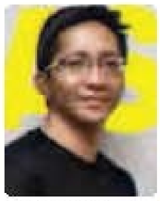
Development of a Robust and Sustainable Malaysian Integrated Ocean Observation System


by Engr. Assoc. Prof. Dr Mohd. Rizal Arshad, En. Khalid Isa and Cik Herdawatie Abdul Kadir

INTRODUCTION

An integrated ocean observation system which utilises multiple platforms that will enable vast discoveries of the complexities of ocean interactions will accelerate the information speed for the forecasting and analysis process. The aim of this research is to develop a reliable and robust ocean observation system aptly named as the Malaysian Integrated Ocean Observation System (MIOOS). MIOOS will be the future backbone of real-time and continuous ocean data measurement system in Malaysia. The availability of a fleet of mobile underwater robotic platforms, together with the fixed (stationary) system will expectantly meet the multitude of ocean-based measurement and monitoring requirements and, thus, provide a more flexible and robust MIOOS.

THE NEED FOR AN ADVANCED OCEAN OBSERVATION SYSTEM

Technological advances and pressing management problems have coerced the development of a new mode of ocean observation. Many of the benefits derived from the earth's eco-systems rely on the knowledge of the current condition of the said eco-systems, the understanding of the controls exercised on those systems and the identification of stressors that might lead to their deterioration in the future. Continuous, real-time information on multiple variables is essential and is increasingly feasible with new instrumentation and communication. This information is essential in measuring the environmental response to unpredicted events in the natural and anthropogenic system. Aquatic systems (including saltwater and freshwater) are currently threatened on a global scale by a variety of contaminants, a multitude of water management practices and destructive uses of land.

The behaviour of contaminants in an aquatic eco-system is complex and can involve precipitation, solubilisation, biological uptake, absorption-desorption, excretion and sedimentation and then re-suspension. Apart from the natural processes that affect water quality, there are also a multitude of anthropogenic impacts, such as man-induced point and diffuse sources, alteration of water quality due to water use and river engineering projects, and also various land uses that detrimentally affect water quality at a micro and macro level in the catchment. The degradation of water sources has increased the need to determine the baseline quality status of aquatic regions so that an indication of changes can be provided, which will subsequently indicate induced anthropogenic activities.

Thus, water quality monitoring refers to the acquisition of representative and quantitative information on the chemical, physical and biological characteristics of a water body in time and space, most preferably in real-time mode. In order to understand the process' dynamics of aquatic zones, a well-designed water quality monitoring system needs to be implemented. In the establishment of a water monitoring programme, an integrated approach is necessary and the nature of the zones as well as the objectives and functions of the system must be considered. If monitoring is not performed correctly or errors are contained within the monitoring programme, sample analysis will not represent the actual situation and will result in an indiscriminate wastage of finances, manpower and time. Therefore, an efficient aquatic or ocean monitoring programme which yields reliable and representative results is certainly very crucial.

WHAT IS AN OCEAN OBSERVATION SYSTEM?

An ocean observation system can be defined as an infrastructure which consists of a set of independent instruments that interact to gather data for the purpose of observing the ocean. Several observation systems have been developed around the world in the past years, such as the U.S. Integrated Ocean Observing System (IOOS), the European Seafloor Observatory Network (ESONET), the Australian Integrated Marine Observing System (IMOS), and the India National Centre for Ocean Information Services (INCOIS).

Basically, the physical systems of the ocean observation are highly specialised in a specific oceanic phenomenon that can be divided into two events, namely the low bandwidth events such as observations of slow biogeochemical phenomena, and high bandwidth events such as ultrasonic biological sources. The physical platforms for the observation system can range from networks of autonomous underwater vehicles, remotely operated vehicles, vertical profilers, surface vessels, unmanned aerial vehicles and buoys. These platforms can provide offline and online data. The data are collected by the data acquisition system and will then be processed in order to prepare the data for digital transmission.

Enormous benefits can be acquired through the implementation of the ocean observation system as this system will support and enhance the efforts in:

i. improving the health of the oceans;
ii. protecting human lives and livelihoods from marine hazards;
iii. supporting defence and security systems;
iv. measuring and predicting environmental changes;
v. providing for the sustainable use, protection and enjoyment of ocean resources;
vi. providing a scientific basis for implementation and refinement of ecosystem-based management;
vii. tracking and understanding climate change and the ocean's role in it; and
viii. supplying important information to ocean-related businesses.

Figure 1: Typical anchor and buoy-mounted measurement devices for ocean observation

MIOOS AIMS

The in-situ data when combined with satellite data enable a more holistic condition of the aquatic or oceanic zones to be modeled and determined. Sustaining the project will allow identification and management of climate change in the coastal marine environment. It will also provide the observations necessarily for better understanding and forecasting of the fundamental connection between the coastal biological processes and the regional or oceanic phenomena that influence biodiversity. The observation system presented here represents a new way for integrated observations of the targeted zones. MIOOS aims to enable and execute a number of basic and applied ocean-related scientific studies. Amongst others, MIOOS serves to gather data for:

i. Episodic large scale events
ii. Episodic small spatial and temporal scale events
iii. Large noise that signal variables
iv. Filling gaps
v. Legacy science information.

MIOOS ARCHITECTURE

The availability of a fleet of underwater robotic platforms, together with the fixed system (buoy), makes MIOOS flexible and robust enough for a multitude of ocean-based measurement and monitoring requirements. This fleet of underwater robotic platforms consists of:

i. Intelligent Hybrid Underwater Vehicle(IHUV)
ii. Underwater Glider Platform
iii. Mini Remotely-Operated Vehicle (ROV)
iv. Autonomous Surface Vessel (ASV)
v. Drosobots (Micro-ASVs with multi-agent applications)
vi. Blimp (Communication Hub).

The research and development efforts for all the underwater robotic platforms were conducted in the Underwater Robotics Research Group (URRG) lab in Universiti Sains Malaysia (USM). MIOOS will also make use of the existing sensor development capability for much better sensing modules and instrumentation suited to the Malaysian maritime eco-systems. The real-time data acquisition will be further enhanced by a built-in intelligent system, whereby a number of data pre-processing and analysis can be done prior to the final decision-making process. The processed data can also provide a better insight on the current oceanic or coastal conditions.

Investigations on the sustainability of the marine eco-system will be enhanced by the installation of MIOOS with its associated capabilities. MIOOS will also be utilised for a number of specific eco-system based studies, and these will be utilised as a proof of concept for its viability and feasibility over a wider usage.

Figure 2: Underwater robotic platforms for ocean observation
(a) Mini Remotely-Operated Vehicle (ROV), (b) Drosobots, (c) IHUV, (d) Blimp, (e) ASV, (f) Glider

IMPLEMENTATION PROGRAMME

The research challenges consist of hardware, software and integration issues. The tasks of developing these platforms are in line with the government's effort for national capacity building, self-reliance, knowledge creation and also highly potential wealth generation goals. Figures 3 and 4 show the complete setup of MIOOS.

The proposed project is divided into three stages. Stage 1 consists of three major components involving platform improvement for existing mobile platforms, the design and development of stationary observation nodes and the development of land-based monitoring and database. The first two components will be tested rigorously through controlled lake and sea tests. The tests conducted will enable detailed performance criteria to be determined. The information will be used to improve and upgrade all the available sub-modules.

In Stage 2, all three components in Stage 1 will be integrated to form an observation system prototype. The major key in this integrated observation system is the wireless communication between sub-modules within each component, data acquisition from the mobile platform to stationary nodes, and the pre-processed data transmission from multiple stationary nodes to land-based monitoring and database. At this stage, dedicated eco-system studies will be conducted and matched to the most suitable platform or group of platforms. A series of tests and further refinement of the dedicated platform will be conducted. The system criteria will be fitted into field applications. Relevant sensor modules will also be tested and further optimised. The land-based monitoring and database centre will be tested for real-time data acquisition, analysis and visualisation. Most research activities occur at this stage of the research.

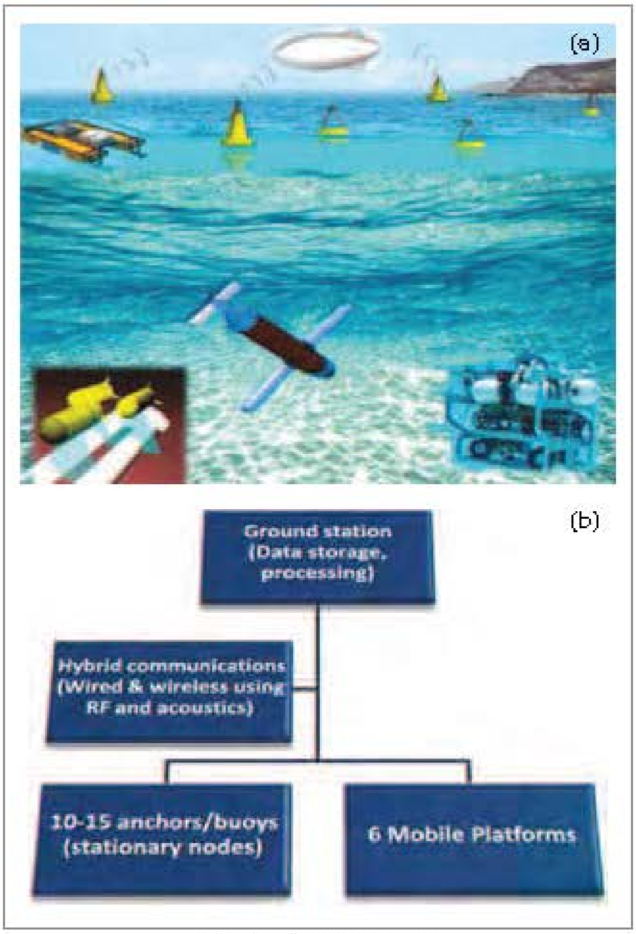


Figure 3: MIOOS Application
(a) Concept, (b) System Components

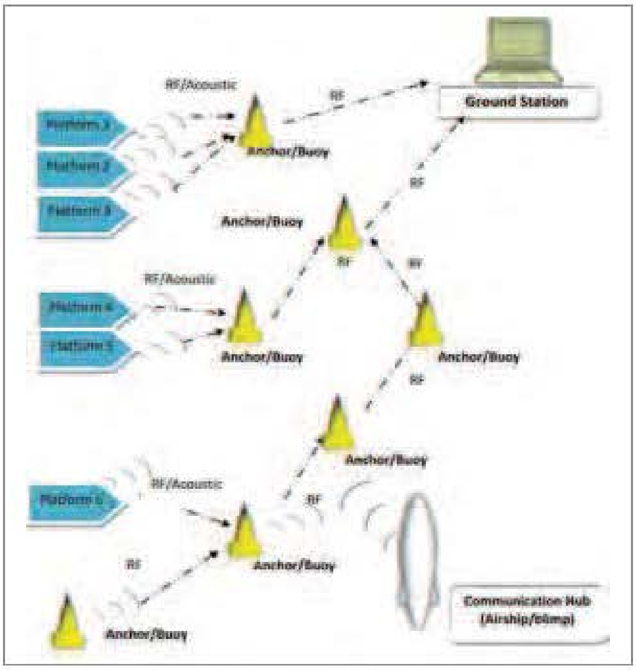


Figure 4: The Complete Setup of MIOOS

Finally in Stage 3, the optimised integrated ocean observation system will be ready for actual industrial application and market identification.

FUTURE PLANS AND FURTHER DEVELOPMENT

Starting from early 2012, the testing period will be used to evaluate the MIOOS setup in a dedicated eco-system where several studies will be done and matched to the most suitable platform or group of platforms. A series of tests and further refinement of the dedicated platform will be conducted. Subsequently, the system criteria will be fitted into field applications. Meanwhile, the relevant sensor modules will also be tested and further optimised. The main control and command centre will be tested for real-time data acquisition, analysis and visualisation. ■

REFERENCES

[1] Muzathik, A.M., Wan Nik, W.B., Samo, K.B. & Ibrahim, M.Z. (2011); *"Ocean wave measurement and wave climate prediction of Peninsular Malaysia"*. Journal of Physical Science, 22(1), 79-94.

[2] Khalid, B.S., Aziani, A., Suzuri, H., Sulaiman, O., & Azizi, A. (2010); *"Underwater noise generated by ferries, boats and dredger at a typical jetty of Terengganu, Malaysia"*, Proceedings of the "3rd. Int'l Conf. on Underwater System Technology: Theory and Application 2010", 1-2 Nov. 2010, Cyberjaya, Malaysia.

[3] Muzathik, A.M., Wan Nik W.B., Ibrahim, M.Z., Samo, K.B. (2008); *"Ocean Wave Energy Potential and Extraction Technologies"*, The 6th. Regional Conference on Marine Technology (MARTEC 2008), 26-27 Aug. 2008, Universitas Indonesia, Jakarta, Indonesia.

[4] Nowlin Jr., W.D. (1999); "A strategy for long-termocean observations", Bulletin of the American Meteorological Society 80-4: 621-628.

[5] F.A. Ian, P. Dario and M. Tommaso (2005); "Underwater acoustic sensor networks: research challenges", Ad Hoc Networks, (3), 257-279.

Links: http://urrg.eng.usm.my/

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En. Khalid Isa graduated from the Universiti Teknologi Malaysia, in 2001 with a BSc in Computer Science. He then pursued his MSc in Computer System Engineering at the Universiti Putra Malaysia, graduating in 2005. Since then, he has been working at the Universiti Tun Hussein Onn Malaysia (UTHM), as a full-time lecturer. Currently, he pursuing his PhD in Electrical and Electronic Engineering at Universiti Sains Malaysia (USM), in a field of Computational Intelligence. He has been with the Underwater Robotics Research Groups (URRG) USM from December 2010. His research interests are computational intelligence, image processing, control and autonomous system.

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