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

- Robust state-of-the-art solid-state sensor
- Proven high precision measurement with six degrees of freedom used and validated by the National Research Council of Canada
- Complete motion measurement
- Cheaper operating costs – solar-charged batteries with a 5-year nominal lifespan.
- Easy deployment with no rolling or spinning limitations (can be rolled off the deck of a ship)
- Internally housed antenna and obstruction light for protection against wave or ship damage
- Easy-access, modularized system components for convenient servicing
- Easy, low-cost battery replacement
- Near real-time power system monitoring
- Infrared port for communication/setup with assembled unit
- External On/Off switch
- Excellent plug and play TRIAXYS™ Digital Receiver and WaveView™ Software
- Intuitive, user-friendly software with automated error checking, archiving and data display (graphing, 3-D directional spectrums)
- Full range of wave statistics calculated and displayed in near real-time
- Configurable software alarms for buoy WatchCircle™ status using GPS position verification

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

A: TRIAXYS™ uses solid-state accelerometers and rate gyros to monitor the buoy motion in six degrees of freedom, with a flux gate compass to provide buoy heading. The AXYS designed and fabricated microcontroller interfaces to the sensors and logs the raw sensor data. This data is processed and analyzed using proprietary algorithms developed by the National Research Council of Canada. The resultant data can be expressed in a number of different formats depending on user requirements.

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

A: The TRIAXYS™ buoy is robust and durable. Its sensor suite is resistant to damage from rolling or collision. While all buoy components are enclosed within the hull of the buoy, the modular design ensures that all major components are readily accessible when the buoy is opened for servicing. Rechargeable batteries augmented by a solar charging system provide power to the buoy. All communication with the buoy for configuration and programming can take place through an infrared serial communications module located within the buoy, which alleviates the requirement to open the buoy for a physical connection to setup and monitor the buoy's operation prior to deployment. Data is logged on-board the buoy as well as transmitted to a shore station – refer to telemetry modes for details.

4. **How is the TRIAXYS™ Buoy constructed?**

A: The TRIAXYS™ hull consists of two parts. The lower half or hull is constructed from a single piece of 316 stainless steel and covered with a thermal powder coat finish. The dome is constructed of clear, high-strength polycarbonate. A rubber gasket seals the interface between the hull and dome, which is secured by a locking ring and studs. Internally, the buoy has a fiberglass-mounted solar panel array (SPA), which also provides mounting for the power distribution module, obstruction light, IR port, Global Positioning System and/or other antennae, depending on telemetry configuration. Underneath the SPA is the Telemetry and Sensor module (TAS), which consists of a waterproof case enclosing the sensors, processors, and other configuration-specific electronics. Electrical connections to the rest of the buoy components are through waterproof Bulgin connectors. Below the TAS module are racks for up to four 100AmpHr rechargeable glass-mat lead-acid batteries.

5. **How is the durable is the TRIAXYS™ Buoy?**

A: The TRIAXYS™ is remarkably durable. The 316 stainless steel hull is corrosion resistant and the rubber bumper mitigates collision damage; the polycarbonate dome is very strong. Extensive destructive testing was conducted to verify that material strengths met or exceeded our service requirements. The solid-state sensors and electronics are not affected by rolling or spinning, and can withstand reasonable accelerative loads as mounted inside the buoy. However, any solid-state device can be damaged by sharp impact, such as being dropped on the deck or swinging into the ship's gunnels or hull. The leak-proof, glass-mat, lead-acid batteries are firmly secured to internal hull brackets. Normal buoy handling procedures will not cause any problems with the TRIAXYS™ buoy.

6. **How do wave buoys compare to bottom mounted pressure sensors and ADCP systems? In terms of cost, operation, measurement precision and maintenance?**

A: The measurements taken by the TRIAXYS™ buoy are measurements of the actual wave conditions using relative motion sensors to collect readings from all six degrees of freedom. This type of measurement is not affected by other environmental parameters, which can degrade the precision of the two other types of sensors. The main limitation of the 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. The ADCP system also suffers from decreasing accuracy with increased water depth. Both systems require a system for data transmission, either a cable to shore or to a buoy on the surface, and a power supply.

7. **How is a TRIAXYS™ Buoy deployed?**

A: The TRIAXYS™ buoy can be deployed in currents up to 3kts, in shallow water without breaking waves to water depths greater than 150m. Currents greater 3kts may cause the buoy to submerge periodically. This doesn't compromise the buoy (as it is sealed) but it may affect data quality and transmission reliability. The TRIAXYS™ Buoy can be deployed from a variety of vessels from canoes to warships, depending on weather conditions and local logistics. The buoy can be handled by as few as four people but for safety considerations 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, and it can be towed for short distances. Normal procedure for deployment of a TRIAXYS™ involves placing the buoy in the water when the vessel is approximately 0.5km away from the final deployment location. The mooring is paid out over the rail of the vessel as it motors slowly towards the final deployment location. The buoy should be floating free of the vessel with the mooring trailing free of tangles or twists. Once the vessel is on station, the anchor is released. For first deployments we recommend having an AXYS Service Technician on site to assist with deployment and provide training.

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

A: Refer to the TRIAXYS™ User Manual for further details.

Mooring:

It is recommended that the rubber compliant section of the mooring be inspected every 6 months and the main mooring section be inspected annually. Once retrieved, each mooring section can be replaced with a new one while the old mooring is taken ashore for inspection. The compliant sections are usually only good for a single, 6-month use, but the main mooring components can be reused once inspected and found to be in good condition.

Biofouling:
Biofouling occurs at different rates depending on marine conditions at the deployment site. If there is algal fouling on the dome, soak with bleach and scrub with a soft brush and detergent: it is important to keep the dome clean to ensure efficient charging of the solar array. Use vinegar-soaked clothes to soften calcite deposits from barnacles or other shellfish: it may take a day or two for the deposits to soften sufficiently to be scrubbed off without scratching or marking the dome, as this would also decrease the solar charging efficiency. The steel hull can be scraped free of biofouling using a car windshield scraper or paint scraper and scrubbed using a hard-bristled brush.

Batteries:
The TRIAXYS™ buoy is fitted with four (4) rechargeable lead-acid absorbed-glass-mat (AGM) batteries that should be inspected as part of the 6-month maintenance schedule. The buoy must be purged (via the purge port) of potentially harmful gasses before it can be safely opened. Battery voltage should be between 12.2V and 12.5V when charged, and a voltage of less than 10.5V indicates that the batteries are substantially discharged. The batteries can be recharged with a charger designed for AGM-type batteries, with care taken not to over-charge the batteries. If the batteries are to be recharged using solar energy, make sure the buoy is turned off, and in direct sunlight with no danger of overheating. Refer to the specifications written on the battery and the TRIAXYS™ User's Manual.

Flange Gasket:
The flange gasket that forms the seal between the dome and hull of the TRIAXYS™ should be inspected for cracks or tears every time the buoy is opened, and replaced as required (at least every two (2) years).

Electronics:
Annual systems diagnostics should be performed while the buoy is ashore. Work instructions are provided as part of the TRIAXYS™ documentation.

9. Can the data be logged on board the buoy?

A: Yes, the TRIAXYS™ can be purchased with a data logger option that records the raw and processed data onto a flash card. The card is removed from the buoy and the data downloaded into a computer to be processed through WaveView™ or AXYS Post Processor. Refer to the TRIAXYS™ User's Manual for more information.

10. What telemetry systems are available on the TRIAXYS™ buoy?

A: The TRIAXYS™ is designed to have two telemetry systems: a primary, or main telemetry system for regular data transmissions; and a secondary telemetry system for WatchCircle™ alarm data for use if the buoy should go off-station. Regardless of telemetry type, transmission durations (quantity of data that can be transmitted) is limited by buoy power, and the acquisition interval/duration of the buoy.

Primary Telemetry Systems:

VHF (standard primary telemetry configuration)
- ~12Nm range (line-of-sight) to shore station
- Requires TDR receiver (shore station)
- Transmit: buoy status, wave statistics, mean wave direction
- Transmission limitations: range, interference
- Message type: data packet sent to TDR

Inmarsat D+ (stand-alone primary/secondary)
- Global coverage (up to 72^{o} North and South)
- Requires Inmarsat D+ account with Axys Technologies (registered Inmarsat D+ service provider).
- Transmit: buoy status, wave statistics
- Transmission limitation: Inmarsat transmission packet size
- Message type: posted to secure web-site, FTP, or email.

Iridium (most reliable primary telemetry configuration)
- Global satellite network
- Requires SIM card, modem and land line
- Transmit: buoy status, wave statistics, mean wave direction
- Transmission limitation: number of retries (input by user)
- Message type: email sent via land line/modem

Cellphone (GSM)
- Range dependant on cell network coverage
- Requires SIM card, modem and land line
- Transmit: buoy status, wave statistics
- Transmission limitation: cell coverage, number of retries (input by user)
- Message type: email sent via land line/modem

Orbcomm
- Coverage varies with location
- Requires SIM card, modem and land line
- Transmit: buoy status, wave statistics
- Transmission limitation: satellite connection, 200 character message size
- Message type: email sent via land line/modem

Secondary Telemetry Systems (activated when buoy leaves the WatchCircle™)

Inmarsat D+ (as a secondary system)
- Global coverage (up to 72^{o} North and South)
- Requires Inmarsat D+ account with Axys Technologies (registered Inmarsat D+ service provider).
- Transmit: WatchCircle™ alarm, buoy status, wave statistics
- Transmission limitation: Inmarsat transmission packet size
- Message type: posted to secure web-site, FTP or email.

ARGOS
- Global coverage (sparse at equator)
- Controlled by NOAA, intended for government and nonprofit organization
- Transmit: WatchCircle™ alarm, buoy status.
- Transmission limitation: satellite window
- Message type: email

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

A: The WatchCircle™ alarm 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. As the primary VHF and Cellular telemetry systems (other than Iridium) have limited transmission distances and can be useless if the buoy drifts out of range of the base station or cellular relay tower, Argos or Inmarsat D+ satellite secondary telemetry systems are generally used to communicate this alarm message. Argos and Inmarsat providers will send this message using a variety of methods including email.

12. Can multiple TRIAXYS™ buoys be used in a network around a single base station?

A: Yes, multiple TRIAXYS™ can be networked around a single base station and feed into a single TDR. All the buoys must be configured for the same VHF frequency as the TDR. The sampling/transmission intervals of each buoy must be offset from the others with sufficient time to allow the TDR to individually receive and process the data through WaveView™. The number of buoys that can be networked together is dependant on the sampling/transmission interval configuration, which is set by the user.

13. What are the mooring requirements for the deployment of a TRIAXYS™ Buoy?

A: Standard moorings for the TRIAXYS™ buoy are designed for a range of water depths, and consist of a compliant section, a wire rope (spacelay) section, polyethylene rope section, and miscellaneous connective hardware. The user customarily supplies the anchoring weight. The

compliant section decouples the buoy motion from the mooring, and consists of a 32mm diameter butyl rubber cord attached to the buoy by a stainless steel swivel. Axys can design moorings customized for specific deployment requirements.