SmartAtlantic – The Benefits of Real-time Metocean Data in Port Operations

How real time metocean data is reducing costs for port operators and users while also reducing risk to mariners through improved awareness of weather conditions.

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I. Introduction

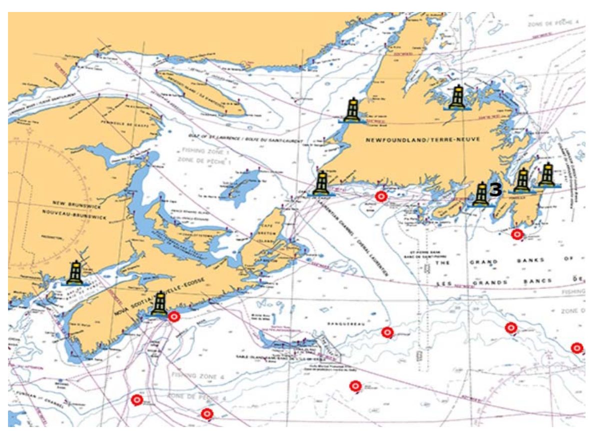
The SmartAtlantic Alliance is an initiative of the Fisheries and Marine Institute of Memorial University of Newfoundland's Centre for Applied Ocean Technology (CTec), the Institute for Ocean Research Enterprise (IORE) and the Canadian Marine Pilots Association (CMPA) [1].

Between these three organizations, a network of nine buoys operate in Atlantic Canada, acquiring and transmitting meteorological and oceanographic data, including wind speed & direction, air temperature, barometric pressure, relative humidity, solar radiation, wave height, period & direction, current speed & direction, conductivity, depth, and temperature in real time. The SmartAtlantic alliance provides this data to a local consulting company who has built and continues to refine meso-scale models, while generating high resolution weather, wind and wave forecasts. The real time data and forecasting services support safe and effective pilot and tanker operations throughout the waters of Atlantic Canada.

This paper will summarize the capabilities of these metocean buoys and outline some specific results that the buoy data provides while addressing the benefits derived from improved awareness of weather conditions.

II. The SmartAtlantic Buoy Network

The SmartAtlantic buoy network began under the brand SmartBay, an initiative led by CTec, to bring an operational buoy network to Placentia Bay, NL. This was where the first buoy was deployed – an AXYS 3 Metre buoy – in the summer of 2006. In June 2010, two additional buoys were deployed – one WatchKeeper at Come by Chance Point, NL and one 3 Metre at the Pilot Boarding Station at the south end of Red Island, NL. In 2012 SmartBay received additional government funding which increased the network scope with 8 more buoys: 4 x 3 Metre buoys and 2 x WatchKeeper buoys along with 2 x TRIAXYS wave buoys. These buoys were received in 2013 and have been deployed in Port Aux Basques Harbour, NL, Bay of Exploits, NL the approach to Humber Arm, near Cornerbrook, NL, Conception Bay, NL and outside the narrows into St John's Harbour, NL. The idea to bring this network to the other Atlantic Provinces had been championed by the CMPA for over 15 years. Finally, in 2013, the buoy network expanded into Nova Scotia.



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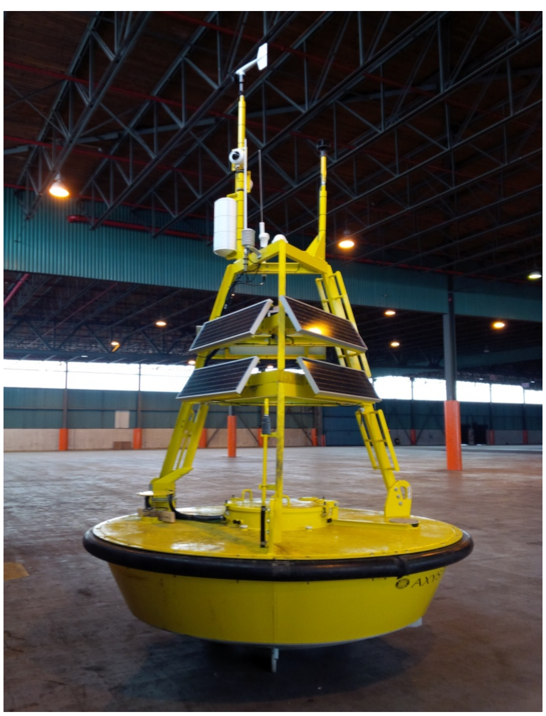
A 3 Metre buoy was deployed four miles northwest of the pilot boarding station in Herring Cove at the mouth of Halifax harbour. With SmartBay already operating data management and data analytics services, including forecasting, it made sense to extend these services to support the new Halifax buoy. The expansion into Nova Scotia resulted in a new buoy network brand – SmartAtlantic.

In early 2015 the network expanded again, this time into the province of New Brunswick. The deployment of a 3 Metre buoy in the Bay of Fundy in the approach to Saint John Harbour.

The real time data from the SmartAtlantic buoy network is freely available and used for a variety of purposes, including improvements to operational efficiencies by Port operators, situational awareness of sea state and safety for all mariners and support to the country's coastal and ocean management efforts.

III. Buoy System

The payload of the buoy used in the SmartAtlantic network has evolved since the initial buoy was deployed in 2006, however, the core technology that allows for effective buoy network management has remained the same.

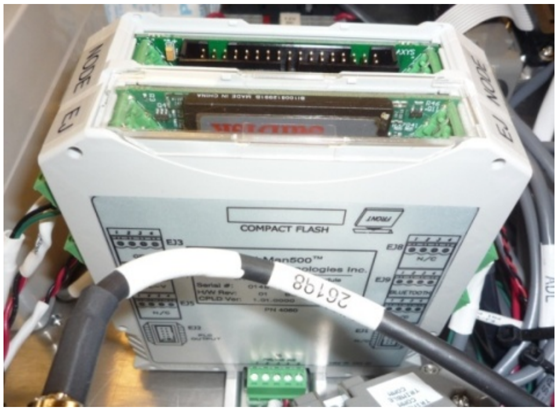


Controller

The core technology on the buoy is the WatchMan500™ (WM500) controller, the device that manages all sensors, communication devices, power management, and system diagnostic and alerting mechanisms. The WM500 was designed as a modular system for expandability, low power and broad capability to interface with any sensor and telemetry device using flexible input/output options. Each module can accept between 6-10 connections (sensors, telemetry), while a system can support up to 127 modules. The WM500 performs onboard processing of data, as required, and transmits data in a variety of formats over multiple telemetry options. Using two way communications, the WM500 allows for configuration changes to individual sensors, whether it is sample rate, sample period, or reporting rate. The system also offers onboard self diagnostics for hardware and software. A flash memory card provides for up to 32GB of data storage, enough to last several years.

Sensors

The SmartAtlantic buoys are equipped with a sensor payload commonly used in operational metocean buoy networks. A suite of meteorological sensors are included on the buoy to measure wind speed and direction, air temperature, relative humidity and atmospheric pressure. The meteorological sensors are complimented with oceanographic sensors to measure directional waves, current speed and direction in the water column, conductivity, water temperature and salinity at the sea surface. Data from these sensors are typically provided as an average of a sample - typically five minutes for the MET, ADCP and CT sensors and twenty minutes for the wave sensor. This data is typically collected every sixty minutes but is user configurable.



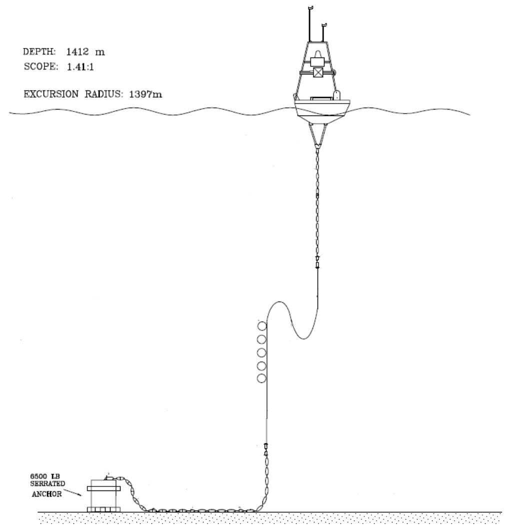
Telemetry

The primary telemetry on the SmartAtlantic buoys varies depending on the deployment location, however, all buoys are designed with multiple methods of communication. An Inmarsat satellite terminal is dual purposed to provide GPS position to the WM500 and a satellite telemetry link. This satellite link is often used for the WatchCircle Alarm feature – offering GPS tracking of the buoy system with regular position messages. The Inmarsat link can also be used for primary telemetry, allowing data from all sensors to be provided in near real time. Technology advancements in the Inmarsat terminal have allowed for increased message sizes to be sent from the buoy system, to the point now where we can transmit 6kb of data in a single message from the buoy.

The buoys are also equipped with Iridium SBD modems, allowing for up to 2kb of data to be transmitted in a single message. The choice of using Inmarsat or Iridium typically depends on where the buoy is located and the access it may have to the respective satellite constellation.

Near shore deployments offer higher bandwidth telemetry options, including GSM and VHF.

All SmartAtlantic 3 Metre buoys are equipped with AIS transponders, which provide the AtoN message 21 to nearby mariners as well as MET/Hydro message 8 using the data from the most recently acquired dataset logged to the WM500.



Mooring

Each SmartAtlantic buoy is deployed with a mooring specifically designed for its deployment location. Mooring simulations are performed using historical metocean data for each location, with consideration to winds, waves and currents using data from 1 year, 10 year and 100 year storm. Tensions are reviewed at anchor and buoy using variations in mooring design and buoy buoyancy and based on optimal performance, a buoy hull and mooring design are recommended for the location.

System Operation

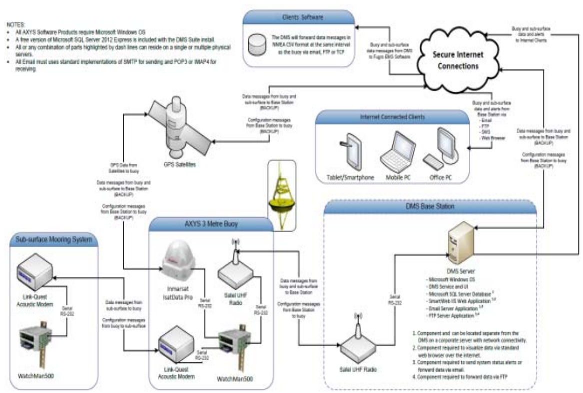
The SmartAtlantic buoys are operational buoys providing important data that is used for a variety of purposes, as previously discussed in the introduction. Ensuring this data is available requires routine observation of system performance. This information is made available in the buoy system diagnostic message which is sent along with the buoy data over the primary telemetry at user configured transmission intervals.

These user configured data transmission intervals, along with the sensor sampling period and interval, must be chosen with consideration to the available power supply on the buoy. A system power budget is performed whereby the available power supply on the buoy is balanced with the sensor payload and requested sampling period, interval and data transmission interval. Using seasonal solar radiation data from buoy deployment locations, a power budget based on available solar power will determine the recommended system configuration.

Recent developments include the inclusion of surveillance cameras, to offer the dual functionality of asset management and situational awareness in the area surrounding the buoy.

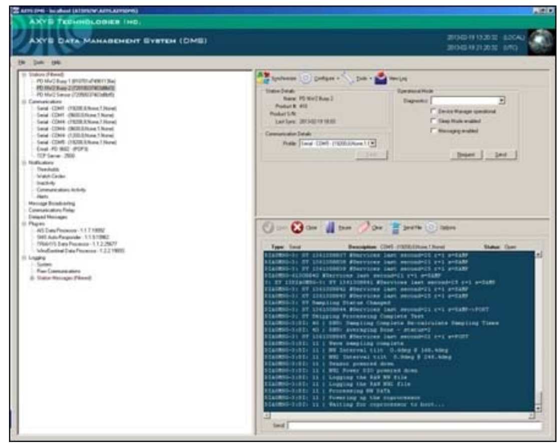
IV. Data Management

Software



The key to efficient data management of a buoy network is ensuring the IT architecture allows for data to be received, stored and disseminated in a secure and reliable manner. It also requires software that is capable of managing large quantities of data, while allowing the user the capability to manage the buoy network. The AXYS Data Management System (DMS) software was designed with this in mind.

In a large network the utilization of different data telemetry methods is often required. This is acceptable, provided the links are reliable and secure. The destination of all data should be equally secure and reliable. The DMS software allows for data to be received, stored and disseminated, as necessary, from multiple buoy systems using multiple telemetry devices, all in a secure infrastructure. A suite of communications ports allow for a network of buoys to call a single server running the DMS software service. Data can be sent from the buoy in a variety of formats, such as AXYS binary or a more generic NMEA format. All data is received by the DMS, parsed and stored to an SQL database, ASCII text files, or other database as required, in a comma delimited format. The generic storage functionality offers users easy access to pull data for other uses. The DMS can also push data, as necessary, to third party destinations.



Using the communication ports in the DMS software, users can also send configuration change commands to the buoys and view detailed system diagnostics. Custom alerts can also be created within the DMS to monitor for data points that may exceed operational thresholds, such as a significant wave height present at a pilot boarding station which may prevent safe pilot transfer. These alerts can generate audible and visual alerts at the operation centre as well as email notification emails.

V. Benefits to Industry

Fuel Costs & GHG Emissions

Canada's ECA Standards

Beginning in early 2015, ships with a capacity of 400 gross tonnage or greater operating within the North American Emission Control Areas (NA-ECA) and throughout Canadian waters south of 60°N are required to achieve sulphur oxide (SOx) emissions equivalent to using fuel with a sulphur content less than 0.1% (1,000 ppm) - a 96% reduction [2]. A "fleet averaging regime" was developed for Canadian ships operating in the "Great Lakes and St. Lawrence waters" whereby compliance with the sulphur content standards is determined by the average sulphur content of all the fuel used by a firm's fleet. In waters outside of the NA-ECA, north of 60°N and including all of Hudson's Bay, James Bay and Ungava Bay, the global standards set under MARPOL for controlling sulphur oxides apply. This currently comprises a 3.50% limit on the sulphur content of marine fuel and after January 1, 2020, the Amendments set the standard to 0.50% [3].

Ships built in 2016 or later will be required to meet a stringent Nitrogen Oxide (NOx) standard in the ECA, representing an 80% reduction from current standards. Emissions can be reduced through the use of lower sulphur fuels and / or use of after treatment technologies (scrubbers, selective catalytic reduction).

North America Emission Control Area (NA-ECA)

The NA-ECA includes waters under Canadian jurisdiction south of 60°N extending out to approximately 200 nautical miles (NM); and waters under the jurisdiction of the United States, including Hawaii and Alaska south of 60°N; and North American waters under the jurisdiction of France — the islands of St. Pierre and Miquelon [3].

Weather Buoys Predict Berthing Delays

CMPA research has shown that most vessels are inside the ECA for the Port of Halifax within 24 hours of their ETA at the pilot boarding station. The data from the SmartAtlantic Herring Cove Buoy, used to produce high resolution forecasting of wind and sea state conditions, provide a 36-hour window to help industry predict the likelihood that a pilot will be able to successfully bring a vessel into port when it arrives at the pilot boarding station. Halifax pilots will attempt to bring in a vessel in seas up to 6m at the pilot boarding station, dependent upon certain criteria.

Industry therefore has more than 24-hour notice to expect a possible 4-6 hour weather delay due to waves of 6m or greater upon arrival at the Port.

Adjust Vessel Arrival by Slow Steaming

The International Maritime Organization (IMO) is investigating technical and operational measures to reduce GHG emissions [4]. IMO recognizes the economic benefit of slow steaming and efficient ship design. For example:

- Estimate a vessel speed reduction of about 3 knots would defer the arrival of a vessel by about 4-6 hours.
- Reducing vessel speed = reducing amount of very expensive 0.1% low sulphur fuel consumed and GHG emissions.
- Reducing vessel speed = eliminating costs of weather delay upon arrival

Planning an optimal vessel speed to arrive at a pilot boarding station when sea state conditions are appropriate to conduct safe pilot transfers can help to significantly reduce fuel costs and cut GHG emissions.

Based on CMPA research, the following table shows that beneficiaries of the free forecasts generated using data from the SmartAtlantic buoy at Halifax Harbour who call the Port of Halifax in the winter months (Nov. 01 – Apr. 30) could reduce 0.1% sulphur fuel costs (equal to CDN $775,000) and also cut GHG emissions equal to the removal of 535 cars from the road for one year.

Ship Type	Vessel Size	# Ships Impacted	Fuel Saving (metric tonnes)	0.1% Sulphur Fuel Cost Saving (000's CDN $)*	Green House Gas Reduction (metric tonnes)
Containership	>50,000 GRT/ avg. 4700 TEU	26	390	$312	1,248
Tankers	Handy size	10	100	$80	320
Auto carriers	53,000 - 70,000 GRT	7	84	$67	269
Bulk carriers	29,000 – 43,000 GRT	8	80	$64	256
General cargo	20,000 – 30,000 GRT	10	90	$72	288
General cargo	10,000 – <20,000 GRT	2	10	$8	32
General cargo	< 10,000 GRT	8	32	26	102
TOTALS		**71**	**786 metric tonnes**	**CDN $775,000.**	**2,515 metric tonnes**

Based on St. Lawrence price for 0.1% sulphur fuel @ CDN $986/tonne, market price January 8, 015

VI. Weather Windows for Vessel & Cargo Operations

The following case study profiling the M.V. Australian Spirit illustrates the value of specific weather information.

Background

A loaded crude tanker was adrift 40 NM from Halifax in Gale force winds, heavy rain, and heavy seas. It was sailing from Placentia Bay, NL to New York, NY when it suffered catastrophic rudder failure in a waterway too deep to anchor. The tanker was carrying 775,000 barrels of Hibernia crude oil as cargo. The main engine was operational, the vessel's steering gear was operational but there was no load on the steering gear. The vessel needed to get into port as quickly as possible to assess the problem, affect repairs and discharge the cargo. Halifax was the closest port of refuge.

Operational Challenge: Find the safe weather window

The weather forecast was a Gale blowing on December 10th with strong winds and heavy seas continuing on the 11th and thick of fog on December 12th. The vessel required tugboat escort to transit Halifax Harbour into Bedford Basin, underneath both Halifax Harbour Bridges (significant wave cannot exceed max. 2.5m). Bedford Basin would provide safe conditions to conduct Ship-to-Ship cargo transfer utilizing 3 pilots and 4 tugboats.

VII. Minimize Costs of Severe Weather Delays

Weather-related delays cost the Halifax marine community in excess of $2.6 million annually – money that could be saved, to a large extent, by using high resolution weather and wave height forecasting to better plan port operations [5].

VIII. Conclusion

The economic benefits of the SmartAtlantic weather buoys include,

- Keeping principals and customers informed of extreme weather, action plan for the port during the event and anticipated time of reopening of the port,
- Availability of high resolution forecasting regarding weather windows will contribute to reducing demurrage costs (For Tankers: weather demurrage generally 50% cheaper than full demurrage).
- Reduce the costs associated with vessel delays through better planning of vessel arrivals and departures.
- Reduce GHG emissions from vessels as a result of efficiencies in vessel speeds and routes
- More effective planning of pilotage resources, tug escort requirements and dispatching of longshoremen.

REFERENCES

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