



Pacific  
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# Pacific Safety of Navigation Project

## Risk assessment for Malakal Harbour, Palau



November 2019



IFAN



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Geoscience, Energy and Maritime

# Pacific Safety of Navigation Project: Risk assessment for Malakal Harbour, Palau

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Geoscience, Energy and Maritime Division, Pacific Community



November 2019

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Original text: English

Pacific Community Cataloguing-in-publication data

Kumar, Saleshe

Pacific safety of navigation project: risk assessment for Malakal Harbour, Palau / Saleshe Kumar, Epeli Waqavonovono and Francesca Pradelli

1. Navigation – Palau.
2. Navigation – Safety measures – Palau.
3. Anchorage – Palau.
4. Harbors – Anchorage – Palau.
5. Harbors – Safety regulations – Palau.
6. Harbors – Risk assessment – Palau.
7. Transportation – Safety – Palau.
8. Transportation – Law and legislation – Palau.

I. Kumar, Saleshe II. Waqavonovono, Epeli III. Pradelli, Francesca IV. Title V. Pacific Community

387.109966

AACR2

ISBN: 978 982 00 1180 9

Prepared for publication at SPC's Suva Regional Office, Private Mail Bag, Suva, Fiji, 2019

[www.spc.int](http://www.spc.int)

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## Executive summary

Palau is a signatory to the International Convention for the Safety of Life at Sea (SOLAS), of which Chapter V Regulation 13.1 requires the contracting governments to provide “such Aids to Navigation (AtoN) as the volume of traffic justifies and the degree of risk requires.”

Palau is one of the 13 targeted Pacific Island countries and territories of the Pacific Safety of Navigation Project implemented by the Pacific Community (SPC) and funded by the International Foundation for Aids to Navigation (IFAN), whose aim is to improve safety of navigation in the Pacific region through enhanced AtoN capacity and systems.

During Phase 1, in 2017, the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) and SPC developed the simplified IALA risk assessment tool (SIRA), a simple qualitative tool to enable smaller states to meet their international obligation of providing AtoN by conducting waterways risk assessments.

In May 2019, during Phase 2 of the project, the Palau government identified Malakal Harbor as a priority area for SPC to conduct a risk assessment using the SIRA tool. This report details the risks identified, the estimated costs in the event of an incident, and suggested risk control options and their costs.

Malakal is the major harbor in Palau and was, therefore, identified by the Ministry of Public Infrastructure, Industries and Commerce as a priority for the risk assessment. Within Palau, the regulatory aspect of AtoN falls within the Bureau of Commercial Development, Ministry of Public Infrastructure, Industries and Commerce. The Department of Port State and Navigation within the Division of Transportation looks after the operational and maintenance aspects of AtoN in the major channels.

Malakal Harbor consists of an international and domestic wharf. The main entrance to the wharf is through the east and west passages. There are currently a number of AtoN in and around the harbor. In Palau, the responsibility to provide and guarantee AtoN service is somewhat fragmented and is divided between the national and regional governments. While Palau has adopted the IALA system A for all buoys and beacons along the main channels, there are many AtoN in and around Palau that are not in conformance with the IALA system.

Palau’s maritime stakeholders identified six scenarios for Malakal Harbour: two collision scenarios (one for state boats in the main shipping channel, and one for local boats in the boating channel), and three grounding scenarios (one for container ships at the west entrance passage, one for passenger vessels at the marine protected area area at the east passage, and one for tugboats towing barges in the main shipping channel). One allision scenario was identified for local boats alliding with AtoN in the shipping and boating channels.

For each scenario in each area, the cost of the incident was estimated and a risk score was given, taking into account the probability of the incident happening and its potential impact on the country. Risk control options were then identified. The risk scores for the scenarios under the current situation were then compared with the new risk scores if the risk control options were put in place.

Scenario	Risk score	Risk control option	New risk score
Collision between two state boats at night in the main shipping channel	15	Installation of new IALA-compliant AtoN in the main shipping channels	5
Collision between two local boats in the boating channels	12	Installation of new IALA-compliant AtoN in the boating channels	4
Grounding of container ship at the west entrance passage	20	Installation of new IALA-compliant AtoN in the main shipping channels	5
Grounding of passenger vessel in the marine protected area at the east passage	20	Installation of new IALA-compliant AtoN in the east passage	5
Grounding of tugboats towing barges through the west passage	9	Installation of new IALA-compliant AtoN in the west passage	3
Collision of local boats with AtoN	8	Installation of new IALA-compliant AtoN and small boat safety awareness programs	4

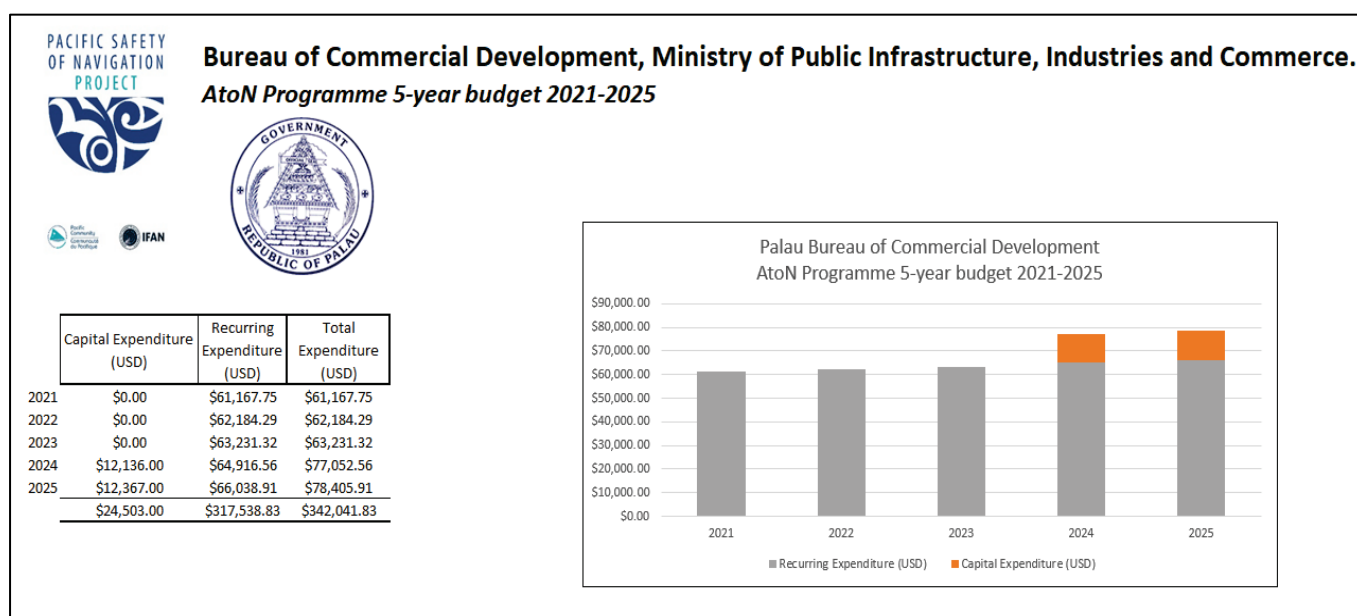
The main outcome of the risk assessment process in Malakal Harbor was six recommendations that aim to reduce the risks to safety of navigation to an acceptable level for stakeholders. To address all of the recommendations, a total cost estimate<sup>1</sup> was provided by the Bureau of Commercial Development for the installation and refurbishment of all AtoN in the main shipping lanes and boat passages. The recommendations and costs of their implementation plus the maintenance of the AtoN are outlined below.

Recommendation 1	Amount (USD)
To reduce the risk of collision of two local state boats at night in the main shipping channel, it is recommended that IALA-compliant AtoN be installed in the main shipping channels	1,943,100.71 <sup>1</sup>
<b>Recommendation 2</b>	
To reduce the risk of collision between two local boats in the boating channels, it is recommended that IALA-compliant AtoN be installed in all boating channels	
<b>Recommendation 3</b>	
To reduce the risk of a container ship grounding at the west entrance passage, it is recommended that IALA-compliant AtoN be installed in the west channel	
<b>Recommendation 4</b>	1,943,100.71 <sup>1</sup>
To reduce the risk of a passenger vessel grounding in the marine protected area around the east passage, it is recommended that IALA-compliant AtoN be installed in the east channel	
<b>Recommendation 5</b>	

<sup>1</sup> Cost estimate for the installation of new navigational buoys.

To reduce the risk of a tugboat grounding in the west passage while towing a barge, it is recommended that IALA-compliant AtoN be installed in the west channel	
<b>Recommendation 6</b>	
To reduce the risk of local boats colliding with AtoN, it is recommended that IALA-compliant AtoN with day boards and lights be installed, and that a small boat safety awareness programme for all boating personnel be carried out	
<b>Maintenance cost<sup>2</sup></b>	57,155.03

As part of the Pacific Safety of Navigation's work on supporting Palau's Ministry of Public Infrastructure, Industries and Commerce, a five-year AtoN programme budget plan for the safe navigation for the whole of Palau was drawn up. The budget plan includes both capital and recurring expenditures.



<sup>2</sup> The cost of maintenance for AtoN is estimated at 5% annual of the initial cost of purchase.

# 1 Background

In early 2016, with support from the International Foundation for Aids to Navigation (IFAN), the Pacific Community (SPC) started the Pacific Safety of Navigation Project in 13 Pacific Island countries and territories (PICTs).<sup>3</sup> The project aims to improve safety of navigation in the Pacific region through enhanced aids to navigation (AtoN) capacity and systems, and hence supports economic development, shipping and trade in the Pacific region through safer maritime routes managed in accordance with international instruments and best practices.

During Phase 1, which ended in July 2018, SPC worked in close collaboration with the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) to conduct technical, legal and economic assessments in the 13 PICTs to identify needs and gaps in these areas. Another significant output of Phase 1 was the development of a new tool for risk assessment in small island developing states, the simplified IALA risk assessment tool (SIRA). In June 2018, IALA trained personnel in 12 of the 13 PICTs on the use of SIRA to conduct AtoN risk assessments in their countries.

Phase 2 of the project builds on the Phase 1 assessments and tools developed to further assist in building capacity to develop and maintain AtoN in PICTs. Activities include conducting risk assessments (as required by Regulation 13 of the International Convention for the Safety of Life at Sea – SOLAS); developing safety of navigation policy and a legal framework; improving budgetary management; and supporting regional coordination related to safety of navigation in the Pacific.

In June 2019, Palau's Ministry of Public Infrastructure, Industries and Commerce invited SPC to assist with conducting a risk assessment of Malakal Harbor where the country's main port is.

The ministry also requested SPC to conduct a field survey to position all of the AtoN around Koror Island to the IALA standard. A field survey was organized by the chief of Port State and Navigation to position all its critical AtoN around Koror Island. SPC – together with the Chief of Port State and Navigation and his team – surveyed the positions of all AtoN in the main shipping lanes and major passes around Koror from 3 to 8 June 2019. A survey grade GNSS GPS<sup>4</sup> (with Fugros MarinStar G2 subscriptions) was installed on the Port State Navigation vessel during fieldwork. In total, 217 AtoN were positioned during the week. The report on buoy positioning is available separately from this SIRA report.

This report describes the risk assessments that were carried out using the SIRA methodology.

Palau is an independent state consisting of 340 islands within 16 states. Of the total population of 17,000, approximately 70% is concentrated in Koror State. Palau is a maritime nation, with a large percentage of its citizens working in the maritime industry or related fields. Shipping is critical to the economic and social welfare of the people of Palau, and safe navigation is vital to secure this welfare and to protect the environment.

Palau is a signatory to a number of conventions and protocols of the International Maritime Organization (IMO) including: Safety of Life at Sea (SOLAS); Collision Regulations (COLREGS); Standard for Training, Certification and Watchkeeping (STCW); Maritime Pollution (MARPOL); and Suppression of Unlawful Acts (SUA).

Regulation 13 of Chapter V of the 1974 SOLAS Convention (as amended) states that “each Contracting Government undertakes to provide, as it deems practical and necessary either individually or in

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<sup>3</sup> Cook Islands, Kiribati, Federated States of Micronesia, Marshall Islands, Nauru, Niue, Palau, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu and Vanuatu.

<sup>4</sup> GNSS = global navigation satellite system; GPS = global positioning system



cooperation with other Contracting Governments, such aids to navigation as the volume of traffic justifies and the degree of risk requires.”

The SIRA risk control process comprises five steps that follow a standardised management or systems analysis approach:

1. Identify hazards
2. Assess risks
3. Specify risk control options
4. Make a decision
5. Take action.

SIRA is intended as a basic tool to identify risk control options for potential undesirable incidents that Palau should address as part of its obligation under SOLAS Chapter V Regulations 12 and 13. The assessment and management of risk is fundamental to the provision of effective AtoN services.

The assessment involved a stakeholder meeting as a first step, to gather the views on hazards and risks in Malakal Harbour from those directly involved with or affected by AtoN service provision. Information provided by this step was then used by Director of the Bureau of Commercial Development, Ministry of Public Infrastructure, Industries and Commerce (Mr William Hayes Moses) and the IALA level 1 AtoN manager and Chief of Port State and Navigation (Mr Levan Toktang) and SPC to complete the full risk assessment matrixes based on six identified possible scenarios for Malakal Harbor.

## 2 Description of the waterway

Malakal is the major harbor in Palau and was, therefore, identified by the Ministry of Public Infrastructure, Industries and Commerce as a priority for the risk assessment. Within Palau, the regulatory aspect of AtoN falls within the Bureau of Commercial Development, Ministry of Public Infrastructure, Industries and Commerce. The department of Port State and Navigation in the Division of Transportation looks after the operational and maintenance aspects of the AtoN in the major channels.

Malakal Harbor consists of an international and a domestic wharf. There are currently a number of AtoN in and around the harbor. The responsibility to provide and guarantee AtoN service is somewhat fragmented and is divided between the national and regional governments. While Palau has adopted the IALA system A for all buoys and beacons along the main channels, there are many AtoN in and around Palau that are not in conformance with the IALA system.

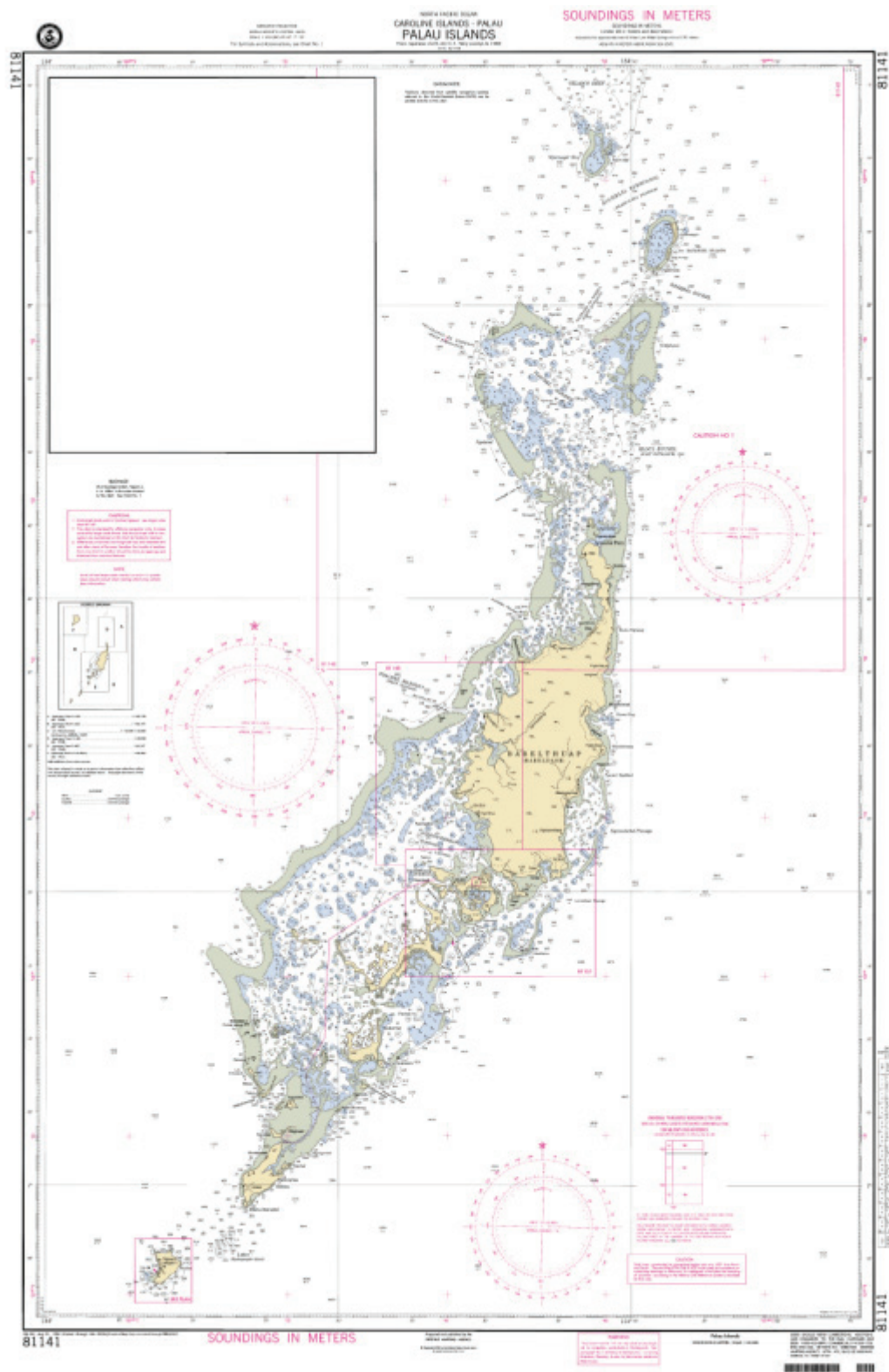
The main entrance into Malakal Harbor is through the east and west channels. The west passage from Toachel Mlengui is about 260 meters wide at the entrance, and is approximately 23 kilometres to the port, with depths ranging from 20 meters to 80 meters. Currents of 2.4 knots are typical of an incoming tide and 2.5 knots for an outgoing tide. This channel is mostly used by large vessels and tankers for the oil terminal at Bkurrengel during daylight hours only. There are several AtoN marking the channel, with the majority of them in need of urgent maintenance.

The east passage from Toachel Ra Kesebekuu is about 100 meters wide at the entrance and approximately 7 kilometres to the port, with depths ranging from 7 to 28 meters. This channel has strong currents during rising and falling tides, and is mostly used by smaller vessels.

The average predicted visibility is around 3 nautical miles (nm) but this can be reduced to 1 nm in bad weather, which typically occurs between July and October. A maximum predicted swell of 5 meter is expected during cyclones and a maximum tidal flow of 3 kt can be expected around the channel entrance during a new and full moon. There are a several hazards present from the east and west

entrances to the harbor such as narrow winding channels, unmarked shoals, a lack of AtoN, strong winds, currents, waves, and these can pose problems for maritime traffic.

Chart 81141 covers Palau Islands at a scale of 1:165,000 (Fig. 1), and chart 81148, Toachel Mlengui, covers the western passage at a scale of 1:25,000. Chart 8115, Arangel Channel and Koror Road, covers the eastern passage at a scale of 1:25,000.



**Figure 1.** Chart 81141 of Palau Islands at a scale of 1:165,000.

### 3 Stakeholder meeting

As the first step of the SIRA process, a stakeholder meeting was organized in Koror, Palau on 11 June 2019 at the Palau Aquarium conference room by Mr Levan Akitaya, Chief of Port State and Navigation, Division of Transportation, Bureau of Commercial Development, Ministry of Public Infrastructure, Industries and Commerce.

This meeting aimed at gathering the points of view of individuals, groups and organizations involved with or affected by AtoN service provision in Malakal Harbor. The stakeholder (Fig. 2) in Palau included staff from the Division of Port State and Navigation, tour operators, shipping agents, governor's office, legislators, dredging companies and others (see Annex A). During the meeting, participants were divided into two groups according to their experience and background. They then helped identify potential hazards and possible scenarios in Malakal Harbor using the latest nautical chart of the area, and other tools such as Google Earth screen shots of the area.



**Figure 2.** Stakeholder meeting in Koror, Palau.

### 4 Hazards and risks

A hazard is something that may cause an undesirable incident. Risk is the chance of injury or loss as defined as a measure of “probability or likelihood” and “severity or impact”. Examples of injury or loss include an adverse effect on health, property, the environment or other areas of value.

The purpose of the stakeholder meeting was to generate a prioritized list of hazards specific to Malakal Harbor. For the risk assessment, SPC and the Chief of Port State and Navigation, Mr Levan Akitaya, and the Director of the Bureau of Commercial Development, Ministry of Public Infrastructure, Industries and Commerce, Mr William Moses, worked together to discuss the risks associated with the identified hazards and identify risk control options and recommendations.

The list of hazards identified for Malakal Harbour is given in Annex B.

#### 4.1 Types of hazard

Twenty-five hazards were identified for Malakal Harbor that were grouped into the following six categories:

- natural hazards, such as storms, earthquakes, safe minimum depth, proximity to danger, minimum visibility, low sun angle and other natural phenomena;
- economic hazards such as insufficient AtoN funding;
- technical hazards such as system or equipment failure, quality and validity of charted information, substandard ships, and failure of communications systems;
- human factors such as crew competency, safety culture, influence of alcohol and/or drugs, and linguistic challenges;
- operational hazards such as seasonal activities, poor promulgation of maritime safety information (MSI), poor response to marking new dangers and ramp launching area; and
- maritime space hazards, such as crowded waterways and wrecks, and missing lights.

The above six types of hazards have the capability of generating seven types of losses:

- health losses including death and injury;
- property losses including real and intellectual property;
- economic losses leading to increased costs or reduction of revenues;
- liability loss resulting when an organisation is sued for an alleged breach of legal duty; such cases must be defended even if no blame is assigned. Liability losses are capable of destroying or crippling an organisation;
- personnel loss when services of a key employee are lost;
- environmental losses (negative impact on land, air, water, flora or fauna); and
- loss of reputation or status.

## 4.2 Risk factors

Any risk analysis needs to consider the range of factors that contribute to the overall risk exposure.

Table 1 lists some of the factors that should be taken into consideration when identifying hazards for waterways and ports.

**Table 1.** Risk factors relating to marine navigation.

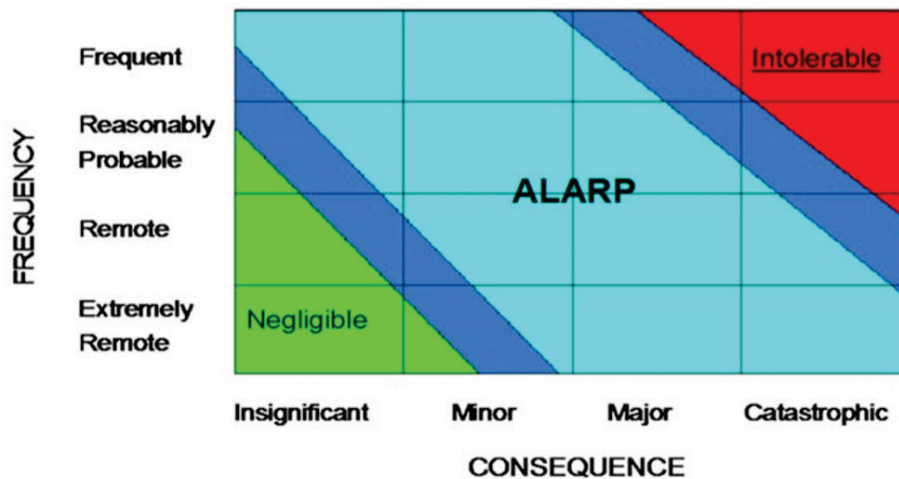
Ship traffic	Traffic volume	Navigational conditions	Waterway configuration	Short-term consequence	Long-term consequence
Quality of boats	Deep draught	Night/day operations	Depth/draft/under-keel clearance	Injuries to people	Health and safety impacts
Crew competency	Shallow draught	Sea state	Channel width	Oil spill	Lifestyle disruptions
Traffic mix	Commercial fishing boats	Wind conditions	Visibility obstructions	Hazardous material release	Fisheries impacts
Traffic density	Recreational boats	Currents (river, tidal, ocean)	Waterway complexity	Property damage	Impacts on endangered species
Nature of cargo	High speed craft	Visibility restrictions	Bottom type	Denial of use of waterway	Shoreline damage
Participation rate in routing systems, such as vessel traffic system ( VTS)	Passenger ships		Stability (siltation)		Reef damage
		Background lighting	AtoN mix and configuration		Economic impacts
		Debris	Quality of hydrographical data		

Risk is evaluated to allow attention to be focused on high-risk areas, and to identify and evaluate factors that influence the level of risk. Once all the risks have been assessed, they are then evaluated



in terms of the documented needs, issues and concerns of the stakeholders, and the benefits and costs of the activity, to determine the acceptability of the risk.

Zero risk is not often realized, unless the activity generating the risk is abandoned. Rather than striving to reduce the risk to zero, authorities should reduce the risk to “as low as reasonably practicable” (ALARP; Fig. 3).



**Figure 3.** Graphical representation of the levels of risk. The risk level boundaries (negligible/ALARP/intolerable) are purely illustrative.

It is important to remember that when communicating with stakeholders about risk, perception is usually different from reality. People make judgements about the acceptability of a risk based on their perceptions, rather than on scientific factors such as probability. The public’s perception of a risk may be influenced by many things, including their age, gender, level of education and previous exposure to information about the hazard. Public perceptions of risk may, therefore, differ from those of technical experts.

## 5 Scenarios

During the stakeholder meeting and discussions with the Director and Chief of Port State Control, various hazards were identified for Malakal Harbor that could lead to a number of different incidents or scenarios. Each hazard was considered carefully and the scenarios it could cause were identified and recorded. The scenarios for Malakal Harbor were classified into three different categories: collisions, groundings and allisions. Annex C lists the identified scenarios.

### 5.1 Grounding

Grounding is defined as a boat being aground or hitting and/or touching shore or sea bottom or underwater objects (e.g. wrecks). Three grounding scenarios were identified for Malakal Harbor. All groundings were on the reef: two at the west passage and another at the east passage due to the lack of IALA-compliant AtoN marking both the west and east passages.

### 5.2 Collision

Collision is defined as striking or being struck by another ship, regardless of whether the ship is underway, anchored or moored. The probability of a collision depends on navigational conditions, waterway configurations, and type and volume of maritime traffic. The basic types of collisions are head-on, overtaking, bend, merging and crossing collisions. An analysis of the routes and their geometry, combined with the volume and mix of traffic for Malakal Harbor, resulted in two probable head-on collision scenarios: two local state boats collide at night in the main shipping channel, and

two local boats collide in the small boat channels. This is attributed to the lack of IALA-compliant AtoN in the main and smaller boating channels.

### 5.3 Allision

The possibility of a boat striking a fixed human-made object such as a wharf, mooring buoy or fish aggregation device (FADs) depends on the position of such structures along the navigation route and the density of maritime traffic. One allision scenario was identified for Malakal Harbor: local boats alliding with AtoN is a major concern due to the AtoN being inconspicuous and unlit.

## 6 Probability and impact

SIRA specifies five levels of probability (Table 2) and five levels of impact that each type of scenario would create (Table 3). Each scenario is allocated a score for both probability and impact, and the risk value is calculated from the product of these scores. In this step of the process, the probability and consequences associated with each scenario were estimated and discussed with the AtoN officer and the Director of Port State and Navigation.

**Table 2.** Levels of probability specified for the simplified IALA risk assessment tool (SIRA).

Classification	Score	Probability
Very rare	1	Very rare or unlikely, will occur only in exceptional circumstances and not more than once in 20 years
Rare	2	Rare, may occur every 2 to 20 years
Occasional	3	Occasional, may occur every 2 months to 2 years
Frequent	4	Frequent, may occur once every weekly to every 2 months
Very frequent	5	Very frequent, may occur at least once every week

**Table 3.** Levels of impact specified for the simplified International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) risk assessment tool (SIRA).

Description	Score	Service disruption criteria	Human impact criteria	Financial criteria	Environmental criteria
Insignificant	1	No service disruption apart from some delays or nuisance	No injury to humans; possible significant nuisance	Loss, including third-party losses, of less than USD 1000	No damage
Minor	2	Some non-permanent loss of services such as closure of a port or waterway for up to 4 hours	Minor injury to one or more individuals, may require hospitalisation	Loss, including third-party losses, of USD 1000–50,000	Limited short-term damage to the environment
Severe	3	Sustained disruption to services such as closure of a port or waterway for 4–24 hours	Injuries to several individuals requiring hospitalisation	Loss, including third-party losses, of USD 50,000–5,000,000	Short-term damage to the environment over a small area

Major	4	Sustained disruption to services such as closure of a major port or waterway for 1–30 days or permanent or irreversible loss of services	Severe injuries to many individuals or loss of life	Loss, including third-party losses, of USD 5,000,000–50,000,000	Long-term to irreversible damage to the environment over a limited area
Catastrophic	5	Sustained disruption to services such as closure of a major port or waterway for months or years	Severe injuries to numerous individuals and/or loss of several lives	Loss, including third-party losses, of over USD 50,000,000	Irreversible damage to the environment over a large area

## 7 The acceptability of risk

Having determined probability and impact scores by consensus, the risk values are calculated by multiplying these scores, as shown in Table 4. To determine whether the risks are acceptable or not, SIRA specifies four color-banded levels of risk (Table 5). These colors are superimposed on the matrix in Table 4.

**Table 4.** Risk value matrix.

		PROBABILITY / (LIKELIHOOD)				
		Very Rare (1)	Rare (2)	Occasional (3)	Frequent (4)	Very frequent (5)
CONSEQUENCE (IMPACT)	Catastrophic (5)	5	10	15	20	25
	Major (4)	4	8	12	16	20
	Severe (3)	3	6	9	12	15
	Minor (2)	2	4	6	8	10
	Insignificant (1)	1	2	3	4	5

**Table 5.** Categories of risk, and action required.

Risk Value	Risk Category	Action Required
1 – 4	Green	Low risk not requiring additional risk control options unless they can be implemented at low cost in terms of time, money and effort.
5 – 8	Yellow	Moderate risk which must be reduced to the “as low as reasonably practicable” (ALARP) level by the implementation of additional control options which are likely to require additional funding.
9-12	Amber	High risk for which substantial and urgent efforts must be made to reduce it to “ALARP” levels within a defined time period. Significant funding is likely to be required and services may need to be suspended or restricted until risk control options have been actioned.
15-25	Red	Very high and unacceptable risk for which substantial and immediate improvements are necessary. Major funding may be required and ports and waterways are likely to be forced to close until the risk has been reduced to an acceptable level.

## 8 Risk control options

The objective of the risk assessment was to identify risk mitigation options for each undesirable incident that would, if implemented, reduce the risk to a level as low as reasonably practicable (ALARP) and which would be acceptable to stakeholders. Before any risk control decisions were made, they were communicated through the stakeholder consultation process. The risks were evaluated in terms of the overall needs, issues and concerns of the stakeholders. The mitigation options include:

- new or enforcement of existing rules and procedures;
- improved and charted hydrographical, meteorological and general navigation information;
- enhanced AtoN service provision;
- improved radio communications; and
- improved decision support systems.

Table 6 shows the risk scores for the scenarios under the current situation at Malakal harbour, and the new risk scores after mitigating the risk. The detailed risk control options for Malakal harbour is shown in the risk control matrix in Annex D.

**Table 6.** Risk control options for Malakal Harbor, and new risk scores.

Scenario	Risk score	Risk control option	New risk score
Collision between two state-owned boats at night in the main shipping channel	15	Installation of new IALA-compliant AtoN in the main shipping channel	5
Collision between two local boats in the boating channels	12	Installation of new IALA-compliant AtoN in the smaller boating channels	4
Grounding of a container ship at the west entrance passage	20	Installation of new IALA-compliant AtoN in the main shipping channel	5
Grounding of a passenger vessel in the marine protected area around the east passage	20	Installation of new IALA-compliant AtoN in the east passage	5



Grounding of a tugboat towing a barge through the west passage	9	Installation of new IALA-compliant AtoN in the west passage	3
Collision of local boats with AtoN	8	Installation of new IALA-compliant AtoN and provision of small boat safety awareness programs	4

## 9 Costing the risk control options

The outcomes of the risk assessment are essentially qualitative and subjective, based on the expert opinions of the stakeholders. The next step is to reach consensus on which risk control options to action. The risk control options are prioritized to facilitate the decision-making process.

Costing of the options is part of the decision-making process. Most of the control options identified require funding. Costs must cover capital, labor and other resources needed for planning and implementation, as well as costs of operation and maintenance throughout the life cycle under consideration. Maintenance is important to ensure that AtoN equipment and systems continue to perform at the levels required for mariners to safely navigate the waterways.

The control measures need to be both effective in reducing risk, but also cost-effective. The cost of the measures should not normally exceed the reduction in the expected value of the loss.

The cost of the options should be evaluated over a time frame equivalent to the economic or useful life of the facilities and assets associated with the option.

## 10 AtoN budgeting and resourcing

In order for the Bureau of Commercial Development, under the Ministry of Public Infrastructure, Industries and Commerce, to provide excellent AtoN services in Palau, it is important that an adequate level of resources be allocated towards AtoN installment, maintenance and management. During the visit, meetings were held with a range of stakeholders to improve the allocation of resources and management of the bureau's AtoN budget.

A meeting was held with Mr Casmir Remengesau, Director of the Bureau of Budget and Planning, and his staff to discuss the resourcing of the Bureau of Commercial Development's Division of Transportation to better meet its obligations to provide quality AtoN services. Mr Remengesau was briefed on the importance of functioning AtoN to the waterways and ports all over Palau, and the need to have regular and resourced maintenance of these AtoN. The role that AtoN play as a key national infrastructure was emphasized. It was made clear that there has not been properly maintained despite its importance to trade, tourism and mobility in general. Palau currently does not collect any light dues for the use of its AtoN.

The main port of Malakal is operated by the Belau Transfer and Terminal Company, which charges port charges such as a port entry, wharfage and dockage fees. During discussions with the Bureau of Budget and Planning, it was put forward that Palau would be interested in looking into the possibility of charging light dues to overseas vessels.

To improve the Division of Transportation's budgetary planning of its AtoN, an AtoN Programme five-year budget (2021–2025) was drawn up in consultation with the Director of the Bureau of Commercial Development, Ministry of Public Infrastructure, Industries and Commerce, Mr Hayes Moses. The

budget disaggregates between capital expenditures and ongoing expenditures. It is expected to assist the Division of Transportation, and in turn the Bureau of Commercial Development to better plan and prioritize AtoN budgetary needs.

The budget sets out what it would cost Palau to fund a dedicated AtoN maintenance programme under its work plan. It shows that the programme would mainly consist of hiring three staff technicians, plus the cost of fuel, paint and equipment procurement. Community consultations at the cost of approximately USD 5000 are also planned to be held every year in Koror State to raise awareness on the use of AtoN among communities. The recurring expenditure is expected to cost the Palauan government approximately USD 61,168 every year.

## 11 Recommendations

A key outcome of the risk assessment for Palau is six recommendations that aim at reducing the risks to safety of navigation to an acceptable level for stakeholders. To address all of the recommendations, a total cost estimate (Annex F) was provided by the Bureau of Commercial Development for the installation and refurbishment of all AtoN in the main shipping lanes and boat passages.

### Recommendation 1 (addressing collision scenario)

This recommendation addresses the potential collision of two local state-owned boats at night in the main shipping channel. This is mainly due to the lack of IALA-compliant AtoN in the main shipping channel.

It is recommended that new IALA-compliant AtoN be installed in the main shipping channel to guide vessels safely in and out of the channel at all times. This recommendation should help to reduce the risk to as low as reasonably practicable.

### Recommendation 2 (addressing collision scenario)

This recommendation addresses the potential collision of local boats in the small boat channels. This is mainly due to the lack of IALA-compliant AtoN in the boat channels.

It is recommended that IALA-compliant AtoN be installed in all boating channels, which should help to reduce the risk to as low as reasonably practicable.

### Recommendation 3 (addressing grounding scenario)

This recommendation addresses the potential grounding of container ships at the entrance to the west passage. This is mainly due to the lack of leading lights and AtoN marking the entrance channel.

It is recommended that IALA-compliant AtoN be installed in the west channel, which should help to reduce the risk to as low as reasonably practicable.

### Recommendation 4 (addressing grounding scenario)

This recommendation addresses the potential grounding of passenger vessels in the marine protected area near the east passage. This is mainly due to the narrow and winding channel, strong currents and bad weather conditions, together with the lack of AtoN marking the east channel.

It is recommended that IALA-compliant AtoN be installed in the east channel, which should help to reduce the risk to as low as reasonably practicable.

### Recommendation 5 (addressing grounding scenario)

This recommendation addresses the potential grounding of tugboats towing barges while being towed through the west passage into Malakal Harbor. This is mainly due to the narrow and winding channel, strong currents and bad weather conditions, together with the lack of AtoN marking the west channel.

It is recommended that IALA-compliant AtoN be installed in the west channel up to Malakal Harbor, which should help to reduce the risk to as low as reasonably practicable.

### Recommendation 6 (addressing allision scenario)

This recommendation addresses the potential allision of local boats with AtoN. This is mainly due to narrow and winding channels, strong currents and bad weather conditions, together with the lack of conspicuous and IALA-compliant AtoN marking the boating channels.

It is recommended that IALA-compliant AtoN with day boards and lights be installed in all boating channels, and that small boat safety awareness programs be conducted for all boating personnel.

The above recommendations should help to reduce the risk to as low as reasonably practicable. The cost to implement all six of the above-mentioned recommendations was provided by the Bureau of Commercial Development as a total cost estimate for the installation and refurbishment of all AtoN in the main shipping lanes and boat passages.

Recommendation 1	Amount (USD)
To reduce the risk of collision of two local state boats at night in the main shipping channel, it is recommended that IALA-compliant AtoN be installed in the main shipping channels	1,943,100.71 <sup>1</sup>
<b>Recommendation 2</b>	
To reduce the risk of collision of two local boats in the boating channels, it is recommended that IALA-compliant AtoN be installed in all boating channels	
<b>Recommendation 3</b>	
To reduce the risk of grounding of container ships at the west entrance passage, it is recommended that IALA-compliant AtoN be installed in the west channel	
<b>Recommendation 4</b>	
To reduce the risk of grounding of passenger vessel in the marine protected area around the east passage, it is recommended that IALA-compliant AtoN be installed in the east channel	
<b>Recommendation 5</b>	
To reduce the risk of grounding of tugboats and barges through the west passage, it is recommended that IALA-compliant AtoN be installed in the west channel	
<b>Recommendation 6</b>	
To reduce the risk of local boats colliding with AtoN, it is recommended that IALA-compliant AtoN with day boards and lights be installed, and that small boat safety awareness programmes be conducted for all boating personnel	
<b>Maintenance cost</b> <sup>5</sup>	57,155.03

## 12 Conclusion

This report completes the risk assessment process as required by Regulation 13 of the International Convention for the Safety of Life at Sea (SOLAS convention). It report should be read in conjunction with the United States Coast Guard Waterway Analysis Management System (WAMS) Assessment report carried out for the Koror shipping channels and completed in October 2018.

<sup>5</sup> The cost of maintenance for AtoN is estimated at 5% annual of the initial purchase cost.

This report is meant to guide the Ministry of Public Infrastructure, Industries and commerce in delivering compliant AtoN services.

SPC can provide further support in relation to capacity development, AtoN services and management, governance, and budget management to assist Palau in offering safe maritime routes and meeting the country's international obligations.

It is suggested that a consistent and wider approach be taken by Palau to include the delivery of hydrographic, marine meteorology, maritime safety information, and maritime search and rescue services in its governance processes.

## Annex A. Stakeholders in Malakal Harbor risk assessment

Safety of Navigation Risk Assessment Stakeholder Meeting (Phase II) – Koror, 11 June 2019				
	Name	Jobtitle	Organization	Email address
1	Edwin Kyota	Ranger	Koro State Government	<a href="mailto:edwin.kyota@gmail.com">edwin.kyota@gmail.com</a>
2	Tiffany Rivera	Shipping Agent	Western Pacific Shipping Co.	<a href="mailto:westernpacific@palaunet.com">westernpacific@palaunet.com</a>
3	Francis Toribiong	Boat Operator	TMC Inc	<a href="mailto:francistoribiong@gmail.com">francistoribiong@gmail.com</a>
4	Midas Ngiracheluolu	Governor	Kayangel State	
5	Kurt Ngriraked	Boat Operator	Kayangel State	
6	Jay Alfred	Boat Operator	Angaur State	
7	Browny Salvador	Staffer	Office of the President	
8	Vann Isaac	Legislator	Koror State Legislation	
9	Desiree Icehad	Chamber of Commerce Rep	WCTC / Chamber of Commerce Rep	<a href="mailto:desiree.icehad@wctc-palau.com">desiree.icehad@wctc-palau.com</a>
10	Sam Scott	Tour operator	Sam's Tours	<a href="mailto:sam@samtours.com">sam@samtours.com</a>
11	Melwant Tmetuchen	CEO	PNQ Sand and Dredging	
12	Aminisl Islam	Manager	PNQ Sand and Dredging	
13	Levan Akitaya	Chief of Port Sate and Navigation	MPIIC	<a href="mailto:levanakitaya@gmail.com">levanakitaya@gmail.com</a>
14	William Moses	Director	MPIIC	<a href="mailto:wm.moses@palaunet.com">wm.moses@palaunet.com</a>

## Annex B. Hazards identified for Malakal Harbor

	Hazards	Value	Remarks
<b>Natural</b>	Safe minimum depth (m)	10	There is a short drop off that is poorly marked, and a shallow area at the eastern entrance into the harbor. Poorly marked buoys with strong currents at certain times
	Proximity of danger (nm)	0	Poorly marked buoys with shallow areas not properly marked. Strong currents at certain times
	Tide, wind, wave and tidal flow effect	2.5 kt	Boat operators have to struggle with strong currents that occur at certain times. Boats can get pulled into shallow areas
	Minimum visibility (nm)	Y	Occasionally, Palau receives heavy rainfall, and this affects visibility considerably when moving around on the water. There have been incidents of boats running into AtoN due to poor visibility and unlit buoys and markers
	Background lighting	Y	City lights are bright and interfere with navigation when vessels approach the eastern entrance
<b>Economic</b>	Legal action	Y	There was an incident regarding the USNS <i>Niagra</i> that ran aground in Koror harbor (27 October 2005). The US Navy was sued by the local state government for damages to the reef. Poor visibility due to faulty AtoN was blamed instead as the cause of the grounding.  EQPB now fines all vessels for running aground
	Insufficient AtoN funding	Y	Yes, as evident by the lack, or non-existence, of maintenance
	Quality and validity of charted information	Y	Charts of Palau are out of date and need to be updated. In some places, features are off by 1000 m
	Loss of communications	Y	The VHF communication network is weak in certain places. There is a need for repeaters
	AtoN failures	Y	Yes, the vast majority of AtoN are unlit
	Substandard ships	Y	Occasionally there are fishing vessels that call into port
<b>Human</b>	Crew competency	Y	There has not been many issues pertaining to crew competency in the past but this could definitely be a problem. Tour and charter boat operators are very careful about who pilots their boats
	Fatigue	Y	There have been few incidents of fatigue affecting operations
	Safety culture	Y	There are issues, such as when local fishermen cast their nets near vessels, and education would be key to addressing this
	Influence of alcohol and/or drugs	Y	Rare to none
	Availability and competency of pilotage services	Y	Pilotage services are available but there is a need for regular re-training

	Piracy or terrorism	N	None, but there is a potential for this given Palau's proximity to the southern Philippines and Indonesia
	Crew medical issues	N	None. Tour and charter boat operators are consistent with trainings
	Crew distractions	Y	Crew averting their attention to social media
<b>Operational</b>	Impact of small vessels	Y	Palau's waters are plied by many small vessels, often tour and charter boat operators or local fishermen
	Seasonal activities	Y	Palau's heavy tourism season is from November to May, and there is significantly more activity on and under the water during this time
	Poor passage planning	y	Rare to none
	Poor promulgation of maritime safety information	y	Rare to none
	Poor response to marking new danger	y	Poor AtoN
<b>Maritime space</b>	The existence of wrecks and new dangers	Y	Wrecks not marked
	Crowded waterway issues	Y	Yes, during the busy tourism season. There are many boats on the water during this period
	The existence of restricted areas	N	There are conservation areas that are mostly well marked

## Annex C. Possible scenarios identified for Malakal Harbor

Scenarios		Remarks
Collisions	Head-on	Two local state-owned boats collide at night in main shipping channel
	Head-on	Two local boats collide in small boat channel
Groundings	Grounding on rock	Grounding of container ship at west passage entrance
	Grounding on rock	Grounding of passenger vessel in the marine protected area at the east passage
	Grounding on rock	Grounding of tugboat towing a barge into Malakal Harbor through the west passage
Allisions	AtoN	Local boat allides with AtoN



## Annex D. Risk assessment matrix for Malakal Harbor

Scenario	Description of incident	Root Cause(s) (Hazards)	Description of Consequences (Short term and long term)	Existing Risk Control Measures	Probability Score	Consequence Score	Risk Score	Cost of Incident (USD)	Further Risk Control Options	New Probability Score	New Consequenc e Score	New Risk Score	cost of RCO(USD)	Remarks	
1. COLLISIONS														1,943,100.71	This cost estimates were provided by the Bureau for the installtion and refurbishing of AtoNs in the main shipping lanes and boat passages.
1.1	Collision of Boats	Two local state boats collide at night in main shipping channel	Lack of AtoNs	Loss of lives, damage to vessel, damage to environment	None	3	5	15	10.37M	Install new IALA standard AtoNs in the main shipping channel	1	5	5		
1.2	Collision of Boats	Two local boats collide in local boat channel	Lack of AtoNs	Damage to boats, injuries to personnel	None	3	4	12	200,000	Install new IALA standard AtoNs along local boat channels	1	4	4		
2. GROUNDINGS															
2.1	Grounding on Rock - West passage	Grounding of container ship at west passage entrance	Lack of AtoNs	Loss of lives, damage to vessel, damage to environment	Vessels not permitted to enter passage at night time	4	5	20	44.25M	Install new IALA standard AtoNs in west passage to Malakal harbour	1	5	5		
2.2	Grounding on Rock - East passage	Grounding of passenger vessel in MPA area east passage	Lack of AtoNs	Major damage to Vessel, oil spill, several lives lost	Vessels not permitted to enter passage at night time	4	5	20	10.37M	Install new IALA standard AtoNs in east passage to Malakal harbour	1	5	5		
2.3	Grounding of Tug boat and barge	Tug boat towing a barge into Malakal harbour through the west passage grounds	Lack of AtoNs	Tug and Barge runs aground halfway through the passage as sunsets	Vessels not permitted to enter passage at night time	3	3	9	720,000	Install new IALA standard AtoNs in west passage to Malakal harbour	1	3	3		
3. ALLISIONS															
3.1	Allision with AtoNs	Local boat allides with AtoN	Fatigue	Boats allides with Fixed daymark during daytime	None	2	4	8	200,000	Install day boards and lights, plus small boat safety awareness program for all boating personnel.	1	4	4		

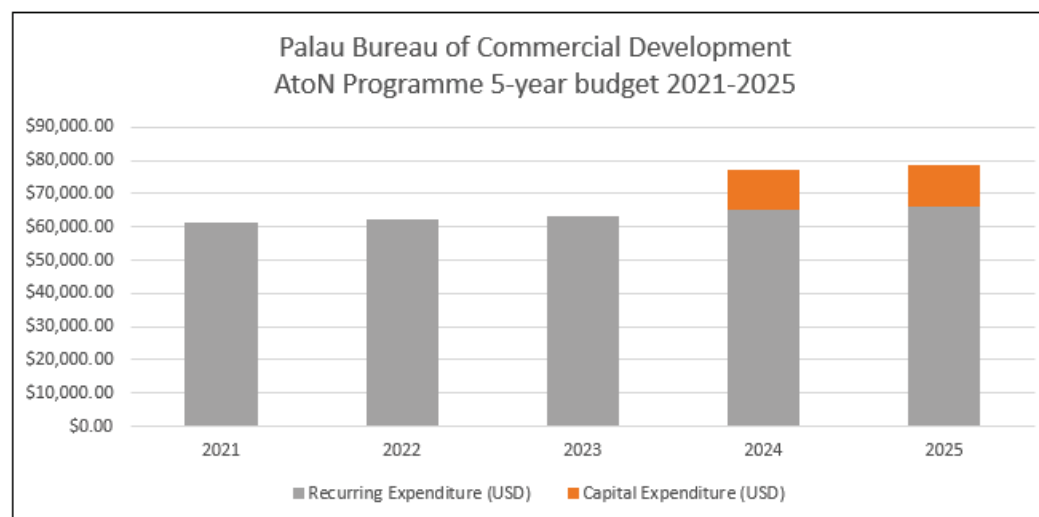
## Annex E. Aids to Navigation Programme five-year budget plan (2021–2025)



### Bureau of Commercial Development, Ministry of Public Infrastructure, Industries and Commerce. AtoN Programme 5-year budget 2021-2025



	Capital Expenditure (USD)	Recurring Expenditure (USD)	Total Expenditure (USD)
2021	\$0.00	\$61,167.75	\$61,167.75
2022	\$0.00	\$62,184.29	\$62,184.29
2023	\$0.00	\$63,231.32	\$63,231.32
2024	\$12,136.00	\$64,916.56	\$77,052.56
2025	\$12,367.00	\$66,038.91	\$78,405.91
	<u>\$24,503.00</u>	<u>\$317,538.83</u>	<u>\$342,041.83</u>



	Unit Cost	Estimated Cost (USD)	Estimated Cost (USD)	Notes
<b>Capital expenditure</b>				
Procurement				
New AtoN				
Freight/Customs				
Total Capital exp			\$0.00	
<b>Recurring expenditure</b>				
Staff salaries	\$10,757.00	\$32,271.00		The Department needs to have 3 AtoN technicians to be able to have a fully-fledged AtoN programme. Each will be at Palau Government Civil Service pay level 7 (Starting rate of \$10,757 plus 3% yearly inc)
Boat Maintenance		\$1,500.00		According to past transactions, servicing cost of boat is approx \$1,500
Fuel		\$12,000.00		Fuel cost for boat. Approx. USD1,000 per month
Paint		\$780.00		Paint on the island: Approx \$30 gallon of primer, \$50 for gallon of ocean green, and \$50 for gallon of ocean red. 6 gallons each needed
Bolts and nuts spares		\$500.00		According to past use, bolts and nuts spare cost about \$500
Reflector tapes		\$6,204.00		Approx. 6m per board to be retaped every 6 months: 47 markers*2 sides*3metres = 282 m. 3M reflector tape costs approx USD22 per metre
Community consultations		\$5,000.00		Venue and catering costs in Koror for community consultations
Contingency		\$2,912.75		
Total Recurring exp			\$61,167.75	
<b>Value added tax</b>				
Total budgeted			\$61,167.75	

	Unit Cost	Estimated Cost (USD)	Estimated Cost (USD)	Notes
<b>Capital expenditure</b>				
Procurement				
New AtoN				
Freight/Customs				
Total Capital exp			\$0.00	
<b>Recurring expenditure</b>				
Staff salaries	\$11,079.71	\$33,239.13		The Department needs to have 3 AtoN technicians to be able to have a fully-fledged AtoN programme. Each will be at Palau Government Civil Service pay level 7 (Starting rate of \$10,757 plus 3% yearly inc)
Boat Maintenance		\$1,500.00		According to past transactions, servicing cost of boat is approx \$1,500
Fuel		\$12,000.00		Fuel cost for boat. Approx. USD1,000 per month
Paint		\$780.00		Paint on the island: Approx \$30 gallon of primer, \$50 for gallon of ocean green, and \$50 for gallon of ocean red. 6 gallons each needed
Bolts and nuts spares		\$500.00		According to past use, bolts and nuts spare cost about \$500
Reflector tapes		\$6,204.00		Approx. 6m per board to be retaped every 6 months: 47 markers*2 sides*3metres = 282 m. 3M reflector tape costs approx USD22 per metre
Community consultations		\$5,000.00		Venue and catering costs in Koror for community consultations
Contingency		\$2,961.16		
Total Recurring exp			\$62,184.29	
<b>Value added tax</b>				
Total budgeted			\$62,184.29	

	Unit Cost	Estimated Cost (USD)	Estimated Cost (USD)	Notes
<b>Capital expenditure</b>				
Procurement				
New AtoN				
Freight/Customs				
Total Capital exp			\$0.00	
<b>Recurring expenditure</b>				
Staff salaries	\$11,412.10	\$34,236.30		The Department needs to have 3 AtoN technicians to be able to have a fully fledged AtoN programme. Each will be at Palau Government Civil Service pay level 7 (Starting rate of \$10,757 plus 3% yearly inc)
Boat Maintenance		\$1,500.00		According to past transactions, servicing cost of boat is approx \$1,500
Fuel		\$12,000.00		Fuel cost for boat. Approx. USD1,000 per month
Paint		\$780.00		Paint on the island: Approx \$30 gallon of primer, \$50 for gallon of ocean green, and \$50 for gallon of ocean red. 6 gallons each needed
Bolts and nuts spares		\$500.00		According to past use, bolts and nuts spare cost about \$500
Reflector tapes		\$6,204.00		Approx. 6m per board to be retaped every 6 months: 47 markers*2 sides*3metres = 282 m. 3M reflector tape costs approx USD22 per metre
Community consultations		\$5,000.00		Venue and catering costs in Koror for community consultations
Contingency		\$3,011.02		
Total Recurring exp			\$63,231.32	
<b>Value added tax</b>				
Total budgeted			\$63,231.32	

	Unit Cost	Estimated Cost (USD)	Estimated Cost (USD)	Notes
<b>Capital expenditure</b>				
Procurement				
New AtoN		\$10,395.00		The department intends to replace its (94) buoy light batteries every 4 years. Assuming this is done over a span of 2 years.
Freight/Customs		\$1,741.00		Approximated freight cost using <a href="https://www.worldfreightrates.com/freight">worldfreightrates.com/freight</a> calculations
Total Capital exp			\$12,136.00	
<b>Recurring expenditure</b>				
Staff salaries	\$11,754.46	\$35,263.39		The Department needs to have 3 AtoN technicians to be able to have a fully fledged AtoN programme. Each will be at Palau Government Civil Service pay level 7 (Starting rate of \$10,757 plus 3% yearly inc)
Boat Maintenance		\$1,500.00		According to past transactions, servicing cost of boat is approx \$1,500
Fuel		\$12,000.00		Fuel cost for boat. Approx. USD1,000 per month
Paint		\$780.00		Paint on the island: Approx \$30 gallon of primer, \$50 for gallon of ocean green, and \$50 for gallon of ocean red. 6 gallons each needed
Bolts and nuts spares		\$500.00		According to past use, bolts and nuts spare cost about \$500
Reflector tapes		\$6,204.00		Approx. 6m per board to be retaped every 6 months: 47 markers*2 sides*3metres = 282 m. 3M reflector tape costs approx USD22 per metre
Community consultations		\$5,000.00		Venue and catering costs in Koror for community consultations
Contingency		\$3,669.17		
Total Recurring exp			\$64,916.56	
<b>Value added tax</b>				
Total budgeted			\$77,052.56	

	Unit Cost	Estimated Cost (USD)	Estimated Cost (USD)	Notes
<b>Capital expenditure</b>				
Procurement				
New AtoN		\$10,626.00		The department intends to replace its (94) buoy light batteries every 4 years. Assuming this is done over a span of 2 years.
Freight/Customs		\$1,741.00		Approximated freight cost using <a href="http://worldfreightrates.com/freight">worldfreightrates.com/freight</a> calculations
Total Capital exp			\$12,367.00	
<b>Recurring expenditure</b>				
Staff salaries	\$12,107.10	\$36,321.29		The Department needs to have 3 AtoN technicians to be able to have a fully fledged AtoN programme. Each will be at Palau Government Civil Service pay level 7 (Starting rate of \$10,757 plus 3% yearly inc)
Boat Maintenance		\$1,500.00		According to past transactions, servicing cost of boat is approx \$1,500
Fuel		\$12,000.00		Fuel cost for boat. Approx. USD1,000 per month
Paint		\$780.00		Paint on the island: Approx \$30 gallon of primer, \$50 for gallon of ocean green, and \$50 for gallon of ocean red. 6 gallons each needed
Bolts and nuts spares		\$500.00		According to past use, bolts and nuts spare cost about \$500
Reflector tapes		\$6,204.00		Approx. 6m per board to be retaped every 6 months: 47 markers*2 sides*3metres = 282 m. 3M reflector tape costs approx USD22 per metre
Community consultations		\$5,000.00		Venue and catering costs in Koror for community consultations
Contingency		\$3,733.61		
Total Recurring exp			\$66,038.91	
<b>Value added tax</b>				
Total budgeted			\$78,405.91	

## Annex F. Cost estimate for installation of new navigational buoys

10643 CIP 01/16

### A. COST ESTIMATE FOR THE INSTALLATION OF NEW NAVIGATIONAL BUOYS

Mobilization	35,000.00
Temporary Facility	30,000.00
Safety Provision & Traffic Control	17,500.00
Environmental Protection	27,500.00
Clearing Works	46,500.00
Installation of New Floating Markers (9 ea.)	174,121.56
Minor Channel Day Markers (107 ea.)	775,671.74
Shipping Channel Day Markers (47 ea.)	428,846.88
Clean-up & Demobilization	15,000.00
General Requirements (Tax, Bonding, etc.)	139,512.62
<b>Total Construction Cost</b>	<b>1,689,652.79</b>
Contingencies (5%)	84,482.64
Inspection & Administration Cost	168,965.28
<b>Total Project Cost</b>	<b>1,943,100.71</b>

### B. COST ESTIMATE DETAILS

#### 1. Floating Buoy with 6500lb Sinker (9 ea.)

Ready-mixed concrete	16.10	cy	175.00	2,817.50
1/2" Ø Deformed Bar (6-m)	18.00	pcs	8.50	153.00
1" Ø Plain Round Bar (6-m)	27.00	pcs	28.00	756.00
Plywood, Ordinary (1/2")	15.00	pcs	57.00	855.00
Lumber (2" x 4" 18')	21.00	pcs	17.00	357.00
8d Common Nails (2.5")	11.00	lbs	1.50	16.50
Tie Wire, Gauge 16	3.00	lbs	1.50	4.50
Chafe Chain, 1-1/4"	810.00	lf	32.05	25,960.50
Riser Chain, 1-1/8"	810.00	lf	26.75	21,667.50
Shackle	36.00	pcs	109.56	3,944.25
Swivel	36.00	pcs	106.25	3,825.00
Polyurethane Floating Buoy	9.00	set	4,160.00	37,440.00
Beacon Light, 5NM	9.00	ea	1,250.00	11,250.00
<b>Total Material Cost</b>				<b>109,046.75</b>
Fabrication Labor Cost				1,944.00
Fabrication Equipment Cost				450.00
Handling Cost (from Fabrication Area to Barge)				586.50
Installation Cost				27,270.00
Overhead & Profit				34,824.31
<b>Sub-Total (1)</b>				<b>174,121.56</b>



