station.

It is important to always put the buoy in the water first, then to release the anchor in sequence.

### **9.6.2. Recovery Procedures**

The procedures to recover a moored TRIAXYS™ Buoy are as follows:

Lift the buoy onto the recovery vessel using the lifting bridle.

Recover the compliant cord. DO NOT lift the anchor using the compliant cord. It is extremely dangerous if the full weight of the anchor comes to bear on this section. If the mooring cannot be recovered without putting tension on the compliant cord, the line should be cut for safety considerations.

Once the compliant cord has been recovered, the balance of the mooring and anchor can be winched aboard as per normal procedures.

### **9.6.3. General Deployment/Recovery Notes**

There are no extraordinary procedures that need to be followed to prevent damage to any of the payload components or sensors. The TRIAXYS™ Buoy is a rugged instrument designed to take minor bumps anticipated through the course of routine field operations. Operators should take precautions when working in extreme conditions, which can jeopardize the safety of both personnel and equipment.

## 10. GLOSSARY

Acceleration of gravity (g) - The rate of change with time of the velocity of an object caused by the earth's gravitational force.

Acquisition Duration (AC DUR) - The duration of a data acquisition event (minutes). This duration is limited to between 1 and 35 minutes. Since the maximum time possible for the processing unit is 34.13 minutes (see Section 2.1.3), a time entered of 35 minutes will default to 34.13 minutes).

Acquisition Interval (AC INT) - The interval between successive data acquisition events (minutes). The allowable intervals are: 5, 6, 8, 9, 10, 12, 15, 16, 18, 20, 24, 30, 32, 36, 40, 45, 48, 60, 72, 80, 90, 96, 120, 144, 160, 180, 240, 288, 360, 480, 720, 1440.

Acquisition Start Offset (AC START OFFSET) - The offset from the top of the hour when the data acquisition starts (minutes).

Amplitude - The magnitude of the displacement of a wave from its mean value. In a pure sine wave, the amplitude is one-half the wave height.

Attenuation - A reduction in wave amplitude.

Average Wave Height (Hav) - Average zero down-crossing wave height (m).

Average Wave Period (Tav, Tz) - Average zero down-crossing wave period (s).

Breaker - A wave that has reached maximum steepness and is breaking.

Capillary Wave - A wave in which the velocity of propagation is a function of the surface tension of the water. Wind waves of wavelength less than about 2.5 cm (1") are considered capillary waves.

Chop - Short-crested waves that spring up following onset of a moderate breeze, and break readily at the crest.

Crest - The highest point on a wave.

Cyclic Merging - See TRIAXYS™ wave analysis chapter.

Deep Water Wave - A wave for which water depth is greater than one half the wave length. Ocean wind waves are negligibly affected by the bottom in deep water.

Diffraction - A wave process in which energy is transmitted along wave crests. When a wave train passes a barrier, diffraction causes energy to propagate into sheltered regions behind the barrier.

Dispersion of Waves - The tendency of longer waves to travel faster than shorter waves due to the proportionality between wave phase speed and wave length.

Duration - In terms of wave growth, the time over which the wind blows at a constant velocity.

Fetch - In terms of wave growth, the distance on the ocean over which the wind blows at a constant velocity.

**Fourier Transform** - A mathematical transform that converts a time series of data that has been collected at a specific sample interval into a series of frequency energy data, e.g., data in meters is converted into m<sup>2</sup>/Hz. A FFT or Fast Fourier Transform is a computationally efficient method of doing a Fourier Transform. For Wave analysis it assumes that a time series of wave height data is the sum of many waves of different frequencies. For example a time series of 512 samples is converted into 256 wave energies of frequencies from 1/(sample interval \*512) Hz to 256/(sample interval \*512) Hz.

**H10** - Zero down-crossing wave height, H10, where H10 is the average height of the highest tenth of the waves (m).

**Height** - The vertical distance between a wave crest and the next wave trough.

**JONSWAP Spectrum** - Was established during a joint research project, the "JOint North Sea Wave Project", and is presented in literature by K. Hasselmann & al., in "Measurements of Wind-Wave Growth and Swell Decay during the Joint North Sea Wave Project (JONSWAP)" Deutsche Hydrographische Zeitschrift, Reihe, No.12, 1973.

**Maximum Wave Height (Hmax)** - Maximum zero down-crossing wave height (trough to peak) (m)

**Mean Direction** - Overall mean wave direction in degrees obtained by averaging the mean wave angle (theta) over all frequencies with a weighting function S(f). Theta is calculated by the KVH method in the TRIAXYS™ Directional Wave Buoy.

**Mean Spectral Period (Tz)** - Estimated period from spectral moments m0 and m2, where  $Tz = \sqrt{m0/m2}$ .

**Mean Spread** - Overall directional spreading width in degrees obtained by averaging the spreading width sigma theta,  $\sigma_\theta$ , over all frequencies with weighting function S(f).  $\sigma_\theta$  is calculated by the KVH method.

**Moments** - Calculated from surface elevation spectrum. i.e.,  $m_k = \sum \{ (f)^k * S(f) * df \}$  where f is the band frequency, k is 0 to 4, and S(f) is band energy.

**Nyquist Frequency** - The highest resolvable frequency in a digital wave record. Frequencies above the Nyquist frequency appear as lower frequencies.

**Period** - A measure of wave repeatability. The wave period is usually considered as the time between two successive crests or the time between two successive zero crossings in the same direction.

**Peak Period (Tp)** - Peak wave period Tp in seconds.  $Tp = 1.0/fp$  where fp is the frequency at which the wave spectrum S(f) has its maximum value.

**Reflection** - The process by which wave energy is returned in the opposite direction after a wave strikes an object or a water boundary.

**Refraction** - The process by which the direction of a moving wave is changed due to its interaction with the bottom topography. Wave heights may be increased or decreased by refraction.

**Shallow Water Wave** - A wave for which the depth divided by the wave length is less than approximately 1/20. Equations for waves can be approximated by special equations for such shallow water where waves are strongly affected by bottom depth.

Shoaling -Changes in wave height as waves move into shallow water. Except for a limited depth region, shoaling increases wave heights. Shoaling occurs even if wave heights and directions do not change as a result of wave refraction.

Significant Period (Ts) - Average period of the significant zero down-crossing waves (s).

Significant Wave height (Hmo) - Significant wave height in metres as estimated from spectral moment mo.  $H_{m0} = 4.0 * \text{SQRT}(m_0)$  where  $m_0$  is the integral of  $S(f)*df$  from  $f = F_1$  to  $F_2$  Hz .

Significant Wave Height (Hs) - Zero down-crossing significant wave height, Hs, where Hs is the average height of the highest third of the waves (m).

Spectrum - A method of representing the distribution of wave energy as a function of frequency.

Te - Wave Energy Period. Derived from the zeroth and first negative moments of the frequency spectrum. ie.  $T_e = M(-1)/M(0)$ . Typically used by wave energy engineers because it is the period corresponding to the weighted average of the wave energy.

Tp5 - Peak wave period in seconds as computed by the READ method. Tp5 has less statistical variability than Tp because it is based on spectral moments. The Tp5 is determined from calculating Fp5 which is the average frequency computed with the weighting function  $S(f)^{**5}$  over the defined upper and lower frequency range. The algorithm is:  $F_{p5} = [\text{Sum of } F_i * (E_i/E_{\text{peak}})^5] / [\text{Sum of } (E_i/E_{\text{peak}})^5]$  where: For  $i =$  low frequency band( $i$ ) to high frequency band  $F_i$  is frequency of band  $E_i$  is energy of band  $i$   $E_{\text{peak}}$  is Energy of Peak Frequency therefore,  $T_{p5} = 1/F_{p5}$

T10 - Average period of the H10 zero down-crossing waves (s).

Trough - The lowest part of the wave between successive crests.

Water Current Direction - The direction from which the water is flowing to.

Wave Direction - The direction from which the wave is coming from.

Wind Direction - The direction from which the wind is coming from.

Zero Crossing - Number of waves detected by zero-crossing analysis of the wave elevation record.

Zero Crossing Wave Period - (Tz, Tav) - The average time interval between similar direction crossings of mean water level for a wave record. The zero crossing period can also be calculated from the moments of wave frequency spectra.  $T_z = \text{square root of}(m_0/m_2)$ . Also called the Mean Spectral Period.

## 11. REFERENCES

References to the software used in the TRIAXYST<sup>TM</sup> Directional Wave Buoy include:

Nwogu, O.U., E.P.D. Mansard, M.D. Miles, M. Isaacson (1987) "Estimation of Directional Wave Spectra by the Maximum Entropy Method". IAHR Seminar on Wave Analysis and Generation in Laboratory Basins, Lausanne, pp. 3 63-376.

Darras, M. (1987) "IAHR List of Sea State Parameters: A Presentation". IAHR Seminar on Wave Analysis and Generation in Laboratory Basins, Lausanne, pp. 11-73.

Nwogu, Okey (1989) "Maximum Entropy Estimation of Directional Wave Spectra from an Array of Wave Probes". Applied Ocean Research, 1989, Vol. 11, No. 4, pp. 176-182.

Miles, M.D., M. Benoit, P. Frigaard, P.J. Hawkes, H.A. Schaffer, C.T. Stansberg (1997) "A Comparison Study of Multidirectional Waves Generated in Laboratory Basins". IAHR Seminar on Multidirectional Waves, 27th IAHR Congress, San Francisco, pp. 89-129.

Hawkes, P.J., J.A. Ewing, C.M. Harford, G. Klopman, C.T. Stansberg, M. Benoit, M.J. Briggs, P. Frigaard, T. Hiraishi, M. Miles, J. Santas, H.A. Schaffer (1997) "Comparative Analysis of Multidirectional Wave Basin Data". IAHR Seminar on Multidirectional Waves, 27th IAHR Congress, San Francisco, pp. 25-88.

Benoit, M., P. Frigaard and H.A. Schaffer (1997) "Analysing Multidirectional Wave Spectra: A Tentative Classification of Available Methods". IAHR Seminar on Multidirectional Waves, 27th IAHR Congress, San Francisco, pp. 131-158.

Miles, M.D. and E.R. Funke (1989) "The GEDAP Software Package for Hydraulics Laboratory Data Analysis". IAHR Workshop on Instrumentation for Hydraulics Laboratories, Burlington, Canada, pp. 325-339.

Miles, M.D. (1986) "Measurement of Six Degrees of Freedom Model Motions using Strapdown Accelerometers". 21st American Towing Tank Conference, Washington, D.C., pp. 369-375.

## APPENDIX A - AXYS WARRANTY AND SERVICE LIMITED WARRANTY

AXYS TECHNOLOGIES INC ("AXYS") warrants that the Equipment shall conform to Specifications and shall remain free from defects in materials and workmanship for a period of twelve (12) months from the date of shipment (the "Warranty Period"); provided, however, that the Equipment is applied, installed, operated and used substantially in accordance with the Specifications. This Warranty shall not apply to Products that have been damaged through negligence, accident, misuse, or acts of nature such as floods, fires, earthquakes, lightning strikes, etc. AXYS shall replace or repair (at its discretion) any Equipment within such warranty period, provided:

- ú AXYS receives written notice of any non-conformance or defect within the Warranty Period.
- ú After AXYS' authorisation, the Equipment is returned to AXYS' factory of origin or to an Authorised AXYS Distributor with all freight charges prepaid.
- ú AXYS determines the Equipment to have a non-conformance or defect covered under this warranty.
- ú AXYS will pay for the return transportation for valid warranty claims. All return shipments shall be by best-way surface freight.
- ú Any products repaired or replaced under this warranty will be warranted for the balance of the warranty period or for a period of 90 days from the repair shipment date, whichever is greater.

### LIMITATION OF LIABILITY

AXYS does not grant any further representations or warranties on the Equipment than as expressly set forth above and expressly disclaims all other warranties, express or implied, including any warranties that the Equipment shall be merchantable, suitable or fit for any purpose other than expressly stated. Notwithstanding any other term of this Agreement, in no event shall AXYS be liable to the Customer, its officers, employees, agents or contractors for any lost or anticipated profits, for any incidental, consequential, exemplary or special damages whether or not AXYS was advised of such claim, or for damages and loss due to personal injury. Under no circumstances will AXYS cover or reimburse the claimant for costs incurred in the removing and/or rein-stalling the equipment. In any event, AXYS' liability shall not exceed the purchase price of the Equipment.

### NON-AXYS MANUFACTURED EQUIPMENT

The above Warranty applies only to Products manufactured by AXYS. Equipment provided, but not manufactured by AXYS, is warranted and will be repaired to the extent of and according to the current terms and conditions of the respective equipment manufacturer.

### WARRANTY SERVICE

To obtain service under the warranty during the warranty period:

- ú Write, fax, e-mail or call AXYS Technologies Inc to describe precisely and completely the nature of the problem;  
PO Box 2219, 2045 Mills Rd West,  
Sidney, BC, Canada V8L 3S8  
Ph 250 655 5874  
Fx 250 655 5856  
Email [info@axystechnologies.com](mailto:info@axystechnologies.com)

- ú Carry out any minor adjustments or service as instructed by AXYS technical personnel;
- ú If proper operation is still not achieved, obtain an RMA (Return Material Authorisation) number from AXYS and return the instrument, freight prepaid, to the factory or to an authorised Service Centre. The instrument will not be accepted by AXYS without an RMA. The instrument will be repaired and returned free of charge in accordance with the terms of the warranty.

ú All systems returning to AXYS are put through an incoming inspection to determine the validity of the warranty claim. If a valid warranty claim is established, an inspection fee is waived; otherwise the owner will be invoiced the minimum inspection fee of \$500.

#### NON-WARRANTY SERVICE

Proceed as for Warranty Service described above. If AXYS personnel can provide assistance by phone, letter, fax, or e-mail they will be pleased to do so at no charge. As with Warranty Service, if the return of the instrument is necessary, an RMA number must be obtained from AXYS prior to shipping. The instrument must be returned to the Company freight prepaid. Once the instrument is received at the factory, a firm estimate of the repair cost will be provided.

## **APPENDIX B - OBSTRUCTION LIGHT FLASH SEQUENCES & CODES**

Light Flash Code Reference - listed by number of flashes

SYMBOLS FL Flash -followed by number e.g., F1 1 S one every second Q Quick flash

VQ Very quick flash

OC Greater period on than off

I SO Equal period on and off

L F L Long flash long

MO Morse code ( ) contains letter

(6)+ LFL10S Means 6 very quick flashes followed by a long flash during 10 second interval.

The longer the period the LED is on, the larger the current draw. The switches A and B are identified on the circuit board. Turn the arrow to switch position to obtain code. The circuit takes 1 minute to activate/deactivate with power on.

### **USE OF PULSE WIDTH SETTINGS**

The IC is programmed to pulse 20 times per second with an on width of 25, 50, 75 and 100%

This facility improves the versatility of the lantern by allowing a reduction in power consumption ie at 25% it reduces power consumption to a quarter The range of the lantern is not reduced in the same proportion. The facility may be used to tailor the lantern to local sunlight conditions. The lantern does not appear pulsing from a distance.

This is activated by pin connectors using the four pins on the circuit board at the end of the IC.

25% - connect two pins adjacent to IC

50% - connect two pins away from IC

75% - connect both sets of pins parallel to end of IC 100% - remove both pin connectors

## 12. APPENDIX C: SAMPLE TRIAXYS BUOY FIELD CHECKOUT/DEPLOYMENT RECORD

### 4.0

General					
Date:	TRIAXYS Serial Number:	TDR S/N:			
Deployment Location:		WaveView Version:			
Form Completed by:	Depth:				
<b>Functional Checkout:</b>			<b>Work Instruction 0260701E Completed:</b>		Y/N <input type="checkbox"/>
<i>Compass: Rotate buoy through a full circle checking the output of buoy North against a hand compass.</i>					
Readings (0):	Readings (90):	Readings (180):	Readings (270):	Passed:	<input type="checkbox"/>
<i>Accelerometers: Buoy at rest and level.</i>					
X Axis : (near 0 ± 0.06 g's)	Passed: <input type="checkbox"/>	Z Axis (Down): (near -1 ± 0.06 g's)	Passed:	<input type="checkbox"/>	
Y Axis : (near 0 ± 0.06 g's)	Passed: <input type="checkbox"/>				
<i>Rate Gyros: Buoy at rest and level.</i>					
X Axis : (near 0 ± 25%/sec)				Passed:	<input type="checkbox"/>
Y Axis : (near 0 ± 25%/sec)				Passed:	<input type="checkbox"/>
Z Axis (Down): (near 0 ± 25%/sec)				Passed:	<input type="checkbox"/>
<b>Other Devices</b>					
Buoy Hull Water Temperature Test:	Ambient Temp.			Passed:	<input type="checkbox"/>
Navigation Light Flash Sequence:	Lamp Test:			Passed:	<input type="checkbox"/>
GPS/Inmsat: <b>Y/N</b>	Local Position: Lat-	Long-		Passed:	<input type="checkbox"/>
IR Port				Passed:	<input type="checkbox"/>
<b>Sampling Configuration, Data Logging and Utility functions</b>					
Station ID:				Passed:	<input type="checkbox"/>
ACINT (mins):	ACDUR (mins):	ACSTART Offset (mins):		Checked:	<input type="checkbox"/>
System Voltage (11.0-14.0):	System Current (0.03-1.15):			Passed:	<input type="checkbox"/>
Battery Current (-1.0-+1.8):	Solar Current (0.0-1.8):			Passed:	<input type="checkbox"/>
System Time and Date Set: <input type="checkbox"/>	Time Zone:			Set:	<input type="checkbox"/>
Watch Circle Enabled: <b>Y / N</b>	Watch Circle Diameter: m			Set:	<input type="checkbox"/>
Boot times Reset to Zero				Zeroed:	<input type="checkbox"/>
Internal Data Logger Installed: <b>Y / N</b>	Type/Size: mbytes			Checked:	<input type="checkbox"/>
Old Data Files Removed: <b>Y / N</b>	First Logged File Time/Date:				
Captured Setup File:	File:			Y/N	<input type="checkbox"/>
Captured Sample Record / Results:	File:			Y/N	<input type="checkbox"/>
<b>Telemetry</b>					
Radio Type:	Frequency:	Tx Repeat:	Data Tests: <b>Y / N</b>	Passed:	<input type="checkbox"/>
Satellite Tx: <b>Y / N</b>	Continuous: <b>Y / N</b>	ID:	Rep Rate:	Passed:	<input type="checkbox"/>
<b>Items To Be Checked if Dome Removed</b>					
Battery Brackets Secure <input type="checkbox"/>	Processor Module Secure <input type="checkbox"/>				
Power/Solar Leads Connectors Secure <input type="checkbox"/>	Navigation Lamp Connected <input type="checkbox"/>				
All Sensors Connected <input type="checkbox"/>	Antenna Connected <input type="checkbox"/>				
Battery #1 SN: Voltage:	Battery #3 SN: Voltage:				
Battery #2 SN: Voltage:	Battery #4 SN: Voltage:				
<b>Mooring Components</b>					
Drawing #	attached: <input type="checkbox"/>	Components inspected	Passed: <input type="checkbox"/>		
Bill of Materiel#	attached: <input type="checkbox"/>	Connectors/Shackles seized	Y/N <input type="checkbox"/>		
Anchor: kgs					
Field Service Report File Name:				attached: <input type="checkbox"/>	

## **13. APPENDIX E - TRIAXYS™ FAQ**

### **General**

#### **1. What are the benefits of the TRIAXYS™ Buoy over a Waverider buoy?**

A: Robust state-of-the-art solid state sensor; proven high precision measurement with 6 degrees of freedom used and validated by the National Research Council of Canada; Complete motion measurement; Cheaper operating costs - Solar powered batteries with a 5 year nominal lifespan. Easy deployment with no rolling or spinning limitations.... can roll buoy off the deck for deployment. Internally housed antenna and obstruction light protected from wave or ship damage.

Easy access to all modularized system components for servicing.

Easy low cost battery replacement.

Near real-time power system monitoring.

Infrared port for system setup communication while fully assembled, either in or out of the water.

External on/off switch.

Excellent plug and play TRIAXYS™ Digital Receiver and WaveViewT Software.

Intuitive user friendly software with automated error checking, archiving and data display (graphing, 3D directional spectrums).

Full range of wave statistics are calculated and displayed in near real time.

Configurable software alarms for buoy watch circle status. (GPS position verification).

#### **What is the operating principle of the TRIAXYS™ Directional Wave Buoy?**

A: The TRIAXYS™ uses solid-state accelerometers and rate gyros to monitor six degrees of freedom or buoy motion and a flux gate compass to provided buoy heading. An AXYS designed and built micro controller interfaces and logs the raw sensor data. This data is processed and analyzed using a proprietary algorithm developed by the Research Council of Canada. The resultant data can be expressed in a number of different formats depending on user requirements.

#### **What design features separate the TRIAXYS™ from its competition?**

A: The TRIAXYS™ Buoy is robust and durable. The sensor suite is resistant to damage from rolling or collision. While all buoy components are enclosed within the hull of the buoy, modular design ensures that all major components are readily accessible when the buoy is opened for servicing. Rechargeable batteries augmented by solar charging system provide power to the buoy. All communication with the buoy for configuration and programming is through an infrared serial communications module located within the buoy, which alleviates the requirement to open the buoy or have an external connector to setup or monitor the buoy's operation prior to deployment. Data can be saved on the buoy in solid-state memory as well as transmitted to a shore station.

#### **How is the TRIAXYS™ Buoy constructed?**

A: The TRIAXYS™ hull consists of two parts. The lower half or hull is constructed of a single piece of 316 stainless steel covered with a thermal powder coat finish and the dome is constructed of clear polycarbonate. The seal between the two halves is a butyl rubber gasket secured by a locking ring and studs. Internally, the buoy has a fiberglass solar panel array mount that also provides mounting for the power distribution module, obstruction light, IR port, Global Positioning System and radio antenna, if ordered. It also covers the Telemetry and Sensor module (TAS), which consists of a waterproof case enclosing the sensors, processors

and the radio transmitter. Electrical connections to the rest of the buoy components are through waterproof connectors. Under the TAS module are racks for up to four 100AmpHr rechargeable batteries.

### **How durable is the TRIAXYS™ Buoy?**

A: The TRIAXYS™ is remarkably durable. The 316 stainless steel hull is corrosion resistant and the rubber bumper allows the buoy to be resistant to collision damage. The polycarbonate dome is also very strong. Extensive destructive testing was conducted on the polycarbonate before it was selected and it met or exceeded all service requirements. The solid-state sensors and electronics are not damaged by spinning or rolling of the buoy. They can withstand high 'g' loads as installed in the buoy, but like any device with solid state sensors and components, the buoy can be damaged by dropping on deck or swinging into a ship's gunnels or hull. Normal buoy handling procedures will not cause any problems with the TRIAXYS™ Buoy. The batteries, which are firmly secured in the hull, are a leak-proof, glass-mat, lead acid type that are very robust.

### **How does this system compare to bottom mounted pressure sensors and ADCP systems? Cost, operation, measurement precision and maintenance?**

A: The measurements taken by the TRIAXYS™ buoy are direct measurements of the actual wave conditions using motion sensors in six degrees of freedom. This type of measurement is not affected by other environmental parameters, which can degrade the precision of the measurements reported by the two other types of sensors. The main limitation of pressure sensors is that they must be deployed in relatively shallow water or all the high frequency energy will be attenuated as a function of pressure differentials and resolutions. Not a simple system to have for real time data. Since they are powered by batteries, this leads to increased service costs.

## **OPERATION & MAINTENANCE**

### **How is a TRIAXYS™ Buoy deployed?**

A: The TRIAXYS™ can be deployed in currents up to about 3kts. Currents greater than this may cause the buoy to submerge periodically. While this will not compromise the buoy in anyway it may affect the quality of the data and the reliability of the telemetry. The TRIAXYS™ Buoy can be deployed from a variety of vessels from canoes to warships, but will be dependant on weather conditions and local logistics available. The buoy can be handled by as few as four people but, again, in the interest of safety, a derrick or lift is recommended for deployment. The robust design of the buoy does allow it to be rolled off of a ship's deck without risking internal damage to the buoy or it can be towed for short distances.

Normal procedure for deployment of a TRIAXYS™ involves placing the buoy in the water after the vessel is in the vicinity of the deployment location. The anchor of the mooring is paid out over the rail of the vessel. The buoy should be floating free of the vessel with the mooring trailing the buoy and free of tangles or twist. The vessel then moves to the desired deployment location. When the vessel is on station, the anchor is released. AXYS Technicians are available to assist with deployment if required.

### **What is the proper orientation of the Magnetic Key with respect to the buoy hull?**

A: The Magnetic Key actually houses a small bar magnet, which has been placed within one of the longer sides of the holder. This side is indicated by a small black epoxy capping, and should be orientated so the long side is towards the buoy bumper, and the black capping is to the right or left, on the top side. Place the

Magnetic Key on the buoy tabs, so that the purge port is visible in the centre of the Magnetic Key. See Section 1.12.

**What are the service requirements of the TRIAXYS™ Buoy?**

A: The TRIAXYS™ requires minimal servicing. The sensor suite does not require calibration adjustment, although periodic system checks should be conducted. The batteries have a design lifetime of approximately four - five years, dependant, of course, on duty cycle and charging history. An external charger can be attached to the power distribution module if the buoy is to be stored indoors or out of the sun for an extended period of time. Contact AXYS technical staff for details.

**What is the recommended TRIAXYS™ Maintenance Schedule?**

A: See the TRIAXYS™ User's Manual Section 9 It is recommended that the rubber cord (compliant section) be inspected every 6 months and the main mooring section be inspected annually. Once retrieved, each mooring system can be replaced with a new one while the old mooring system can be taken ashore for inspection. The rubber cord sections can seldom be re-used, however, the main mooring components may be able to be re-used later if they are still in good condition. Biofouling will occur at different rates depending on the marine conditions of the deployment site. If the biofouling on the dome is algae, soak with bleach, and then scrub with a soft brush and detergent. Avoid scratching or marking the polycarbonate dome, as this will affect the efficiency of the solar charging system. If the biofouling appears to be calcite from barnacles or other shellfish, use vinegar soaked cloths to soften the deposits prior to scrubbing. It may take a day or two of covering these deposits with cloths to soften them sufficiently. If biofouling is an issue it may be necessary to repaint the hull with antifouling paint. It is suggested that this be performed every year.

TRIAXYS™ buoys are fitted with four rechargeable lead acid absorbed glass matt (AGM) style batteries and they should be inspected periodically. Be sure to follow the dome and solar panel assembly removal instructions in the manual. You must check the level of gases in the dome via the purge port prior to removing the dome. Battery voltage should be between 12.2 and 12.5 volts when charged. A voltage of less than 10.5 VDC indicates that the batteries are substantially discharged. Recharging can be done by placing the buoy in direct sunlight (with the buoy turned off), although this may take up to a week if they were seriously discharged. A battery charger can also be used but you must ensure it is designed to charge AGM type batteries. Care must be taken not to over-charge the batteries and the charging requirements are written on the battery. Please refer to the User's Manual for instructions on removal and replacement of the batteries.

The flange gasket between the dome and hull of the TRIAXYS™ should be replaced as required or every two years to ensure its condition is sufficient to allow the dome and hull to form a seal prior to deployment. Annual system diagnostics should be performed while the buoy is ashore. Work instructions for this are available from AXYS at no cost.

**Are the batteries still being charged when the Magnetic Key is on the buoy (i.e., buoy is not running)?**

A: Yes, the charging is independent of the Sensor/Telemetry module and will always allow solar charging if the solar panels are not obstructed.

**Can the data be logged on board the buoy?**

A: Yes, the operator can log the processed and raw data onto Flash RAM residing in the buoy. Refer to sections 1.15 for capacity and 2.1.4 for data recovery and uploads.

**When configuring the TRIAXYS via the IR Port, what type of computer should be used?**

A: As detailed in Section 2.0 of the TRIAXYS™ Manual, the buoy will need to be configured with your operating parameters if you require a set up that is different from the default settings. The PC or Laptop you use for this setup procedure must be equipped with a RAW IR driver and of course a hyperterminal or IR terminal. Most computers are preconfigured with IRD drivers, which will not work properly with our system. The RAW IR driver may not be the default driver but speak with your IT department or the manufacturer of the computer and they should be able to assist you in properly enabling this driver.

## TELEMETRY

### **Why don't I hear any sound when I press in the "SPEAKER" button on the front of the TDR?**

A: The speaker will only emit a sound when the TDR is receiving a signal (i.e., when the buoy is transmitting). If the orange RX modem light on the back of the TDR is solid (i.e., not flashing), then the speaker should emit a digital sound when the button is pressed.

Note: You must hold the button in to emit an audible signal.

### **15. What is the difference between Inmarsat and Argos in terms of telemetry?**

A:

INMARSAT D+

- WatchCircle Monitor
- Wave Data, GPS Position

Two way for configuration

Geostationary Satellite; always in view

Higher Power

Inexpensive transmission costs

ARGOS:

- WatchCircle Monitor

Limited Wave Data, GPS Position

- ARGOS Position

Polar Orbiting Satellite; are not always in view

Low Power

Can be expensive and difficult to activate

### **How does the WatchCircle Alarm Feature work with the various telemetry options available on the TRIAXYS™?**

A: The WatchCircle Feature is included as a standard feature of the TRIAXYS™. This system uses the buoy coordinates provided by the GPS receiver to determine if the buoy is within a predefined area (the WatchCircle). Should the buoy drift outside of its WatchCircle, a message is generated by the buoy and relayed to the customer. However, for this feature to work effectively, the message must reach the user or the basestation. VHF and Cellular telemetry have limited transmission distances and can be useless if the buoy drifts out of range of the base station or cellular relay tower. For this reason, Inmarsat D+ or ARGOS satellite telemetry are generally used to communicate this alarm message. Inmarsat and Argos providers will send this message using a variety of methods including email and fax.

### **Can multiple TRIAXYS™ buoys be used in a network around a singular base station?**

A: Deploying multiple TRIAXYS™ around a singular base station is possible. As one TDR will be used for all TRIAXYS™ the buoys must be using the same VHF frequency. The sampling/transmission intervals of the buoys must be offset to allow the TDR and WaveView to receive and display the data one at a time.

Multiple licenses of WaveView will need to be purchased to allow recognition and display of the wave data. The number of buoys that can be used around a single base station is dependant on the sampling interval chosen by the user.

### **How does Cellular Telemetry work?**

A: Cellular telemetry on the TRIAXYS™ buoy takes advantage of the Global System for Mobile Communications (GSM) which uses a circuit switched technology that allows data to be transmitted over a GSM link at speeds of 9.6 kbps (9600 baud). AXYS also offers Code Division Multiple Access (CDMA) cellular mode for clients who do not have GSM coverage but still want to make use of the benefits of cellular data transfer. AXYS offers 800 MHz CDMA, 800 MHz analog and 1900 MHz CDMA cellular module. CDMA is described as a "spread spectrum" technology meaning it spreads the information contained in a particular signal over a much greater bandwidth than the original signal.

To take advantage of the GSM telemetry option, a Subscriber Identity Module (SIM) card must be obtained from your local cellular provider at the time you are setting up a GSM account. The activated SIM card, enabled for circuit switched data (CSD) can be forwarded to AXYS with the phone number and PIN for installation in the buoy. Alternately AXYS can provide you with work instructions for installation of the SIM card once you receive the buoy. Note that we use the 1900 MHz band in North America, whereas most other regions of the world, including Europe and Asia use the 900 and 1800 MHz band.

We suggest that customers who are considering GSM or CDMA telemetry complete a thorough test of the availability of this technology in the deployment area. The best way to test the effectiveness of cellular coverage in the area of deployment is to physically travel to the deployment site and attempt a cellular phone call to someone on shore. If you can transmit clearly for approximately 5 minutes you can expect to have the same success with sensor data being transmitted from the TRIAXYS™ to shore. One should also contact the local service provider to obtain coverage information.

## **TECHNICAL INFORMATION & TROUBLESHOOTING**

### **Is Mean Magnetic Direction in WaveView the direction the waves are coming from or the direction they are traveling to?**

A: Mean Magnetic Direction found in the .wave files produced by WaveView lists the direction waves are going not the direction that they originated.

### **How is Local Magnetic Variation handled on the TRIAXYS™ and on WaveView?**

A: Local Magnetic Variation is not corrected for on the TRIAXYS™. The wave data sent from the buoy to the base station will not have any corrections for true north applied. In addition, WaveView makes no corrections for local magnetic variation. The GPS portion of the status message will give an accurate reading of the local magnetic variation, which then must be applied manually by the user for true north readings.

### **What are the different methods of data recovery from the TRIAXYS™ Buoy?**

A: (Dependant on the options ordered)

VHF transmitted data - all spectral and zero crossing analysis data (Directional and Non-directional), status data and GPS location

Inmarsat D+ - wave statistics, position and buoy configuration

Other Telemetry such as Iridium, ARGOS, Orbcomm, GSM, CDMA

Logged data (Flash RAM card) - raw acceleration, rates and compass data at 4 hz, status and GPS data. This data can then be post processed to create the full spectral and zero crossing analysis, which are the same as those transmitted.

### **Solar Panels and Charging**

A: The solar panels can supply 60 watts in total but typically deliver 16-20 Amps on sunny days and 3+ watts on quite overcast days. The buoy will obtain both direct solar energy as well as solar energy reflected from the water's surface. The actual solar current throughout the day can be viewed by looking at your status files from WaveView. In general, the buoy goes through deficit and surplus power months based on the time of year and long-term weather patterns. If the buoy is deployed with a full charge it will continue to operate without any problems, although it will reach a lower voltage (but sufficient to run) toward the end of the winter months. There should be more than enough solar and battery capacity to recharge throughout the spring and summer and be ready again for the next winter. It is very important to ensure the TRIAXYS™ is deployed with batteries at full charge or seasonal solar radiation fluctuations may result in a buoy with too little battery power to function.

### **What is the typical power budget of the TRIAXYS™ buoy?**

A: Typical Battery Voltage: 12.5-13.1 Volts

Typical Light Operation: 12 hours/day (5 one second group flashes in 20 seconds)

Typical Sample Duration: 26 minutes

Typical Sample Interval: 30 minutes

WatchCircle Beacon (INMARSAT D+ or ARGOS): on for one hour per day VHF transmissions: 1

Although the processing and transmission times are proportional to the sampling time, the difference between 26 minutes and 34 minutes is quite small with regard to the processing and transmitting power requirements. For the above configuration, the results are as follows:

0.23 A/hour x 24 hours (for sampling, processing and transmissions)

0.17 A/hour x 1 hour (for WatchCircle: INMARSAT D+ or ARGOS)

0.06 A/hour x 12 hours (typical light hours)

Total: 6.4 Ahr/day (~76Whr/day)

SEE SECTION 1.4.1: Power Budget

### **What are the TRIAXYS™ buoy and TDR packed weight and shipping dimensions?**

A:

Weight: 550lbs

Shipping Dimensions: 48" x 44" x 42" h

TDR Weight: 26lbs

TDR Dimensions: 24" x 21" x 10"

### **What data is stored on the optional on-board 1GB datalogger and how does one determine the length of time it will take before the logger is at maximum capacity?**

A: TRIAXYS™ are manufactured with a datalogger. This 1GB Flash RAM card stores both the raw and processed data as sampled by the buoy. In previous versions of the TRIAXYS™ separate dataloggers were used for raw and for processed data and were purchased separately. Older buoys can be fitted with the 1GB Flash RAM card while at AXYS facilities for upgrade or repair. Logger capacity is shown in Section 1.6.2

### **What can be done to trouble shoot poor VHF reception?**

A: Generally poor VHF reception is caused by interference in the area of the base station. The rule of thumb is that the buoy must be within line of site of the base station and the two must not be any further than 14 nautical miles apart. Possible sources of VHF interference include large metal objects/buildings or other users of VHF in the area. Interference in the area can be measured by determining the baseline and receive voltage on the TRIAXYS™ Digital Receiver (TDR). By pressing the DISPLAY button on the TDR, (when the TDR is NOT receiving), the baseline voltage will be displayed. This voltage is normally in the 1.0 to 2.5 volt level; much more than 2.5 volts means there is a large amount of ambient noise in the area. By following the same procedure when the TDR is receiving, the receive voltage will be displayed. This voltage must be at least 1.0 volt higher than the baseline voltage. IF this is not the case, the reception signal is not good enough and one or more of the following should be assessed:

- o Check all antenna and antenna cabling connections.
- o Ensure perfect line of sight is achieved between the receive antenna to the buoy (you should be able to see the buoy from the receive antenna location with binoculars, however, trees will not affect line of site). Confirm that there are no devices in the area transmitting or creating signals on the TRIAXYS™ frequency band.

Move the base station closer to the buoy (or vice versa) to see if the signal improves.

Baseline Voltage:

Below 1.0 volts: Likely an antenna problem, not connected, bad connection, cut cable, etc.

Between 1.5 and 2.5 volts: best conditions

Above 3.0 volts: there is likely another source of RF noise being received by the TDR which will interfere with the TRIAXYS™ signal.

Receive Voltage:

Less than 1.0 Volts above the baseline: Bad Connection, weak incoming signal, no line of site, wrong frequency.

\*Note: this voltage should be 1.5+ volts higher than the baseline voltage to guarantee 100% reception.

On the buoy we have moved to an "Untenna" brand of antenna rather than the "rubber duck" style that was originally installed. Our sea trials indicate that with the Untenna and the Ringo Ranger receive antenna you can expect reliable transmissions up to 14 nautical miles and possibly to 20 nautical miles under ideal conditions. This range expectation requires that there be at least a 2. differential between idle and reception signal strengths. If a high gain antenna such as a Yagi tuned to the transmit frequency and directed at the buoy is used, you may be able to increase this range.

Radio reception is affected by many environmental factors. Reconfiguration of the base station installation may be required to optimize its performance. Range may be affected by:

The heavy fog causing signal loss to ground. Insulate RF connectors with waterproof tape or coating.

Signal loss due to antenna cable length or construction. Line losses for a cable 120 ft long should be less than 1 db at this transmit frequency, but poor connections can increase this significantly. Bear in mind that a 3dB signal loss cuts power in half. Check with rf power meter.

### **Viewing data recovered from the TRIAXYS™ internal data logger:**

A: It's NOT possible to view logged TRIAXYS™ data without AXYS' proprietary Data Post Processing software, which consists of a Post Processor plus a Data Viewer. The Post Processing Software allows the user to recover raw or semi-processed data from the buoy's flash memory card and complete the final processing normally carried out by WaveView. This processed data can then be viewed using the Data Viewer.

Note: It is not possible to view the data archived by WaveView with the Data Viewer. The Data Post Processing Software outputs processed wave data in the following files: DIRSPEC, FOURIER, HNE, MEANDIR, NONDIRSPEC, and UVH. There are also Error.txt, Status.txt and Summary.txt files created.

The Error file will have data only if there were problems detected during processing of semi-processed or raw files. Any corrupted files will be logged here. The Summary file lists the wave statistics. Status files list the buoy ID, battery voltage, water temperature and the buoy location. Note that the Error, Status, Fourier and Summary files cannot be displayed graphically using the Data Viewer. Additionally, WaveView CANNOT be used to view post processed data from a flash memory card.

If desired, AXYS offers data post processing of your logged data, which can then be viewed using Excel's graphing function.

**WaveView does not run when loaded:**

A: Check the settings in Windows. WaveView will only run properly if the English setting is used in the Regional Settings of Windows.

**How can the Summary and Status files be generated from the Raw data if the data wasn't collected via VHF?**

A: By using the latest version of the Post Processing software to process the raw data files logged on the optional Flash RAM card you can re-create all of the wave and status data from the deployment period. The Post Processing software can post process the raw data to produce all the same files as WaveView except for the status and wave files. From the post processor, these are called status.txt and summary.txt respectively. This data is a replacement for lack of VHF and thus all data is available with the post processor.

**Why would the TRIAXYS™ sensor report no longitude and latitude positions for periods up to several hours long?**

A: There are several possible explanations for this. GPS satellites are under the control of the United States Air Force and are turned on or off from time to time. In addition, the GPS system consists of orbiting satellites and a minimum of four satellites have to be in range of a GPS receiver before a position can be calculated and these satellites have to be spread over the visible hemisphere in geometrically stable positions to provide accurate GPS readings. There are periods of time in which there are not enough satellites in view or they are too clustered to determine a position. Atmospheric ionic activity also affect the receptivity and accuracy of GPS satellite signals which is especially so during sunset and sunrise. Also, if the buoy has been moved more than 200km, it will have to establish its prime location which takes some time.

**If WaveView is not updating the messages from the buoy, how can I tell if the buoy is still working?**

A: Look in the data archive. The transmitted files are stored in accordance with the path set-up (see Section 5.2.3 Settings). The Rx files will indicate whether or not WaveView received the data (See Section 5.3).

## **MOORINGS**

**What are the mooring requirements for the deployment of a TRIAXYS™ Buoy?**

A: Moorings for the TRIAXYS™ Buoy are sold based on water depth and include polyethylene rope, wire rope, shackles and a compliant mooring section (bungee). The user typically supplies an anchor. The compliant mooring section that decouples the buoy motion from the rest of the mooring. The balance of the mooring is designed and constructed to suit the water depth and conditions at the deployment location. The compliant section consists of a 32mm butyl rubber cord usually attached to the buoy through a SS swivel. For water depths to 75m the balance of the mooring is constructed of polypropylene line and Nylspin,,

coated cable. For water depths greater than 75m false bottom or reverse catenary designs can be implemented. The mooring should be inspected every six months with replacement each year.

Anchor weight should be about 3 00kg wet. It can consist of heavy link chain or other iron material. If a concrete anchor is desired, then its air weight must be approximately 600kg or twice the wet weight. The anchor requirements will increase if there are significant currents running at the buoy location.