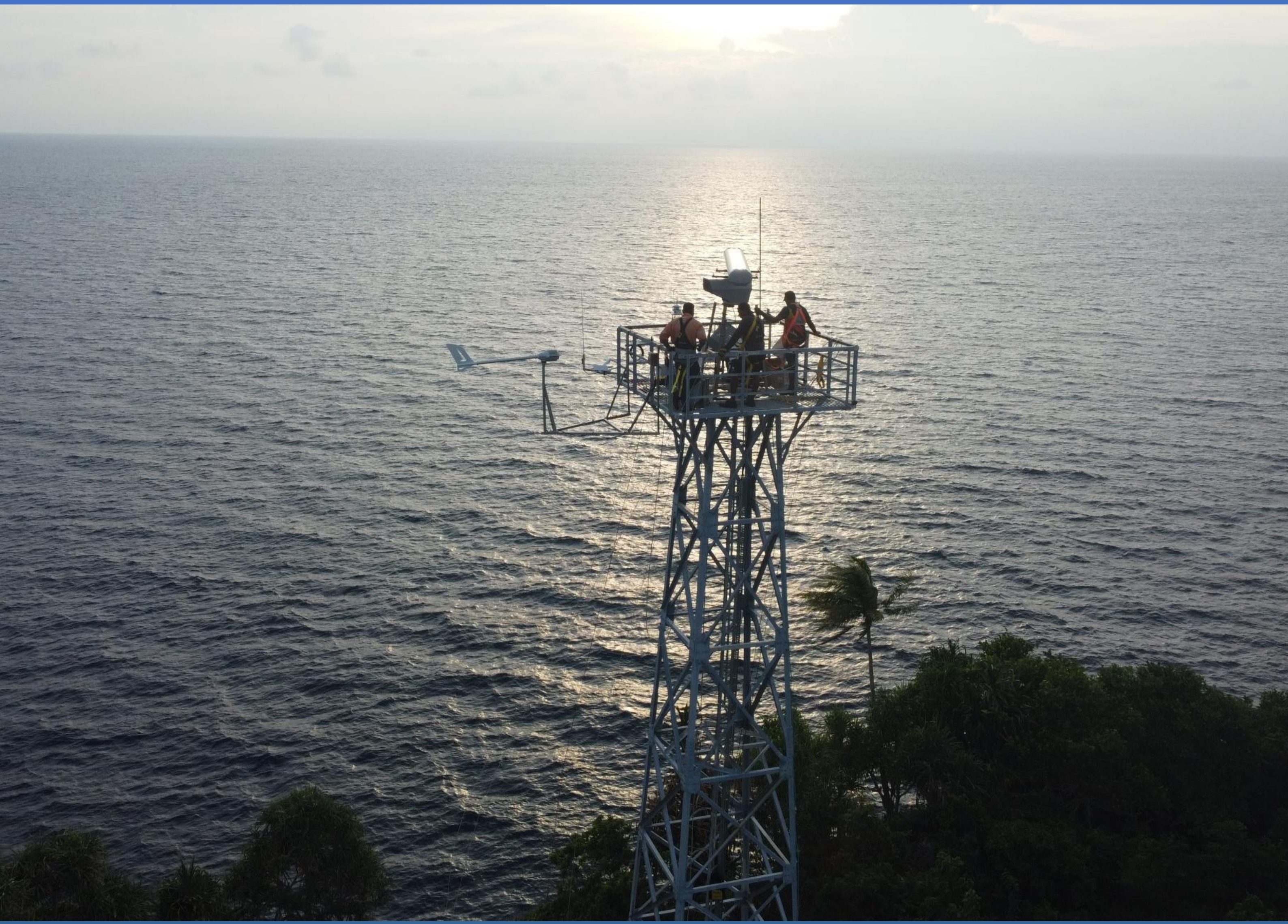
WHITE PAPER

Design and Installation of a System to increase Maritime Safety, Surveillance and Doman Awareness in Papua New Guinea



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Contents

Introduction

The 'National Maritime Safety Authority (NMSA)' of 'Papua New Guinea (PNG), through the 'Asian Development Bank (ADB)' funded 'Maritime and Waterways Safety Project (MWSP)', sought to develop a maritime monitoring and surveillance system to improve maritime safety, reduce environmental risk related to shipping, and to increase domain awareness throughout its coastal waters.

'With over 600 islands spanning a total sea area of 3.1 million square kilometres and 65% of its population residing in in coastal areas, Papua New Guinea (PNG) relies heavily on its network of coastal shipping services. Passenger and cargo services allow citizens to access health, education and other services essential for inclusive growth' (https://www.adb.org/projects/44375-013/main).

Likewise, due to its geographical location, there is a network of well-established, heavily trafficked international shipping lanes between Asia and Australasia passing through PNG's coastal waters. Shipping through these lanes consist of both vessels on international transit and international cross-over operators.

The complexity and volume of shipping is further complicated by the presence of shipping lanes in pristine marine environments, which presents significant risk to the marine environment unless hazards are well marked and there is a capacity to monitor and respond to potential incidents. This is especially evident in areas like the Jomard Entrance, which is a navigable strait in the Milne Bay Province, where the convergence of north and south bound international shipping poses considerable risk of impact on the marine environment. The level of risk in that location prompted PNG to successfully lobby for the area to be designated a 'Particularly Sensitive Sea Area (PSSA)' by the 'International Maritime Organization (IMO)', one of only seventeen (17) worldwide.

At the advent of the MWSP project there was no operational network of infrastructure through which NMSA could monitor shipping through PNG coastal waters. Coastal stations previously installed were no longer serviceable due to a number of contributing factors. The need to re-introduce such a system was responded to through the 'Automatic Identification System (AIS) Coastal Network Extension and Base Station Installation' project, which provided the scope for the replacement and installation of a series of new AIS coastal stations in strategic locations around PNG.

The bidding process for this contract commenced in December 2018, and was officially awarded to Vissim AS, of Norway, in June 2019. The contract was signed in September 2019, at which time the design process commenced.

The PNG AIS Coastal Station Project

The scope of the contract required Vissim to design, install and commission a series of fifteen (15) x AIS Coastal Stations in locations around PNG's coastlines. These AIS Coastal Stations were to be designed to suit the operating conditions in remote, aggressive marine environments and to collect AIS signals from vessels within range, and reliably transmit that data to a central 'Vessel Monitoring Centre (VMC)' to be established at NMSA headquarters in Port Moresby.

Vissim partnered with M-NAV Solutions, a specialist Aids to Navigation (AtoN) product and service provider, who have extensive experience in remote site works and the design and operation of AtoN in the Asia Pacific Region, including PNG.

The complex requirements of the project and the remoteness of the coastal station sites presented several unique technical challenges that could not be met by off-the-shelf equipment. As such, Vissim and M-NAV developed a concept design for an AIS Coastal Station system to meet these challenges and ensure equipment performed in difficult and remote environments with a high level of reliability. Some of the key issues were the;

(i) Extreme remoteness and difficulty of access for many of the sites,
(ii) Lack of a reliable power supply to power and operate the electronics with a high level of availability, and
(iii) Tropical conditions, particularly the high heat and humidity, in which the electrical equipment would need to operate.

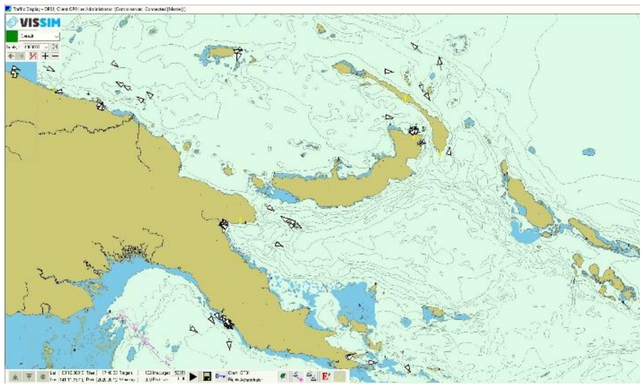
These issues were addressed in the selection of a modular, lightweight, durable telecommunications enclosure for housing of the AIS base station and other electronics. The modular nature of the enclosure allowed for transport to difficult-to-access sites by helicopter and for ease of installation on site.

A fully autonomous power supply, incorporating solar panels and an internal battery bank, was designed based on providing a minimum of 10 x days autonomy, ensuring that the coastal stations would continue to operate even during extended periods of inclement weather or low sunlight.

The enclosures were also designed to allow cooling through efficient natural airflow and ventilation, avoiding the use of power-hungry air-conditioning whilst still ensuring operating temperatures inside the cabinet were optimally maintained.

An innovative method of ground mounting was also incorporated, using specially engineered ground anchors to ensure the coastal station could be installed with a high level of stability, regardless of the ground conditions. This allowed Vissim and M-NAV to avoid the use of concrete foundations, which would have required mobilization of a large volume of materials to site and increased the risk of environmental impact.

Installation of the fifteen (15) x AIS Coastal Stations was successfully completed over a 7-month period between March and September 2020.



Communication links between the remote sites and the VMC were critical, and the majority of sites were connected to the Telikom system, allowing for transmission of data through a country-wide network leased by the NMSA. AIS Coastal Stations were co-located on Telikom sites, with enclosures ground-mounted adjacent to Telikom structures, and VHF antennas installed at the top of the towers for maximum elevation and coverage.

For sites where Telikom networks were not available, BGAN satellite terminals were used, to provide high-performance, reliable connectivity.

After completion of site installations, the VMC was installed and commissioned. Networks were configured for the reliable transmission and receipt of data from all remote AIS Coastal Stations into the VMC servers, where it was received, processed and made available for intuitive display on the Vissim VTMS software platform.

A dedicated server room was used for the controlled storage of the redundant servers, power distribution system and a rack mounted UPS system designed to provide several hours of back-up power in the event of power failures. The central VMC room was designed to incorporate 2 x operator work stations and 1 x supervisor work station. Each work station consisted of 3 x LED display screens and a PC networked to the AIS servers. A multi-screen LED wall was also installed, consisting of 8 x 50" LED screens, providing a geographical overview of PNG coastal waters, displaying all AIS targets within range of coastal stations. This large multi-screened wall display provides operators a snapshot of vessel traffic activity throughout the country, allowing them to check locations or vessels in more detail at their operator stations when needed.

At the completion of the project, the NMSA now have a system whereby they can monitor shipping on a 24/7 basis, both domestic and international, through the majority of PNG's coastal waters, with data collated from the network of remote AIS Coastal Stations, from a central monitoring location at NMSA headquarters. This provides a significant increase in the NMSA's capacity to carry out monitoring and surveillance, which increases an understanding of activity within PNG's coastal waters (both real-time and historical) and vastly improves maritime safety, search and rescue and incident response, and protection of the marine environment. Access to real time information and historical data will also allow inter-agency and inter-departmental cooperation with other sectors of the PNG government, to provide additional support for defence, security, customs, maritime border awareness, fisheries surveillance and law and order.

The focus on using fit-for-purpose enclosures, where robust, high quality marine electronics can be operated in stable, controlled conditions, powered by autonomous renewable power supplies, ensures the system is reliable and operates with high availability levels.

The success of the project and the enhanced capacity it provides in delivery of their mandate of the management of maritime safety, prompted NMSA to look at the possibility of upgrading other critical infrastructure and integrating it into the same system, namely the Tuam Island and Jomard Island Coastal Monitoring Stations (CMS).

The CMS Upgrade Project

The Tuam and Jomard Island CMS sites were installed by the NMSA in 2014 – 2015. The CMS locations were chosen due to their proximity to major international shipping routes in PNG waters.

Tuam Island is located in Morobe Province, on the east side of the Vitiaz Strait, which is a heavily trafficked shipping lane for both domestic and international shipping.

The location of the CMS at Jomard Island was particularly important, as the Jomard Entrance is a critical convergence point for vessel traffic through PNG waters, to and from Asia and Australia. The designation by the 'International Maritime Organization (IMO)' of the Jomard Entrance as a 'Particularly Sensitive Sea Area (PSSA)' made the requirement for monitoring and traffic management even more critical. The IMO define a PSSA as a "an area that needs special protection through action by IMO because of its significance for recognized ecological or socio-economic or scientific reasons and which may be vulnerable to damage by international maritime activities". Th designation of the Jomard Entrance as a PSSA allowed PNG, via an IMO mandate, to introduce mandatory ship routing measures as a means of controlling and regulating traffic on both the northern and southern approaches.

However, the effectiveness of such measures is restricted to the level of compliance by vessels, and the Jomard Island CMS provided the most effective means of monitoring vessels and gathering data with which to pursue vessels that do not comply.

The original sites were equipped with a number of data acquisition technologies, including radars, AIS base stations, CCTV cameras and weather stations. Communication links were established through installation of large satellite dishes on site, facilitating transmission of the data to a monitoring centre at NMSA headquarters in Port Moresby. Due to the remote nature of the sites, the system was designed to be powered by solar and battery systems, with some supplemental power supplied by wind turbines.

The sites were successfully installed and operated as required for an extended period. The concept proved successful, however the technical trade-offs required to meet the site related challenges meant some operational issues were been experienced.

These included the need to choose very low power consumption radars with limited radar performance across the entire spectrum, providing some limitations to range and target identification and tracking and the need to use very low-resolution CCTVs to meet the size restrictions of the satellite link.

The sites operated for several years, but due to lack of maintenance, the age of power supplies, and issues identifying a suitable satellite communication provider, the sites eventually stopped operating.

The success of the concept however, provided an opportunity for NMSA for improvement and upgrading. Advancements in the technology that the CMS sites initially used have been significant, providing the possibility for better performance, lower power consumption and smaller communication links.

As such, during the implementation phase of the PNG AIS project, NMSA requested Vissim to explore the possibility of rehabilitating and upgrading the CMS sites. This process eventually led to a formal direct contracting to Vissim and their subcontractor, M-NAV Solutions, for the design, supply and installation of the Tuam and Jomard Island CMS upgrades.

The complex requirements of the project, the range of sensors needed and the extremely remote and difficult-to-access natures of the sites presented serious technical challenges that required an experienced approach to the site design. Some of the key issues were;

(iv) Extreme remoteness and difficulty of access for many of the sites and the need to manually carry all equipment to site.

(v) Lack of a reliable power supply to power and operate the electronics with a high level of availability.

(vi) Tropical conditions, particularly the high heat and humidity, in which the electrical equipment would need to operate.

(vii) Selection of an economic and appropriately sized method of satellite transmission for large amounts of data.

These issues were similar to those experienced and successfully addressed in the PNG AIS project and as such a similar approach was taken – by installing equipment and power supplies in modular, lightweight, durable telecommunications enclosures. Due to the amount of equipment to be utilised on the CMS sites, a different selection of cabinet sizes was chosen. The modular nature of the enclosure allowed for manual handling and transport between vessels, the shoreline, and transport to site.

The power consumption of the CMS systems was calculated to be approximately thirty (30) times more than the AIS Coastal Stations and the power supply was designed based on an analysis of historical wind and solar irradiation data. An

autonomous hybrid power supply was designed, incorporating both solar panels and a wind turbine powering a large internal battery bank. The system was designed with enough autonomy to ensure the sites would operate reliably even during extended periods of inclement weather or low sunlight.

The enclosures were designed to allow cooling through efficient natural airflow and ventilation, with fans placed in optimum locations to ensure circulation and regulation of temperatures inside the cabinet.

The actual rehabilitation phase site works commenced in November 2021 and were complete after 4 weeks. NMSA and the Vissim / M-NAV installation team were based aboard a liveaboard survey vessel for the duration of the site works, with over fifteen (15) tonnes of equipment stored and transported on three different vessels.

All equipment was manually transferred from vessel to shore and local communities and resource owners were engaged to assist with transportation of the equipment to site.

Communication links between the CMS sites and the VMC was critical, with satellite communication the only option. The provision of the final satellite communications was outside the scope of the Vissim contract and were installed separately by a contractor engaged directly by NMSA. Site layout required careful consideration and the CMS enclosures were installed in locations to optimize solar gain and to avoid shading, yet close enough to the structures where the VHF antennas, weather stations, CCTV and radars were installed on the top platforms. Locations also took into consideration the position of the satellite dish foundation and the required cable runs.

Whilst site works were completed in 2021, delays in the procurement of the satellite communications meant that the satellite links were not commissioned until March 2022. Once links were established, the final configurations and calibration of the sites and the VMC was undertaken.

The existing servers were reconfigured with additional software modules, now providing NMSA operators a suite of new monitoring and identification methods at both Tuam and Jomard, including:

- The viewing and interrogation of all AIS targets,
- Viewing of radar targets, which the software platform automatically integrates with visible AIS targets,
- Visual identification and tracking of vessels through the Jomard Passage, via the CCTV,
- Real-time information on weather conditions, including wind speed, temperature, humidity, precipitation, air pressure and visibility,

- VHF radio capabilities, including the ability to scan and monitor a range of VHF channels, and to communicate directly with vessels, and;
- The ability to remotely monitor the status of the site power supplies, including solar charging levels, battery voltages and equipment power consumption.

Integration of the CMS data into the existing VMC has resulted in a major enhancement of the NMSA's ability to monitor and carry out surveillance in PNG waters, and in particular, vessel activity in 2 new locations where the complexity and volume of vessel traffic creates significant risk.

In the case of the Jomard Entrance, it will allow the NMSA to study whether vessels are complying with the mandatory routing measures stipulated by the IMO as part of their designation of the area as a PSSA. Access to data will also allow the NMSA to further lobby the IMO for additional protection measures if they are deemed needed.

The data from the CMS sites will also increase cross-agency and government departmental cooperation in protection of PNG's sovereign interests in the maritime domain.

Furthermore, the flexibility of the system allows for the addition and integration of additional sites which will allow the NMSA to focus on installing infrastructure in locations where a lack of coverage is identified or the level or risk identifies that additional monitoring, surveillance and response is required.

The overall design, particularly the site enclosures and choice of high-quality equipment, can be easily adapted to meet any technical requirements or site conditions, and forms the basis of a system that can be operated remotely, cleanly and reliably from a central location.

Suitability of Concept for the Asia Pacific Region

System Design

In a region where maritime transport is so critical, the need for systems to improve maritime safety, for marine surveillance and monitoring or for better management of shipping is undeniably important.

The capabilities, performance and reliability of those systems should be based on a carefully managed design process, which takes into account all factors that will impact both performance and reliability.

The actual capabilities of systems should firstly be designed to respond to the end-user's requirements. Whilst those requirements are often understood by governments and/or their designated safety authorities, there are still several key issues that should be considered in early-stage system design. These include, but are not limited to;

- Domestic or inter island shipping patterns, particularly in smaller Pacific Island Countries where small island communities are serviced by ferries, cargo or passenger vessels or small craft. This includes an analysis of the most prevalent communication systems on vessels.
- An analysis of international shipping lines that transit through territorial waters, including identification of the volume of shipping, the types of vessels, the nature of the transit and the cargoes carried. This analysis should identify the potential risk of shipping related incidents and the navigational situation under which they might occur.
- An assessment of the presence of pristine environments, natural or man-made navigational hazards and the risk of environmental impact that is associated with shipping activities.
- A review of the history of shipping related incidents.
- Inclement weather patterns and natural disasters and the impact they have on maritime safety.

The above process will allow experienced professionals to identify the core elements of a suitable system, including a concept layout, the identification of locations for a central monitoring / control centre and selection of the core technologies that are required. At this conceptual stage, it is possible to state the capabilities that the system will offer the end-user.

This then allows for a more detailed design process. The Asia Pacific region poses numerous unique challenges that can impact the performance and suitability of these systems. Extreme remoteness and geographical layout can affect range and performance of monitoring technologies and propagation modelling should be carried out based on actual conditions, in order to identify the extent of coverage. Heat and humidity also present a major danger to the operation of remote sites and marine electronics, which is not always understood by manufacturers and suppliers. Equipment must be carefully chosen based on its operating parameters, and as can be seen by the PNG AIS and CMS case studies, the enclosures or method of storage have to be carefully selected to ensure operating temperatures are maintained, humidity is controlled and that there is a stable, reliable power supply that has been designed to suit the site conditions. Modern satellite communications provide numerous options for the transmission of data, and the most suitable can be chosen once the system design and layout is established.

At this stage, the design is progressed to a point that it can accurately costed and the most appropriate means of implementation identified.

This is the process by which the NMSA's MWSP projects were implemented, with the end result being a highly reliable, functional, country-wide monitoring and surveillance system that is administered and managed from a central location at the NMSA's headquarters.

Not all countries have the amount of coastline, ocean area and shipping volume that PNG has, and many smaller Pacific Island Countries have very different and unique challenges. Systems do not need to be unnecessarily complex – when not needed – but they should always respond to the requirements.

An Example Scenario

An example scenario for a monitoring and surveillance system for a smaller Pacific Island Country that wishes to improve maritime safety (via communication and vessel monitoring) for domestic inter-island shipping could be as simple as a series of remote AIS Coastal Stations (similar to those examined in this white paper) on outlying islands, with a central monitoring station at the authority headquarters, allowing for tracking of inter-island vessel movements between remote island communities via AIS. At the same time, depending on international shipping lanes, it may allow for the monitoring of international vessel traffic.

The installation of appropriate satellite terminals on those remote AIS Coastal Stations would facilitate reliable transmission of data. Any coverage gaps related to distance could be supported by the inclusion of a 3rd party satellite AIS subscription, however that also requires an analysis of the carriage of appropriate AIS equipment on board smaller, non-SOLAS vessels.

Other system additions are again dependent on the end-user requirements. For example, domestic vessels navigating the routes to be monitored can be fitted with the correct AIS technology to ensure full integration. The system could also be designed to include the ability to communicate over VHF from the central monitoring location. Marine AtoN could also be integrated into the system, via the installation of appropriate marine lanterns on coastal stations, fitted with satellite monitoring, allowing authorities to remotely monitor the status of those AtoN.

As reiterated, any design should be focused on responding to the main requirements, then tailored according to local conditions. The above example scenario is just that, an example, and some navigational environments may necessitate a more complex system, including the use of other surveillance technologies such as radar, CCTV or weather monitoring.