Ocean Observation Using Network ODAS Buoy

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An ocean observing system can be defined as an infrastructure comprising several independent instruments with the ability to collaborate in order to collect relevant and crucial scientific data for understanding the ocean. This system, serving as a support system and an eye on the ocean, has the following benefits:

i. Maritime economy
ii. Decision making to improve health of the oceans
iii. Reinforcing coastal safety
iv. Safe and rescue
v. Measuring and predicting sea and ocean changes
vi. Providing the environmental information for wide range of sectors

In order to better understand oceans, partnering with more ocean observation programmes will certainly boost the number of information sources. So, integrating ocean observation programmes at numerous locations will enable real time observation by a variety of sectors (government, private sector and academia) on a large area. In fact, the current data on the seas and oceans is very important for understanding the impact on human activities and climate.

Over the past few years, several observing systems have been developed around the world, such as the Global Ocean Observing System (GOOS), US Integrated Ocean Observing System (IOOS), the European Seafloor Observatory Network (ESONET), the Australian Integrated Marine Observing System (IMOS), the India National Centre for Ocean Information Services (INCOIS), the Texas Coastal Ocean Observation Network (TCOON), the Southern Ocean Observing System (SOOS), the European Global Ocean Observing System (EuroGOOS), Global Ocean Observing System in the Indian Ocean (IOGOOS), the Mediterranean Ocean Observing system for the environment (MOOSE) and the Monterey Ocean Observing System (MOOS). The overall map of the GOOS partner is shown in Photo 1.

As an example of the integrated ocean observation framework, the U.S. IOOS comprises 11 Regional Associations (RAs) providing ocean data into the framework:

i. Alaska (AOOS)

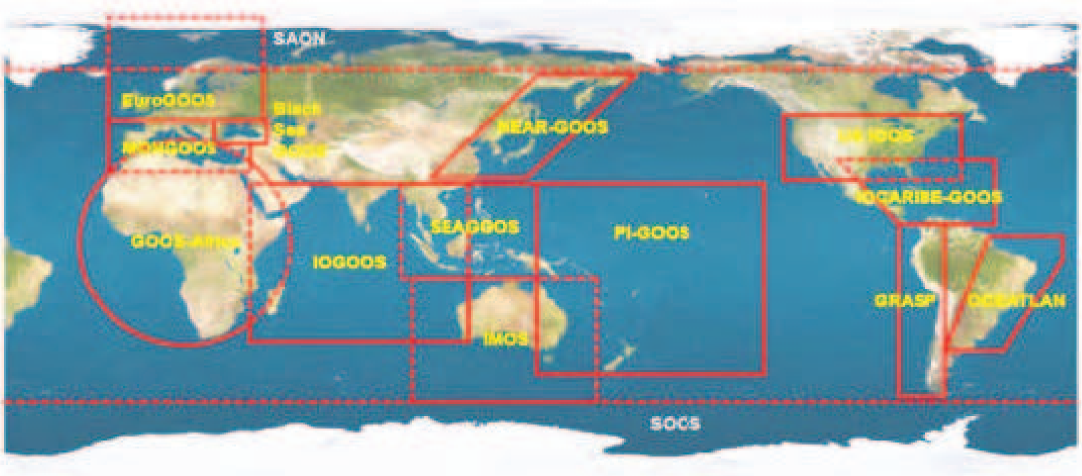


Photo 1: GOOS Regional Alliances Map: The European Global Ocean Observing System (EuroGOOS), Mediterranean Ocean Network GOOS (MONGOOS), Black Sea GOOS, NEAR (North-East Asian Regional)-GOOS, PI-GOOS, Indian Ocean GOOS, IOCARIBE-GOOS, GOOS for Africa, USA IOOS, Southeast Asian GOOS (SEA-GOOS), OCEATLAN, GRASP and IMOS. Other developing regional alliances such as Sustaining Arctic Observing Networks (SAON) and Southern Ocean Observing System (SOOS) [1]

ii. Caribbean (CaRA)
iii. Central and Northern California (CeNCOOS)
iv. Gulf of Mexico (GCOOS)
v. Great Lakes (GLOS)
vi. Mid-Atlantic (MARACOOS)
vii. Pacific Northwest (NANOOS)
viii. Northeast Atlantic (NERACOOS)
ix. Pacific Islands (PacIOOS)
x. Southern California (SCCOOS)
xi. Southeast Atlantic (SECOORA)

The RAs serve the nation's coastal communities, as well as the Great Lakes, the Caribbean and the Pacific Islands and territories. The SECOORA programme consists of several alliances such as NCCOOS, Caro-COOPS, SABSOON, COMPS and EFSIS. Photo 2 shows a sample of ocean observation region coverage.

There are also observation and data network programmes collecting ocean information such as European Marine Observation and Data Network (EMODnet) (2), Data Buoy Cooperation Panel (DBCP) (3), JCOMM in-situ Observing Platform support centre (JCOMMOPS) (4), Observing system monitoring center (OSMC) (5), National Data Buoy Center (NDBC) (6) and Sea Data Net(7). These use several platform types such as mooring, drifting, gliders, profiler, argo, ferry box, radar, shore and bottom station.

In the long run, the partnership programmes increase access to greater ocean information and save users time and cost. A better understanding of the oceans can be sampled and compared with a range of platforms. However, such programmes only focus on certain ocean areas as mentioned earlier and there are several areas which still lack ocean observation programmes.

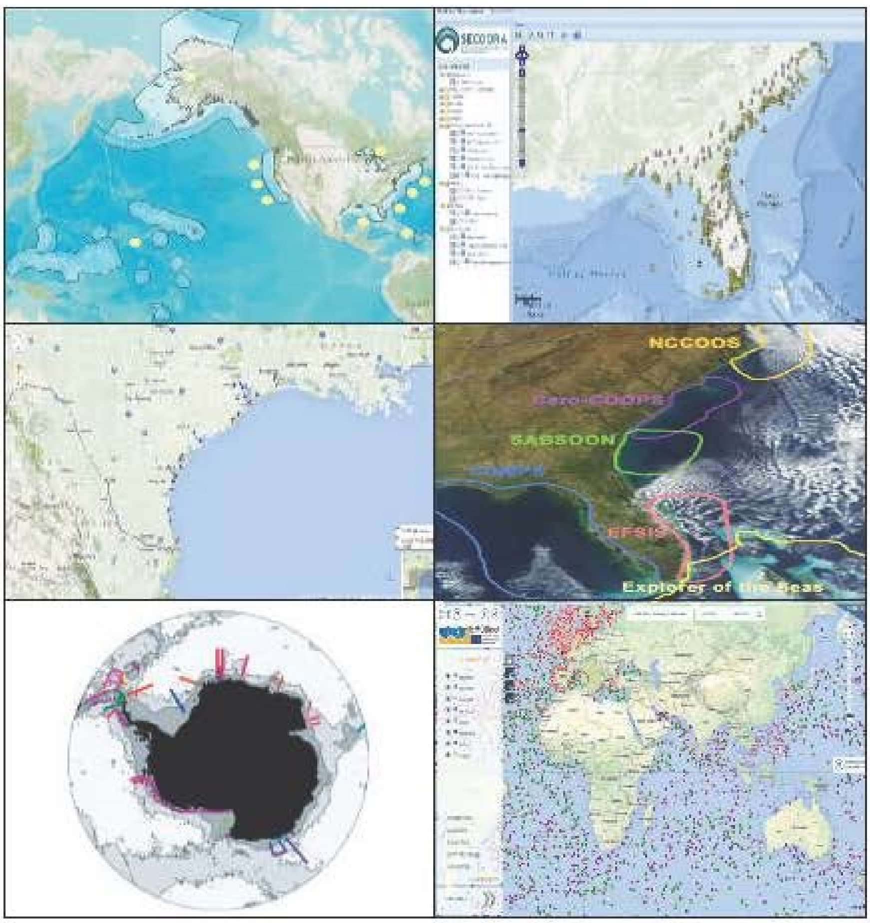
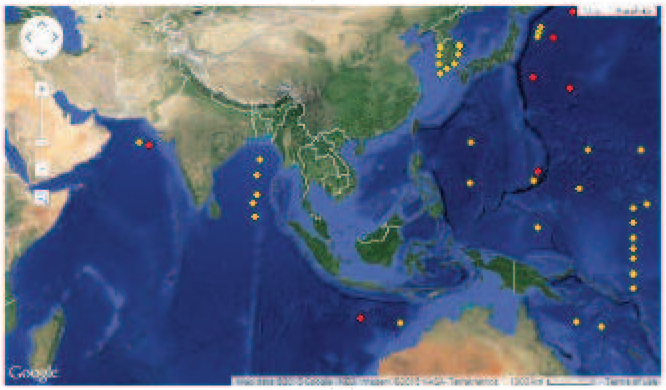


Photo 2: Sample of Ocean Observation programme (a) US IOOS [8] (b) SECOORA [9] (c) TCOON [10] (d) SECOORA reliance [9] (e) SOOS [11] (f) EMODnet [2].

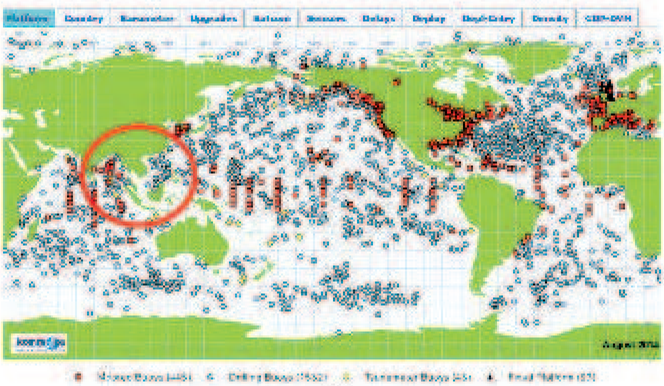
NEED FOR NETWORK BUOY IN MALAYSIAN WATERS

Despite the intensive ocean observation programme networks around the world, certain regions are not covered in the framework. According to Prof. Somkiat Khokiattiwong, Chair of WESTPAC and SEAGOOS, the partnership of ocean observation programmes has helped to mitigate the risk for society and the ecosystem for the regional observation (12).

Southeast Asia is still lacking an operational ocean observation programme. To fill the gap, SEAGOOS has introduced two pilot projects – Ocean Forecast Demonstration System (OFDS) and Ecosystem Impacts (MOMSEI) – covering the Malaysian eastern shelf and the Gulf of Thailand. The programme has been successfully initiated and is in progress. Malaysia lacks programmes supporting ocean observation. Photo 3 shows a sample of existing ocean observation platforms in Malaysia.



(a)



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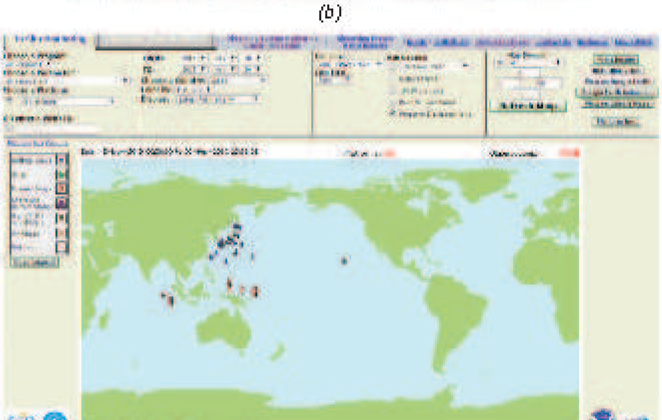

(c)

Photo 3: Sample of existing ocean observation platform in Malaysia: (a) Recent data collected form NDBC with program filter from the NDBC meteorological/ ocean, International partners, IOOS partners, marine METAR, NERRS, NOS/ CO-OPS, oil and gas industry, TAO and Tsunami[6] (b) DBCP[3] (c) OFDS[12]

Malaysia needs an integrated observation system. This is important to understand the trend of coastal and open water seas, which will increase the understanding of long term environmental anomalies. Observation activities as well as internal partnerships between the government, public sector and universities will provide a larger platform network.

One way to continuously monitor ocean data is by using scientific buoys known as Ocean Data Acquisition System (ODAS) buoys. Deploying several buoy nodes at potential coastal areas will offer near real-time data of sea water and surroundings. The network buoy will contribute to numerous applications, which will facilitate the continuous understanding of natural processes such as marine forecasting, seasonal forecasting, safety at sea, fisheries and coral reef area resources.

THE OBJECTIVES

The primary objective of a network ODAS buoy is to have an interconnected observation system. A commonly used communication method for a buoy is based on a cellular network with a coverage range that is dependent on transmission frequency and the substation. However, this method is costly for data transmission in continuous operation mode.

Alternatively, communication based on radio frequency (RF) communication can be used where unlimited data can be transmitted at minimum cost but this has one draw-back, its limited communication range. However, if there is a risk of losing direct communication or unreachable link (for wider operation area) between the ground station and the buoy, an intermediate buoy can act as a hopping point so that the transmitted signal can reach the ground station. This communication is usually bi-directional communication architecture where command is sent to the buoy and buoy transmits the requested data to the shore station. Alternatively, a one directional communication system can be employed if buoys are set to transmit data periodically and continuously to the shore station.

As stated earlier, the network ODAS buoy is used mainly to monitor a wide observation areaand at the end, data is synchronised by a single central station. This is important because Malaysia has a long coastline. So, synchronisation is important for efficient monitoring, data organisation and reinforcement. In addition, the system should be capable of providing sufficient data related to ecosystem observations, including water quality, sea creature behaviour, intruder detection and early warning in case of natural disasters. To achieve this, a sophisticated sensor-and-communication system is essential.

The ODAS buoy system should also be able to withstand an unpredictable ocean and environment condition. In other words, this system should be robust enough to with stand climate changes, wave amplitude and frequency, wind speed, water current, corrosion and weather effects.

SYSTEM ARCHITECTURE

In general, a network buoy consists of multiple buoys interconnected wirelessly. The general architecture of the network buoy is shown in Photo 4. A buoy collects desired data through the attached sensors and sends the data to the shore station. Shore stations collect data from the buoys wirelessly but are limited to buoys connected to each shore station. The shore stations are positioned nearest to the ocean to enable the wireless transmission from the buoy.

The data is then sent to the central station through internet networking, i.e. cable networking system. The central station is responsible for gathering, processing and storing data from all buoys, collected through multiple shore stations.

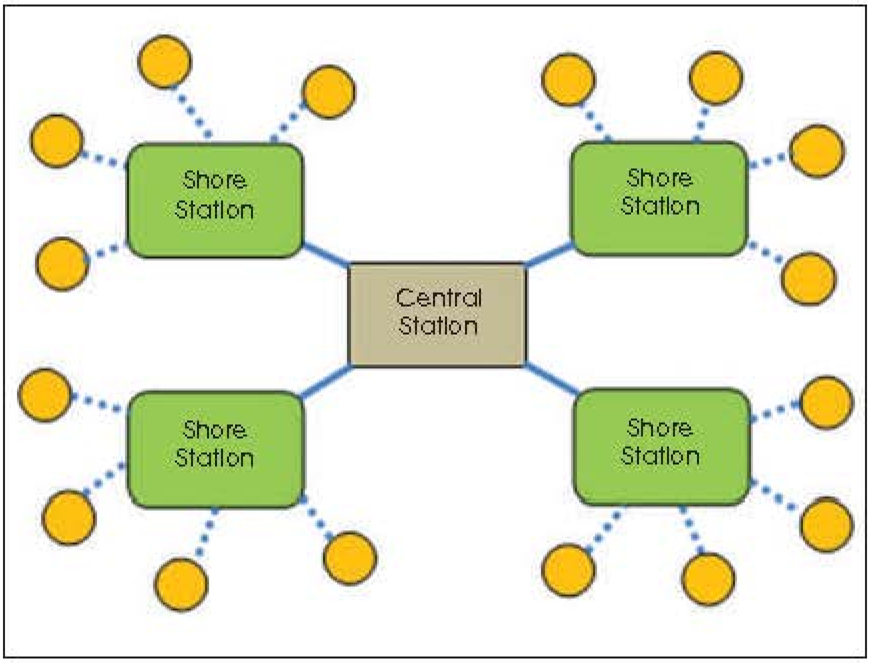

Photo 4: General architecture of the network buoy system

A possible network buoy system for the Malaysian coastal area is illustrated in Photo 5 where the operation and monitoring activities are controlled by the central station in a strategic location and monitored by an authorised organisation. These locations depend on the purpose of the buoy installations, such as monitoring of coral reefs and fisheries.

Since the peninsula and Sabah/Sarawak are separated by a large body of water, a few central stations can be introduced for more efficient ocean monitoring. A buoy system can be separated into a few sub-systems, namely sensor system, mechanical system, power system and communication system. A network buoy is different from a single buoy system only in terms of communication architecture.

Photo 5: Illustration of network buoy implementation

A mechanical system consists of body design, mooring design and anchoring design. The most important factor to be considered when designing the mechanical system is the ability of the buoy to withstand the rigorous ocean environment.

In terms of power supply, buoys are usually powered by batteries which can be recharged through solar energy. On the other hand, a sensor selection is flexible and depends totally on the parameters to be measured, similar to a single buoy system. The most common sensors used for meteorological, oceanographic and water quality parameters are summarised in Table 1. The attachment of the sensor should be according to need. For example, in coral reef areas, sensors for water quality, turbidity and temperature, should be installed to monitor parameters that affect coral life.

Table 1: Common sensors attached to an ODAS buoy

Sensor	Parameter
Anemometer	Wind speed and direction
Conductivity, Temperature & Depth (CTD)	Water's conductivity, temperature and depth
Barometer	Barometric pressure
Air Temperature Sensor	Air temperature
Sea-surface Temperature Sensor	Sea-surface temperature
Wave Sensor	Ocean wave
Subsurface Temperature Sensor	Subsurface temperature
Current	Ocean current
Humidity	Humidity level
Water quality sensor	Temperature, pH, dilute oxygen, conductivity
Turbidity sensor	Water clarity
GPS	Buoy position (latitude and longitude)
Oxygen Sensor	Oxygen dissolution
Camera and Omnidirectional Camera	Underwater and surface visibility
Hydrophone	Underwater sound
Compass	Orientation and tilt

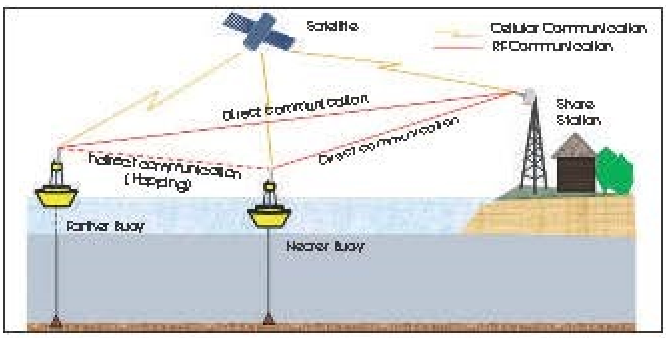

Photo 6: Communication method

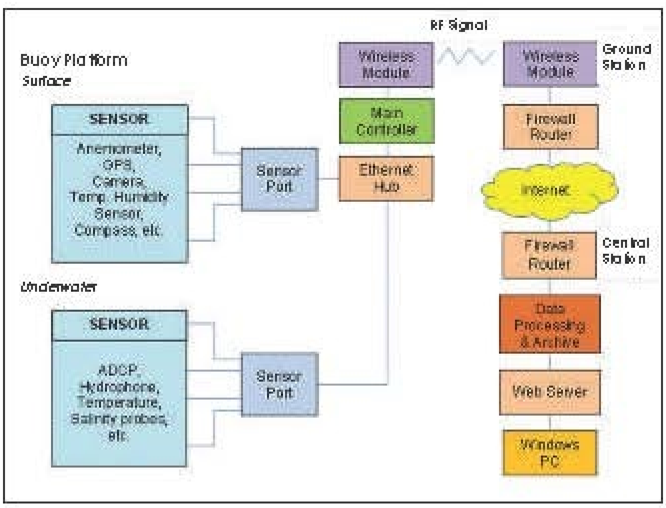

Photo 7: Data transmission architecture

Photo 6 illustrates communication architecture for both cellular and RF communication systems. As stated earlier, RF communication is a preferred choice compared to cellular communication. Because of the shorter range of RF communication, indirect communication can be established to ensure the signal reaches the shore station. Hopping points are introduced on the buoys located between the shore station (nearer buoy) and the transmitted buoy (farther buoy) if the direct communication with the shore station is not possible. Details of overall data transmission architecture are shown in Photo 7.

FUTURE PLAN

An early version of a single buoy system has been successfully developed and deployed in actual working environments. In the future, we plan to integrate the multiple buoys system into a single network by integrating embedded communication between the buoys and between the buoys and the shore station.

Further research is needed to study the performance of the network buoy in various coastal environments and to identify problems if any. The development of the design and development was initiated by the UCRG, USM. We are also looking for partners to expand our works and new collaborations. This work was funded by the Ministry of Science, Technology and Innovation (MOSTI), e-Science 305/PELECT/6013410 and Universiti Sains Malaysia. ■

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IEM DIARY OF EVENTS

Title: Professional Interview Workshop (Mechanical)

12 September 2015

Organised by : Professional Interview Board
Time : 2.00 p.m. – 5.00 p.m.
CPD/PDP : 2.5

Title: Healthcarebuild Environment Asia Conference & Exhibition (HBE Asia 2016)

28-31 March 2016

Venue : PWTC, KL
Time : 8.30 a.m. – 5.30 p.m.

Registration

Tel No. : Local : +60 3 6734 7887
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Fax No. : +60 3 2166 7010
Mobile : +60 12 723 5973
Email : suffian@urban-forum.com
Web : http://www.urban-forum.com

Title: One-Day Course on Safety Integrity Levels (SIL) Training For Workshop Participants

10 September 2015

Organised by : Chemical Engineering Technical Division
Time : 8.30 a.m. – 5.00 p.m.
CPD/PDP : 6.5

Title: 2nd Annual General Meeting of Women Engineers Section, IEM

12 September 2015

Organised by : IEM Women Engineer Section
Time : 8.45 a.m. – 10.45 a.m.
CPD/PDP : 2

Title: Professional Interview Workshop (Chemical)

12 September 2015

Organised by : Professional Interview Board
Time : 2.00 p.m. – 5.00 p.m.
CPD/PDP : 2.5

Title: Talk on Coupled Fluid-Particle Modelling of Debris Flow

18 September 2015

Organised by : Geotechnical Engineering Technical Division
Time : 5.30 p.m. – 7.30 p.m.
CPD/PDP : 2

Title: One-Day Course on Internet of Things (IOT) for Building and Factory Automation

26 September 2015

Organised by : Mechanical Engineering Technical Division
Time : 8.30 a.m. – 5.30 p.m.
CPD/PDP : 7.5

Kindly note that the scheduled events below are subject to change. Please visit the IEM website at www.myiem.org.my for more information on the upcoming events.