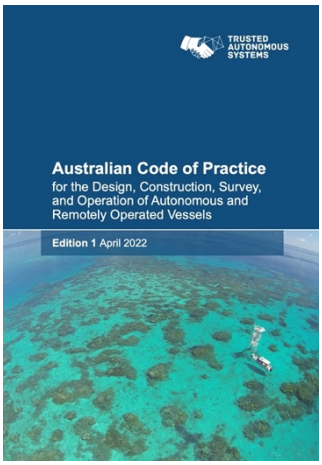

GUIDANCE MATERIALS

to support the Australian Code of Practice for the Design, Construction, Survey and Operation of Autonomous and Remotely Operated Vessels

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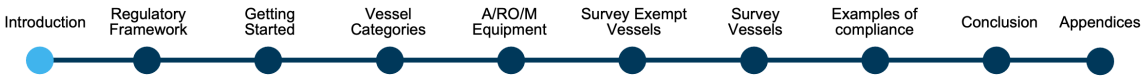


1. INTRODUCTION AND OVERVIEW

INTRODUCTION

The Australian Code of Practice for the Design, Construction, Survey, and Operation of Autonomous and Remotely Operated Vessels, referred to here as 'the Australian Code of Practice', is intended to represent best practice and deliver greater certainty to industry by providing voluntary, clear standards that are tailored for common autonomous and remotely operated vessels ('autonomous vessels') in Australia.

The Australian Code of Practice provides a common set of standards and expectations for designers, builders, operators and regulators of autonomous vessels, which is intended to enable greater certainty and efficiency.

To date there has been little by way of common references and resources for designers and users to efficiently communicate expectations and capability concerning autonomous vessels, including Autonomous Underwater Vehicles (AUVs) and Autonomous Surface Vessels (ASVs). The Australian Code of Practice is intended to bridge this gap, to help build trust in designs, and to make the operation of autonomous vessels safer and more reliable, particularly when operated in proximity to other waterway users.

The Australian Code of Practice is not law, but rather a voluntary standard that was informed by significant consultation with a broad range of designers, builders, operators, and regulators from the Australian commercial and defence sectors. The Australian Code of Practice will evolve as the Australian and international regulatory frameworks and technology demands.

These Guidance Materials will help you interpret the Australian Code of Practice for your own use. They include flowcharts to help you quickly navigate to the relevant sections of the Code, along with examples, templates, and answers to frequently asked questions.

OVERVIEW

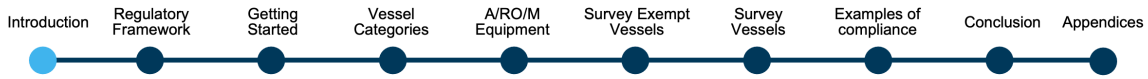
Purpose of these Guidance Materials

These Guidance Materials aim to support the use of the Australian Code of Practice, including by operators wishing to demonstrate compliance with the Code to seek certification by AMSA under the Australian maritime regulatory framework. These Guidance Materials apply to autonomous or remotely operated vessels operating as surface or sub-surface vessels in Australia.

These Guidance Materials will assist operators to:

- Understand what the Australian Code of Practice is, how it fits into the maritime regulatory framework, and the process to follow when seeking certification from AMSA
- Understand some key terminology through the Glossary at Appendix 1
- Determine which category their vessel is likely to fit into, and the corresponding requirements
- Understand how to address the applicable requirements, including by explaining what each requirement means, providing examples and templates, and identifying where to get further information

These Guidance Materials will assist interested parties to understand what the Australian Code of Practice is, how it fits into the maritime regulatory framework, the categories available, the requirements for each category and how operators might seek to comply with them.



What is the Australian Code of Practice?

The Australian Code of Practice supports the design, construction, survey, and operation of autonomous and remotely operated vessels in Australian waters. It provides guidance for people who design, build, manufacture, own, operate or regulate these vessels and aims to assist in achieving certification under the Australian maritime regulatory framework. **The Australian Code of Practice is targeted at domestic commercial vessels (DCVs) but may also be instructive for regulated Australian vessels and recreational vessels.**

The Australian Code of Practice was developed through a Queensland Government funded Trusted Autonomous Systems (TAS) project, with the intent of addressing the lack of tailored Australian standards for autonomous vessels. Before drafting the Code a review was undertaken of existing international standards and codes (Report available here), which informed the development of a set of guiding principles. These principles were tested through a series of public workshops, which then informed the development of the draft Code. Public consultation on the draft Australian Code of Practice occurred in late 2021, with the final version of the Australian Code of Practice published in April 2022.

The Australian Maritime Safety Authority (AMSA) has been closely engaged throughout the development of the Australian Code of Practice, ensuring it will be accepted as truly representing best practice in Australia.

What are the key principles underpinning the Code?

The principles that guided the development of the Australian Code of Practice are:

- The Code should align with the Australian regulatory framework for conventional domestic vessels. The areas requiring new tailored requirements are:
  - situational awareness
  - control systems
  - software integrity and testing
  - safe states
- The operational requirements that apply to conventional vessels in Australia should apply to autonomous and remotely operated vessels, but with some differences:
  - The safety management system requirements need to be tailored to autonomous and remote vessel operations.
  - The minimum crew and crew competency requirements need to be modified.
  - There will be additional requirements for contingency planning and control hierarchies, which should be informed by the content of the available Codes and standards.
- A risk analysis approach, which focuses on the impact of potential failures, should apply to the development and testing of novel systems on the vessel, including the systems for situational awareness and control and all systems which do not meet the requirements of the conventional vessel standards.
- Requirements should be commensurate with the risk posed.

How to apply the Australian Code of Practice

The Australian Code of Practice is intended to be applied as follows:

1. A reference point for best practice for the design, construction, survey, and operation of autonomous and remotely operated vessels in Australia

2. A voluntary standard against which to demonstrate compliance when applying to the Australian Maritime Safety Authority (AMSA) to operate via a Specific Exemption, General Exemption, or other certification

Once the Australian Code of Practice has been used and iterated, AMSA may choose to incorporate it as a more formal part of the Australian maritime regulatory framework.

Where to get more information

Further information can be obtained as follows:

- On the development of the Australian Code of Practice:
    - TAS: info@tasdcrc.com.au, https://tasdcrc.com.au/blog/

- On the general Australian maritime regulatory framework:
    - AMSA: amsaconnect@amsa.gov.au, https://www.amsa.gov.au/
    - TAS: RAS-GATEWAY *(under development)*

- On the specific category and related standards for your vessel:
    - AMSAConnect: amsaconnect@amsa.gov.au, https://www.amsa.gov.au/about/who-we-are/amsa-connect
    - an accredited marine surveyor: https://www.amsa.gov.au/vessels-operators/domestic-commercial-vessels/find-accredited-marine-surveyor
    - a Recognised Organisation: https://www.amsa.gov.au/vessels-operators/flag-state-administration/how-flag-state-administration-works-australia

What other resources are available that help people understand the Australian maritime regulatory framework

Trusted Autonomous Systems are developing a new platform, RAS-GATEWAY, which is intended to assist people to navigate the Australian maritime regulatory framework. RAS-GATEWAY will include a Knowledge Hub containing a repository of information and resources, together with a Maritime Regulatory Pathfinder Tool providing access to semi-tailored information on regulatory requirements and applicable processes. The RAS-GATEWAY will initially focus on the Maritime domain, before expanding to include the Air domain.

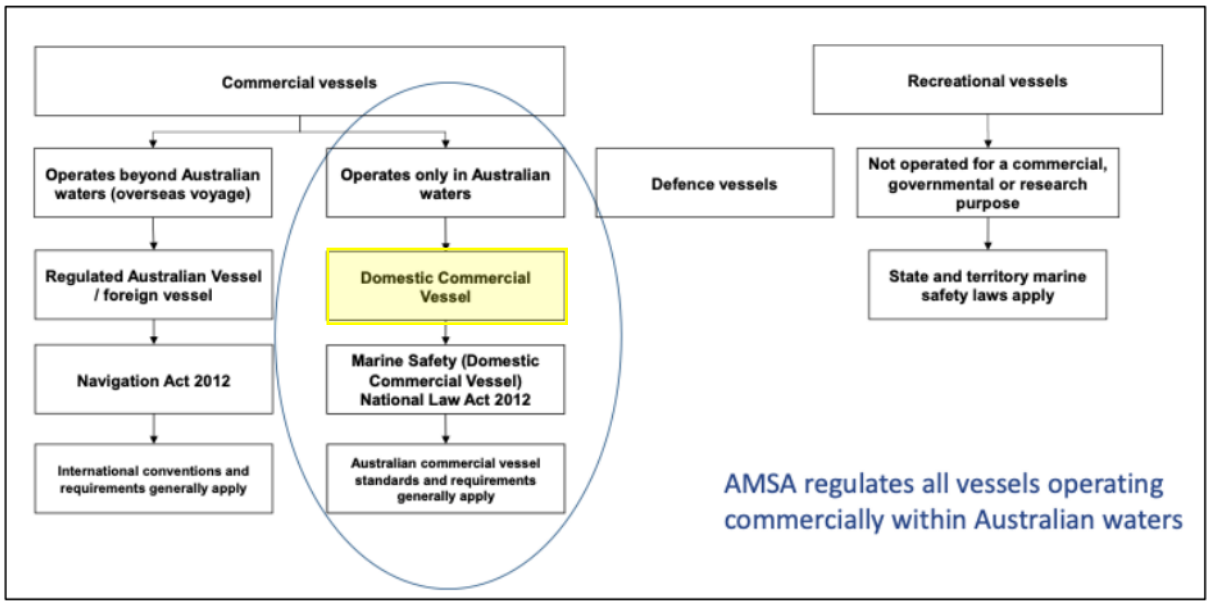
The RAS-GATEWAY contains information and guidance on using Australia's autonomous systems test ranges, including ReefWorks at the Australian Institute for Marine Science and the Queensland Flight Test Range at Cloncurry.

2. INTRODUCTION TO THE AUSTRALIAN REGULATORY FRAMEWORK

The Australian maritime regulatory framework is administered by the Australian Maritime Safety Authority (AMSA). There are two main categories of vessels: domestic commercial vessels regulated under the *Marine Safety (Domestic Commercial Vessel) National Law Act 2012* (National Law) and regulated Australian vessels regulated under the the Navigation Act *2012* (Navigation Act). It is up to the vessel owner to determine which category applies, or is most suitable for their vessel. However, a vessel which operates, or intends to operate, beyond Australia's Exclusive Economic Zone (EEZ) must be a regulated Australian vessel and cannot be a domestic commercial vessel.

To date, all Australian commercial autonomous vessels have been domestic commercial vessels. The focus of the Australian Code of Practice and these Guidance Materials is domestic commercial vessels.

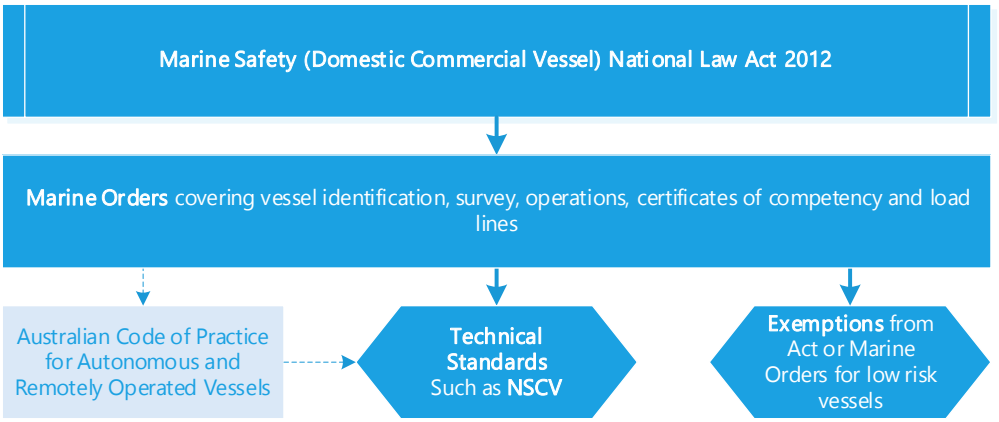
The below diagram shows how vessels are regulated in Australia:



Regulatory requirements

Under the National Law domestic commercial vessels, also referred to as DCVs, are required to have a **unique vessel identifier**, a **certificate of survey**, be listed on a **certificate of operation**, and be **crewed by persons holding the required qualification**, unless a specific exemption or general exemption applies. **General safety duties** also apply to the owner, operator, crew, and other persons interacting with the vessel. A **Safety Management System** (SMS) must also be developed for the vessel and proposed operations. The detailed requirements that must be complied with to obtain certification are set out in Marine Orders 501 – 507, and the technical standard that must be complied with to obtain a certificate of survey is the National Standard for Commercial Vessels (NSCV).

The relationship between the National Law, Marine Orders and technical standards is illustrated below:



Common regulatory issues for autonomous vessels

The common regulatory difficulties for autonomous vessels are:

- **Technical standards:** To obtain a certificate of survey a vessel must comply with the National Standard for Commercial Vessels (NSCV), which was written for traditional vessels with humans onboard. The NSCV does not contain provisions specifically tailored to autonomous and remotely operated vessels. Prior to the publication of the Australian Code of Practice there was no alternative Australian standard to refer to. The Australian Code of Practice aims to supplement the NSCV for autonomous and remotely operated vessels enabling compliance to be achieved with the same safety outcomes

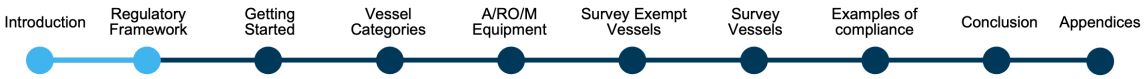
- **Crewing:** To obtain a certificate of operation, the minimum crewing requirements of Marine Order 504 must be complied with. To date AMSA's policy has been that vessels without a crew onboard cannot meet the minimum crewing requirements, meaning a specific exemption must be sought to enable operation

- **Assurance:** To date there are no Australian assurance standards that set out how to demonstrate compliance with applicable technical standards for autonomous vessels. The is also a lack of accredited marine surveyors or Class Societies available with subject matter expertise in autonomous vessels to conduct surveys and to support operators in Australia. While work is underway to address this gap, currently it means operators and AMSA are having to identify evidence requirements on a case by case basis.

Most common current regulatory approach for autonomous vessels

The most common regulatory approach for autonomous vessels in Australia to date is to have:

- Unique vessel identifier
- Certificate of operation
- Specific exemption from:
    - Requirement to comply with minimum crewing
    - Requirement to hold a certificate of survey



These Guidance Materials are intended to assist designers, builders, and operators to understand the regulatory requirements that apply to them, how to demonstrate compliance with the applicable requirements in the Australian Code of Practice, and how to apply to AMSA for certification as a domestic commercial vessel.

*Note that you could elect for your autonomous vessel to be a **regulated Australian vessel** regulated under the Navigation Act 2012, even if you only intend to operate domestically. You should seek advice directly from AMSA, an accredited marine surveyor, or a Class Society, on which category is most suitable for your vessel and proposed operation. While the Australian Code of Practice is likely to be instructive for regulated Australian vessels, it is not specifically tailored for the applicable regulatory requirements or relevant considerations.*

The remainder of these Guidance Materials assume that the reader has elected to pursue certification as a domestic commercial vessel.

3. GETTING STARTED: WHAT REQUIREMENTS APPLY TO YOU

This section aims to help you identify the requirements that apply to your vessel and proposed operation. It will lead you through a series of questions to identify:

1) Is your vessel a domestic commercial vessel subject to regulation by AMSA?

2) Does the Australian Code of Practice apply?

3) What category in the Code applies to your vessel?

4) What requirements apply?

5) What do you need to do next?

Question 1 of 5: Is my vessel a domestic commercial vessel?

For a vessel to be considered a domestic commercial vessel it must meet the definition of "vessel" and of "domestic commercial vessel" in the National Law.

Please review the below list. If every single statement is **true** for your vessel, it is likely to be considered a domestic commercial vessel:

- the vessel is capable of being used in navigation by water (however propelled or moved)
- the vessel is for use in connection with a commercial, governmental or research activity
- the vessel is not a foreign vessel or defence vessel
- the vessel is not owned and operated by a prescribed community group
- the vessel is not being used by a volunteer search and/or rescue organisation for the purpose of conducting searches and/or rescues beyond sheltered waters and/or beyond 2 nautical miles of the low water mark

More information on the meaning of 'foreign vessel', 'defence vessel' and 'prescribed community group' is available on the AMSA website: https://www.amsa.gov.au/

Examples are provided below of vessels that are or are not domestic commercial vessels:

Examples of DCV Autonomous Vessels
AUVs used for Surveying Infrastructure
AUVs or ASVs used for Habitat Mapping
AUVs or ASVs used for Hydrographic Surveying
ROV used in the Aquaculture Industry
ASVs used for Environmental Monitoring

Examples of non DCV Autonomous Vessels
AUVs or ASVs owned and operated by Defence
AUVs, ROVs or ASVs for personal use only
AUVs, ROVs or ASVs owned and operated by foreign companies
AUVs, ROVs, or ASVs which operate, or are intended to be operated, beyond Australia's Exclusive Economic Zone

Note: Tethered vessels, such as tethered subsea vessels, may not be considered domestic commercial vessels – advice from AMSA should be sought on this issue. The Australian Code of Practice does not specifically consider the risks and operations of tethered vessels. However, some aspects of the Code of Practice may be informative for tethered vessels.

Note: Vessels registered outside of Australia, which are considered Foreign Vessels, are subject to different requirements under the Navigation Act 2012 and are outside the scope of this Guidance Material.

Question 2 of 5: Does the Australian Code of Practice apply to my vessel?

If you have determined that your vessel is classified as a domestic commercial vessel, you can use the below flowchart to determine whether the Australian Code of Practice is applicable to your vessel and proposed operation.

Even if your vessel is not being certified under DCV, the code may still be relevant for you.

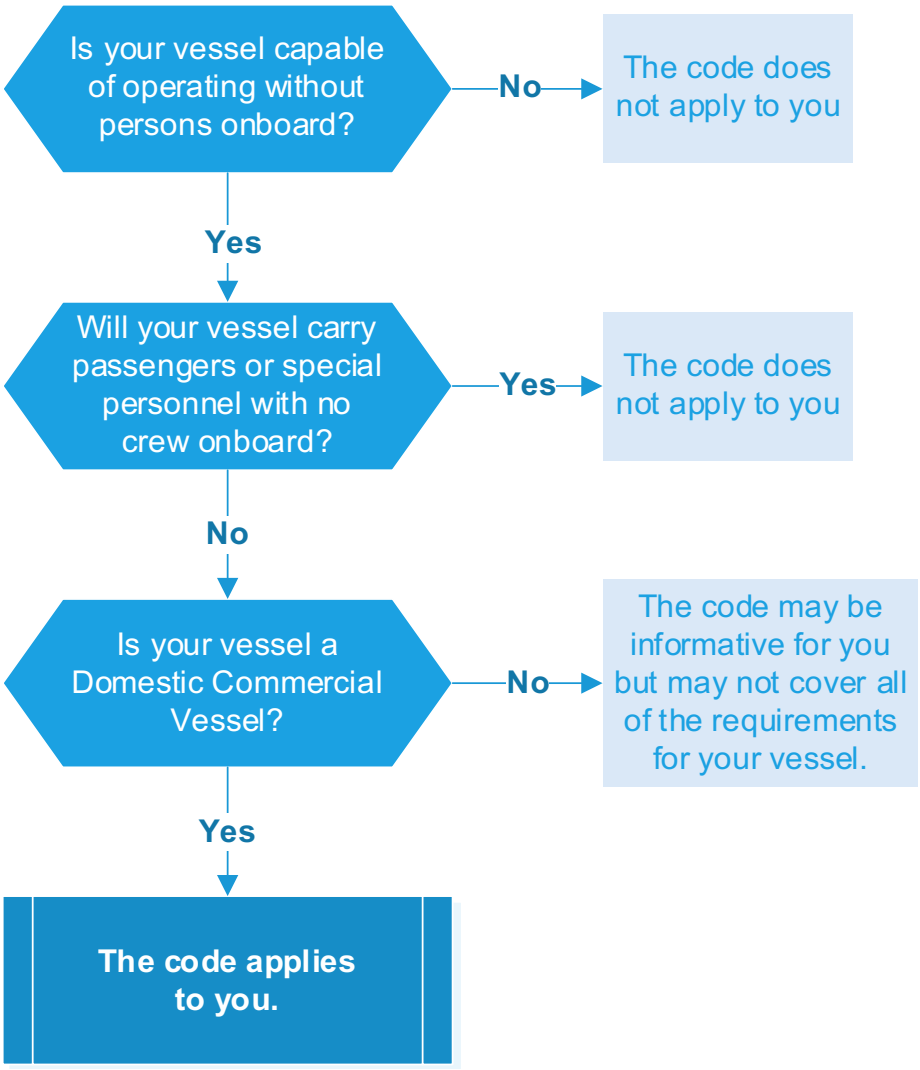


Figure 1: Does the Australian Code of Practice apply to you.

Question 3 of 5: Which category applies to my vessel?

If you have determined that your vessel is classified as a domestic commercial vessel, and the Australian Code of Practice applies, you can use the below flowchart to check which category might apply to your vessel and proposed operation.

Note that the flowchart is intended to provide a quick reference and you should carefully read the criteria for each category in the Code to confirm which is most appropriate. The parameters in the Code are intended to be flexible, allowing for users to determine which is most appropriate, with guidance from AMSA, an accredited marine surveyor or a Class Society where needed.

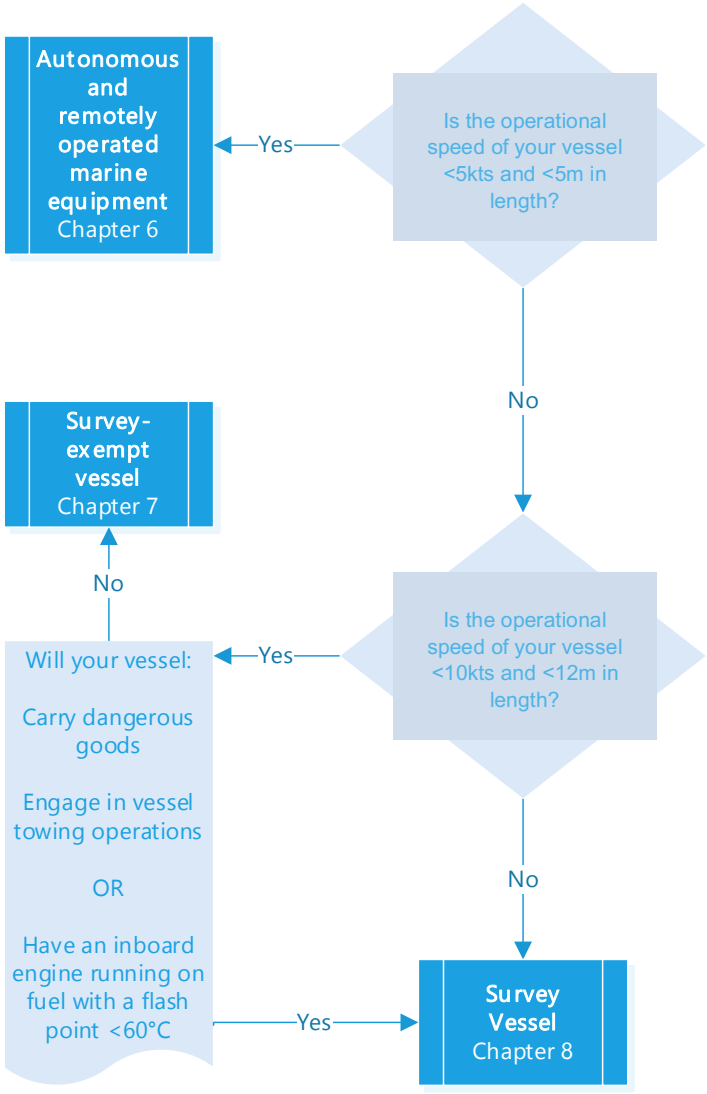


Figure 2: What category is my vessel and what chapter will I find the corresponding requirements in?

Question 4 of 5: What requirements apply based on the applicable category?

You can use the below flowchart to determine which requirements apply, based on the category you have determined applies to you.

(Note SPEX refers to a specific exemption, which you may apply to AMSA for to exempt you from some or all requirements under the National Law, except for the requirement to have a safety management system and to comply with General Safety Duties)

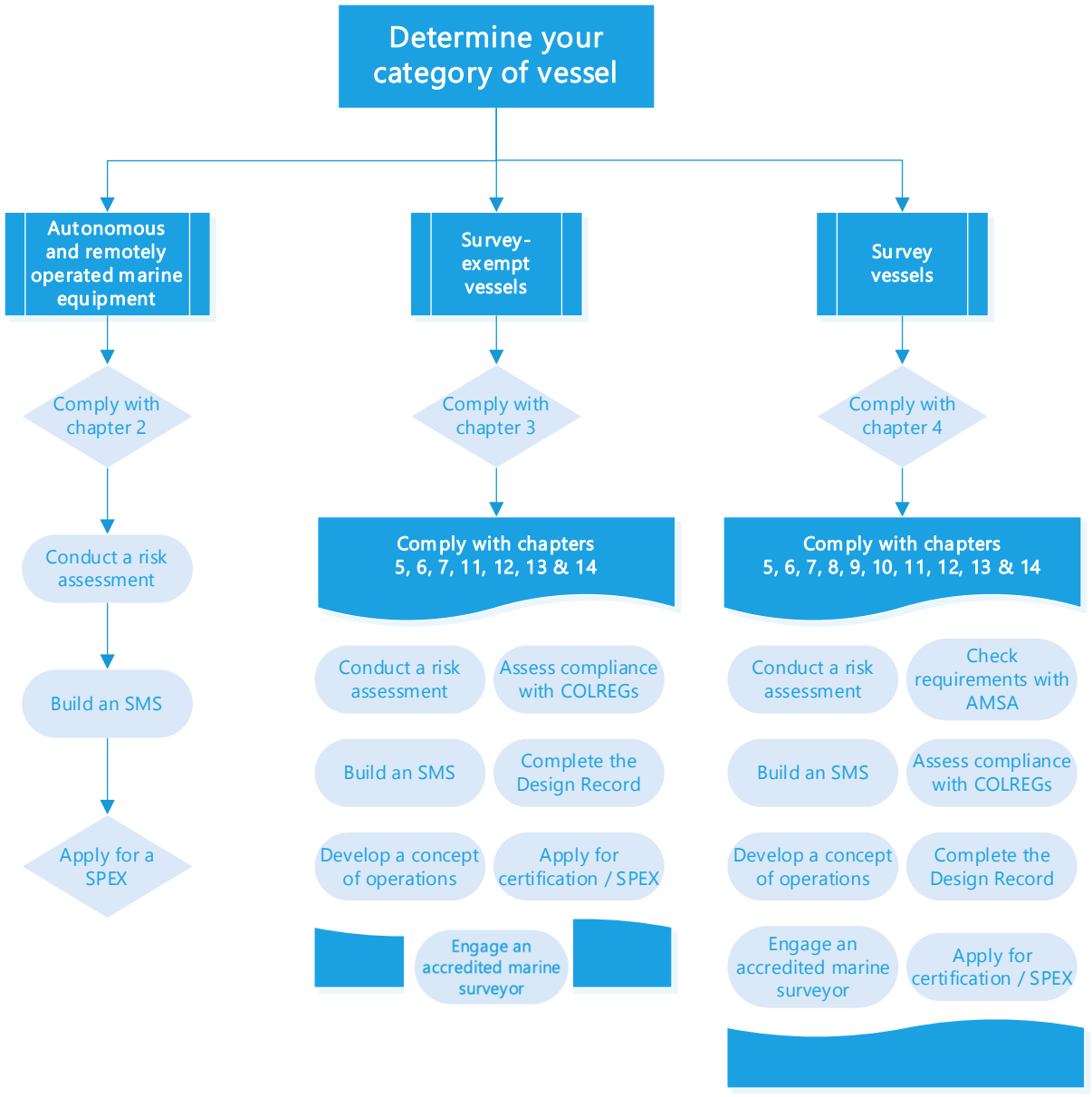


Figure 3: Pathway to Certification

Question 5 of 5: Now that I have identified the requirements, what next?

Once you have identified the requirements that apply to your vessel and proposed operation, you will need to identify the documentation you need to prepare, and consider what regulatory treatment is most suitable for you.

As described earlier in these Guidance Materials, all vessels must have a certificate of operation and certificate of survey, unless an exemption applies. You should consider the regulatory treatment most suitable for your vessel – for example it could be a specific exemption from the requirement to have any certification, or it could be having a certificate of operation and certificate of survey, with a specific exemption from some applicable requirements of each certificate. You can seek advice from AMSA, an accredited marine surveyor, or a Class Society to help determine the best path for you.

The following table outlines your responsibilities on the path to certification.

<table>
<tr><th colspan="6">Responsibilities in the path to getting your Certification</th></tr>
<tr><th colspan="6">Determine your Category of Vessel</th></tr>
<tr><th colspan="2">Autonomous and remotely operated marine equipment</th><th colspan="2">Survey Exempt Vessels</th><th colspan="2">Survey Vessels</th></tr>
<tr><th>Designer / Builder</th><th>Operator / User</th><th>Designer / Builder</th><th>Operator / User</th><th>Designer / Builder</th><th>Operator / User</th></tr>
<tr><td rowspan="6">No specific responsibilities, however, the guide could be useful information.</td><td>Conduct a risk assessment</td><td colspan="2">Prepare Concept of Operations</td><td colspan="2">Prepare Concept of Operations
Contact AMSA to confirm applicable requirements and process</td></tr>
<tr><td rowspan="2">Prepare an SMS</td><td>Comply with requirements of the code</td><td rowspan="2">Prepare an SMS</td><td>Comply with requirements of the code</td><td>Conduct an operational risk assessment</td></tr>
<tr><td>Complete the design record and system design risk assessment</td><td>Complete the design record and system design risk assessment</td><td>Prepare an SMS</td></tr>
<tr><td rowspan="3">Apply for a specific exemption from all certification requirements</td><td colspan="2">Assess compliance with COLREGs</td><td colspan="2">Assess compliance with COLREGs</td></tr>
<tr><td colspan="2">Engage an accredited marine surveyor to review the risk assessment(s) for any novel systems on the vessel (including the situational awareness and control systems)
Note that review by an accredited marine surveyor may not be required for all vessels – see Chapter 13 of the Code of Practice</td><td colspan="2">Engage an accredited marine surveyor to carry out Initial Survey and review the risk assessment(s) for any novel systems on the vessel (including the situational awareness and control systems)</td></tr>
<tr><td colspan="2">Apply for certification, for example:
• A certificate of operation and certificate of survey, with a specific exemption from the requirement to comply with minimum crewing and from survey requirements; or</td><td colspan="2">Engage an accredited marine surveyor to carry out Initial Survey
Apply for certification, for example: a certificate of survey and certificate of operation, with a specific exemption from minimum crewing requirements and specific survey requirements as needed</td></tr>
</table>

		• a certificate of operation and a specific exemption from the requirement to comply with minimum crewing and to have a certificate of survey; or • a specific exemption from all certification requirements	**NOTE:** • Application for certificate of operation is carried out by the user. • Application for certificate of survey can be carried out by either designer / builder or user.

This is the end of Section 3 of the Guidance Materials. The next parts describe in more detail the concepts in the Australian Code of Practice and the requirements of each chapter.

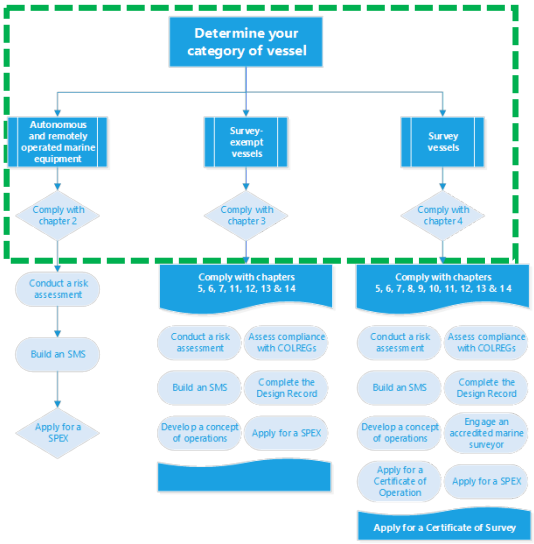
4. WHAT ARE THE VESSEL CATEGORIES IN THE CODE?

Three schemes of autonomous vessel are established under the Australian Code of Practice. They are:

- **Autonomous and remotely operated marine equipment (Refer to Chapter 2 of Code)**

Small, light surface and sub-surface vessels which are not capable of inflicting significant damage or causing significant safety risks.

Note. Guidance on the size, weight and speed limitations of this scheme is provided in Chapter 2.



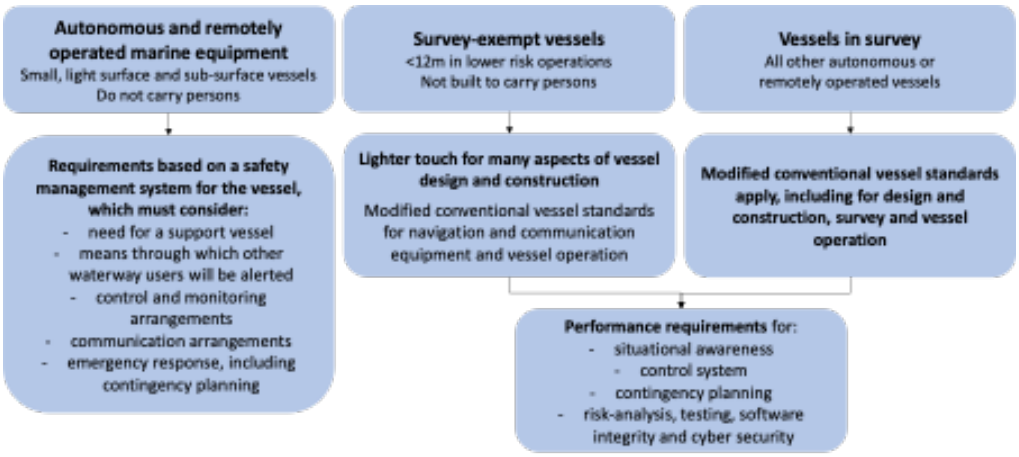
- **Survey-exempt vessels (Refer to Chapter 3 of Code)**

Vessels <12m in lower risk operations. In line with the general requirements for domestic commercial vessels, a lighter touch regime applies to these lower risk vessels.

- **Vessels in survey (Refer to Chapter 4 of Code)**

All other autonomous or remotely operated vessels.

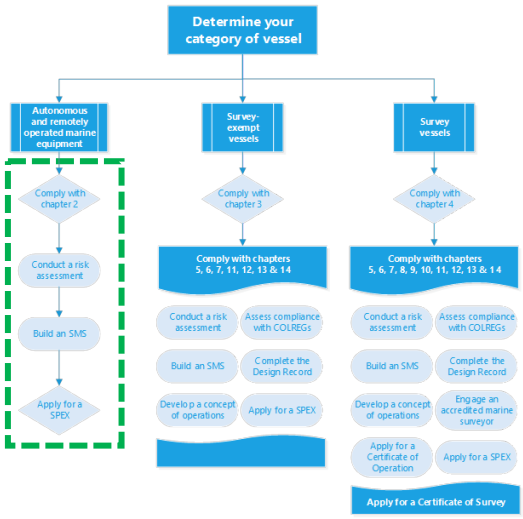
The requirements for each category are outlined in the below image:



5. AUTONOMOUS AND REMOTELY OPERATED MARINE EQUIPMENT

This section explains the requirements for vessels which are "autonomous and remotely operated marine equipment," and provides guidance on how to meet these requirements. It also explains how to apply to AMSA for a specific exemption to enable operation.

A vessel which is "autonomous and remotely operated marine equipment" is likely to be less than 5m in length and be limited to an operational speed of 5 knots.



How does my vessel comply with the Code?

If your vessel fits the category "autonomous and remotely operated marine equipment", then you are obliged to comply with Chapter 2 of the Code. You do not need to comply with Chapters 5 – 14 of the Code, but you may find them informative.

To comply with Chapter 2 of the Code you will need to:

- Prepare and implement a **Safety Management System**.
- Prepare an **appropriate crewing assessment** in accordance with Marine Order 504.
- Ensure that the vessel **complies with applicable light requirements of COLREGs** whilst the vessel is on the surface or ensure operation avoids areas of heavy vessel traffic.
- Have an appropriate support vessel on standby in applicable situations.
- Review and understand the other requirements and guidance set out in Chapter 2.

Chapters of the Code that apply to me:

1. **Chapter 2 – Autonomous and remotely operated marine equipment** provides definitions, requirements, and guidance for your vessel, including issues that the Safety Management System must consider and address for "autonomous and remotely operated marine equipment".
2. **ANNEX A – Application of COLREGs Requirements and Evidence of Compliance.**

How do I prepare a Safety Management System (SMS)?

An SMS for a domestic commercial vessel will generally have the following sections:

- Vessel details, contact person, responsibilities, and appropriate crewing
- Procedures for onboard operations, emergency preparedness, hazardous occurrences and non-conformances and supporting documentation
- Risk assessment

The Code requires inclusion of the following additional considerations:

- The need for a support vessel
- Means to alert other water users about the presence of your vessel
- Vessel data recording

Helpful information for developing an SMS

1. An example SMS can be found within Appendix 7 of these Guidance Materials
2. Chapters 2 and 14 of the Code contain guidance information to follow when preparing your SMS
3. AMSA have also developed a guideline for developing an SMS that can be found here.

Preparing a Risk Assessment

A good place to start when preparing an SMS is to carry out the risk assessment. The risk assessment provides a foundation for your SMS as it identifies key daily tasks, emergency situations and risks to your vessel which need to be controlled and managed. The risks must consider your specific vessel, its operational environment, and people, other vessels, and equipment on or near your vessel.

Preparing your risk assessment	
1	Start by outlining all the activities that your vessel is required to carry out.
2	Identify all the hazards associated with those activities.
3	For each hazard – Assess the risk using an appropriate risk matrix based the hazards likelihood and consequence.
4	If possible, eliminate the hazard completely or put in place some mitigations to manage and lower the risk.
5	Assess how well your mitigations are working.
6	Re-evaluate: • If your mitigations are not working, adjust them. Continual improvement is key. • If you start carrying out new activities, update your risk assessment.

Helpful information for developing a Risk Assessment

1. An example Risk Assessment can be found within Appendix 2 of these Guidance Materials
2. For more information refer to AMSA 651 – Risk Management in the National System

Preparing an appropriate crewing assessment in accordance with Marine Order 504.

(The information provided below is a summary of the information available on the AMSA website)

There are two key concepts related to crewing for domestic commercial vessels – 'minimum crewing' and 'appropriate crewing'.

Minimum crewing refers to the minimum number of certified and uncertified crew required, including the master, applicable to a vessel based on length. There is a table in Marine Order 504 that sets out minimum crewing.

Appropriate crewing refers to the number of certified or uncertified people that are needed to safely operate a vessel. It may change depending on the kinds of operation being carried out and the tasks involved. It must be determined by the vessel owner as part of the general safety duties, and needs to be documented in the vessel's safety management system. 'Appropriate crewing' is determined by conducting an 'appropriate crewing assessment', also called an 'appropriate crewing evaluation'.

Appropriate crewing must be equal to or higher than minimum crewing. Appropriate crewing may be the same as minimum crewing if the risk assessment carried out by the owner determines that minimum crewing is adequate to eliminate or minimise all risks.

Method for determining appropriate crewing

The method for determining appropriate crewing is an 'appropriate crewing assessment', also referred to as a 'crewing evaluation'. This assessment considers the kind of operations being performed, the operational environment, and the people on or near the vessel. Marine Order 504, Schedule 1, clause 6(6) provides a list of facts to be considered, including:

- What tasks will the vessel undertake and what will the crew be required to do?
- How many persons will the vessel carry and how will they be monitored?

- What equipment or aids to navigation are fitted on the vessel? What training do the crew require to be able to use such equipment or aids?
- Where will the vessel operate? What are the expected traffic, weather, sea, and visibility conditions? How will conditions affect the performance or duties of the crew?
- When will the vessel operate? How long will the vessel operate for? What arrangements are there for the crew to rest?
- How will fatigue affect the crew? How will fatigue be managed?
- How will the vessel's crew deal with an emergency? What training will be required?
- What maintenance tasks need to be carried out by the crew? Are the crew trained to carry out maintenance safely?
- How does the vessel's operations affect the environment? Are people onboard or near the vessel impacted by the vessel's operations?
- What are the qualifications and experience levels of the crew? Are their qualifications and experience sufficient to carry out the required duties?
- What support is available to the vessel if required? Are all crew aware of communications methods? Do they know how to seek help?

There is an appropriate crewing evaluation template available on the AMSA website, and replicated here as Appendix 3. Guidance on crewing for domestic commercial vessels, including 'appropriate crewing' requirements, and a number of examples, is available on the AMSA website.

Helpful information on preparing an appropriate crewing assessment:

1. Use online template for an Appropriate Crewing Evaluation.
2. If you have any questions contact AMSAConnect (amsaconnect@amsa.gov.au)

Ensuring the vessel complies with applicable light requirements of COLREGs whilst the vessel is on the surface or ensure operation avoids areas of heavy vessel traffic

The Collision Regulations or COLREGs refers to the *Convention on the International Regulations for Preventing Collisions at Sea*. In Australia, the COLREGs are implemented through Commonwealth, state, and territory laws. COLREGs apply to all vessels, regardless of their size or nature of operation, in all navigable waters, from inland waters to the high seas.

Contravention of COLREGs may jeopardise the safety of life and endanger the environment. Under the Navigation Act 2012, it is an offence for an owner or master to operate a vessel to contravene the COLREGs (implemented by Marine Order 30 (Prevention of collisions) 2016).

Operators must understand the COLREGs or collision avoidance requirements that apply to their vessel and the specific operations being undertaken. Autonomous and remotely operated marine equipment by virtue of the size and speed limitations inherent in that category, may be subject to a reduced number of COLREGs rules, and avoiding specific situations which give rise to many of the remaining COLREGs rules will further limit the number of rules to be complied with.

Operators should refer to the COLREGs Operator Guidance Framework annexed to the Australian Code of Practice to identify the specific rules that will apply based on their intended operations.

Helpful information on complying with COLREGs:

1. Access the COLREGs Operator Guidance Framework annexed to the Code for guidance on the specific requirements that apply to your vessel and proposed operation
2. Helpful general information about COLREGs can be found on the AMSA website

What competencies do I need to operate a vessel which is "autonomous and remotely operated marine equipment"?

Guidance can be identified within Chapter 2 of the Code with regards to operator competencies.

As a minimum, the operator should have:

1. A recreational boating licence or a certificate of competency from AMSA; and
2. Vessel specific training.

It may also be necessary for the operator of "autonomous and remotely operated marine equipment" to have specific autonomous vessel training, and for the operator or a member of the crew to have the appropriate training and qualifications to operate the radio or other communication equipment fitted on the vessel or in the control station.

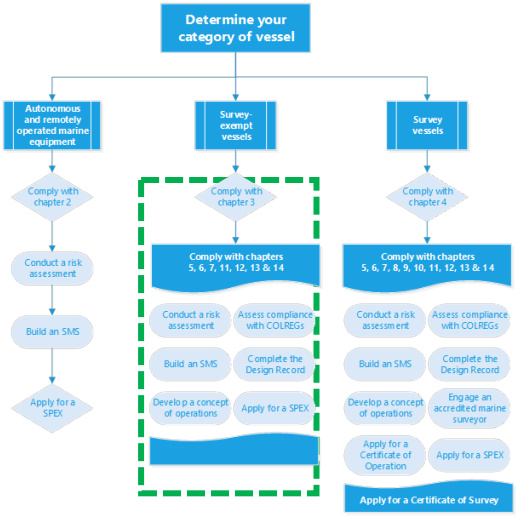
Applying for a specific exemption (SPEX)

Following successful completion of your Safety Management System, you will be able to apply to AMSA for a specific exemption from the requirement to have a certificate of survey and a certificate of operation (if that is your chosen approach). You will need to state you have complied with the Australian Code of Practice and supply your SMS to AMSA when you submit the SPEX application.

Process for applying for a specific exemption:

1. Use online form AMSA 547– Application for Specific Exemption.
2. Upload your prepared SMS and any other supporting documentation.
3. If you have any questions contact AMSAConnect (amsaconnect@amsa.gov.au)

6. SURVEY-EXEMPT VESSELS



This section explains the requirements for vessels which are "survey-exempt vessels," and provides guidance on how to meet these requirements. It also explains how to apply to AMSA for the necessary certification to enable operation.

A "survey-exempt vessel" is likely to be less than 12m in length and limited to an operational speed of 10 knots.

How does my vessel comply with the Code?

If your vessel fits the category "survey-exempt vessels", then you are obliged to comply with the following requirements in the Code:

- Prepare a **Concept of Operations**
- Prepare a **System Design Risk Assessment**
- Prepare and implement a **Safety Management System**.
- Prepare an **appropriate crewing assessment** in accordance with Marine Order 504.
- Ensure that the vessel **complies with applicable COLREGs** requirements. You may wish to complete the **Design Record Template** to assist with this step.
- Comply with the Chapters of the Code identified below

The applicable requirements for survey-exempt vessels are set out in Chapter 3.2, Table 3 of the Code.

Chapters of the Code that apply are:

- **Chapter 3 – Survey Exempt Vessels** provides definitions and what requirements your vessel will need to comply with, including where the vessel needs to comply with other chapters within the code. Chapter 3 also includes technical requirements for the design and construction of the vessel, including its construction, flotation, stability, machinery, electrical systems, anchor/station keeping system and so on.
- **Chapter 5 – Navigation System and Situational Awareness** covers systems used to acquire information and achieve COLREGS compliance.
- **Chapter 6 – Control System** provides analysis of the information acquired, decision making and execution.
- **Chapter 7 – Communication Systems** covers requirements for physical communication and transmitted communication to nearby stakeholders and control stations.
- **Chapter 11 – Contingency Planning and Vessel Recovery** covers contingency plans in the event of vessel malfunction, loss in communication and vessel retrieval.
- **Chapter 12 – Risk Assessment, Verification, Testing and Certification for Novel Systems** covers risk-based assessment, failure analysis and testing of novel systems.
- **Chapter 13 – Surveys and Review of Risk Assessment** covers verification of risk assessments.
- **Chapter 14 – Operations** covers SMS requirements, minimum crewing, and crew competencies as well as qualification requirements.
- **ANNEX A – Application of COLREGs Requirements and Evidence of Compliance.**
- **ANNEX B – Documentation Requirements.**

Preparing your Concept of Operations

The first step is to understand the basic operational concept of the vessel to ensure it is being designed to the needs of the proposed operation. This can be done by preparing a Concept of

Operations Document. This should be carried out and prepared with the assistance and input of the operator.

What is a Concept of Operations Document?

The Concept of Operations document, also referred to as a CONOPS, is a user-oriented document that describes an asset or system, its primary objective, its functions, its intended operational area and describe scenarios as to how it will achieve its objectives and functions. The concept of operations document is used as a basis of design.

What information do I need to prepare a Concept of Operations?

Some things to think about when preparing a Concept of Operations Document:

1. Outline what the vessel is required to do.
2. Elaborate on what you have described above by outlining the operational statements or scenarios for the vessel.
3. Identify what speed the vessel is required to go to achieve the operational objectives.
4. Identify where the vessel is intended to operate.
5. Identify what systems the vessel needs (examples listed below):

    a. means of propulsion
    b. means of buoyancy control
    c. means of navigation and collision avoidance
    d. means of power generation
    e. means of power storage
    f. methods of communications with the vessel
    g. means of achieving operational objectives

6. Define the tasks of the vessel and whether they are handled remotely by a human or autonomously.

A full list of requirements for the Concept of Operations document can be seen within ANNEX B of the Code. A Concept of Operations template can be found within Appendix 8.

System Design Risk Assessment: Design Risk Assessment, Verification, Testing and Certification for Novel Systems

You will need to complete a system design risk assessment for your vessel and proposed operation, as set out in Chapter 12 of the Code, to verify compliance with Chapters 5, 6, 7 and 11 of the Code. The risk assessment is to be completed on the system, and all sub-systems, and must identify the likelihood and impact of potential system failures on the vessel, third parties and the environment.

This type of risk assessment is required for all systems that are new in their implementation of onboard autonomous platforms and which do not meet the conventional vessel standards.

There are several recognised methodologies outlined within Chapter 12 of the Code that can be utilised for undertaking the required risk analysis, which include:

- **Failure Mode Effects Analysis (FMEA);**
- Failure Mode Effects and Criticality Analysis (FMECA);
- Fault Tree Analysis (FTA);
- Event Tree Analysis (ETA);
- Crisis Intervention and Operations Analysis (CRIOP), for systems involving remote operations from a control station; and
- Operating and Support Hazard Analysis (O&SHA), for systems involving remote operations from a control station.

A FMEA template example has been provided within Appendix 9. Note that each system will need to be broken down into subsystems and all components of the subsystem will need to be assessed.

Helpful information for carrying out a System Design Risk Assessment

1. An Example FMEA can be found within Appendix 9 of these Guidance Materials
2. Chapter 12 of the Code has some guidance to follow when preparing your system design risk assessment and testing.
3. For guidance on FMEA, FMECAs, Event Trees, Fault Trees, Markov Analysis etc. refer to the following locations:
    a. Aerospace Recommended Practice 4761/4761A
    b. Annex C to NSCV Subsection F1
    c. MIL-STD-882E

How do I prepare a Safety Management System (SMS)?

An SMS for a standard domestic commercial vessel will generally have the following sections:

- Vessel details, contact person, responsibilities, and appropriate crewing
- Procedures for onboard operations, emergency preparedness, hazardous occurrences and non-conformances and supporting documentation
- Risk assessment

The Code requires the inclusion of the following additional considerations:

- The need for an appropriate support vessel
- Means to alert other water users about the presence of your vessel
- Vessel data recording

Helpful information for developing an SMS

1. An example SMS can be found within Appendix 6 of these Guidance Materials
2. Chapter 14 of the Code has some guidance to follow when preparing your SMS
3. AMSA has also developed a guideline for developing an SMS that can be found here.

Preparing a Risk Assessment

A good place to start when preparing an SMS is to carry out a risk assessment. The risk assessment provides a foundation for your SMS as it identifies key daily tasks, emergency situations and risks to your vessels operation that need to be effectively controlled and managed.

The risks must consider your specific vessel, the operational environment, and people/other vessels/equipment on or near your vessel.

Preparing your risk assessment	
1	Start by outlining all the activities that your vessel is required to carry out.
2	Identify all the hazards associated with those activities.
3	For each hazard – Assess the risk using an appropriate risk matrix based on likelihood and consequence.
4	If possible, mitigate the hazard completely or put in place some mitigations to manage and lower the risk.
5	Assess how well your mitigations are working.
6	Re-evaluate: • If your mitigations are not working, adjust them, continual improvement is key. • If you start carrying out new activities, update your risk assessment.

Helpful information for developing a Risk Assessment

1. An Example Risk Assessment can be found within Appendix 1 of these Guidance Materials
2. For more information refer to AMSA 651 – Risk Management in the National System

Preparing an appropriate crewing assessment in accordance with Marine Order 504

(The information provided below is a summary of the information available on the AMSA website)

There are two key concepts related to crewing for domestic commercial vessels – 'minimum crewing' and 'appropriate crewing'.

Minimum crewing refers to the minimum number of certified and uncertified crew required, including the master, applicable to a vessel based on length. There is a table in Marine Order 504 that sets out minimum crewing.

Appropriate crewing refers to the number of certified or uncertified people that are needed to safely operate a vessel. It may change depending on the kinds of operation being carried out and the tasks involved. It must be determined by the vessel owner as part of the general safety duties, and needs to be documented in the vessel's safety management system. 'Appropriate crewing' is determined by conducting an 'appropriate crewing assessment', also called an 'appropriate crewing evaluation'.

Appropriate crewing must be equal to or higher than minimum crewing. Appropriate crewing may be the same as minimum crewing if the risk assessment carried out by the owner determines that minimum crewing is adequate to eliminate or minimise all risks.

Method for determining appropriate crewing

The method for determining appropriate crewing is an 'appropriate crewing assessment', also referred to as a 'crewing evaluation'. This assessment considers the kind of operations being performed, the operational environment, and the people on or near the vessel. Marine Order 504, Schedule 1, clause 6(6) provides a list of facts to be considered, including:

- What tasks will the vessel undertake and what will the crew be required to do?
- How many persons will the vessel carry and how will they be monitored?
- What equipment or aids to navigation are fitted on the vessel? What training do the crew require to be able to use such equipment or aids?
- Where will the vessel operate? What are the expected traffic, weather, sea, and visibility conditions? How will conditions affect the performance or duties of the crew?
- When will the vessel operate? How long will the vessel operate for? What arrangements are there for the crew to rest?
- How will fatigue affect the crew? How will fatigue be managed?
- How will the vessel's crew deal with an emergency? What training will be required?
- What maintenance tasks need to be carried out by the crew? Are the crew trained to carry out maintenance safely?
- How does the vessel's operations affect the environment? Are people onboard or near the vessel impacted by the vessel's operations?
- What are the qualifications and experience levels of the crew? Are their qualifications and experience sufficient to carry out the required duties?
- What support is available to the vessel if required? Are all crew aware of communications methods? Do they know how to seek help?

There is an appropriate crewing evaluation template available on the AMSA website, and replicated here as Appendix 3. Guidance on crewing for domestic commercial vessels, including 'appropriate crewing' requirements, and a number of examples, is available on the AMSA website.

Helpful information on preparing an appropriate crewing assessment:

1. Use online template for an Appropriate Crewing Evaluation.
2. If you have any questions contact AMSAConnect (amsaconnect@amsa.gov.au)

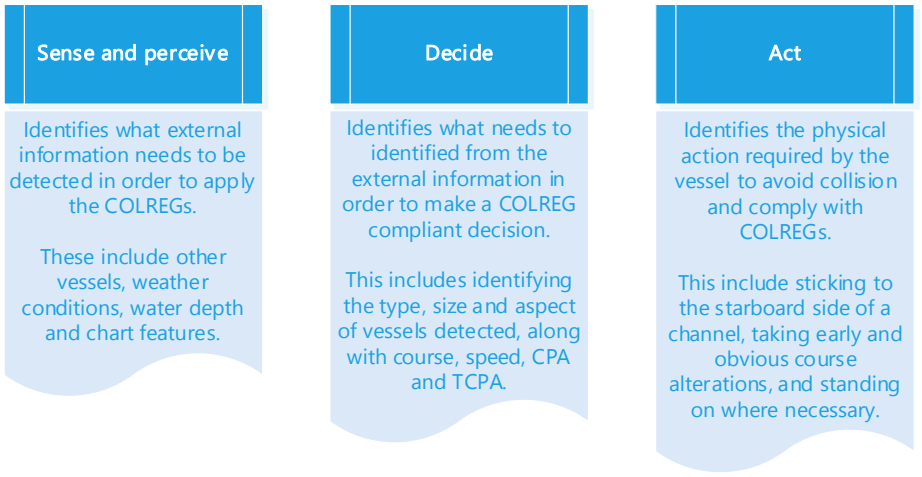
Complying with COLREGs (collision avoidance requirements)

What are COLREGS?

The Collision Regulations or COLREGs refers to the *Convention on the International Regulations for Preventing Collisions at Sea*. In Australia, the COLREGs are implemented through Commonwealth, state, and territory laws. COLREGs apply to all vessels, regardless of their size or nature of operation, in all navigable waters, from inland waters to the high seas.

Contravention of COLREGs may jeopardise the safety of life and endanger the environment. Under the Navigation Act 2012, it is an offence for an owner or master to operate a vessel to contravene the COLREGs (implemented by Marine Order 30 (Prevention of collisions) 2016).

Operators of autonomous and remotely operated vessels must demonstrate compliance with the COLREGs for each of their vessels. Annex 1 of the Code breaks down each rule into three functional capabilities to assist with autonomous vessel compliance:



What do operators need to do?

Operators must understand the COLREGs requirements that apply to their vessel and the specific operations being undertaken, and ensure they are compliant. To aid operators in undertaking this assessment, and in identifying the level of compliance, it is recommended that the Design Record Template and COLREGs Operator Guidance Framework be utilised.

Operators may wish to supply the completed Design Record to AMSA as part of the evidence for their application for a Specific Exemption or other certification.

Completing the Design Record

The **Design Record Template** has been prepared to assist operators and AMSA in identifying applicable COLREGs requirements and the level of compliance for a specific vessel and proposed operations. Design elements captured in this record include the operational context, communication systems, and the specifications of the sensor used to obtain data. These may then be used for navigational decisions and collision avoidance actions.

The Design Record Template is available to download with the Code, and it contains instructions on how to fill it out.

Using the COLREGs Operator Guidance Framework

The **COLREGs Operator Guidance Framework** has been prepared to assist operators to identify the COLREGs requirements that apply to a specific vessel and proposed operations.

The framework translates the stated and unstated capabilities described, and the terminology used, in the Rules of COLREGs into a vocabulary and format that is suitable for consideration of autonomous and remotely operated vessels. It is intended to be an enabling framework to:

- Help vessel designers understand what capabilities COLREGs requires vessels to have.
- Help operators understand what capabilities COLREGs requires and how mission planning can mitigate or remove the need for solving some of the more complex elements of COLREGs.
- Help regulators apply a consistent methodology for assessing the capability of a vessel with regards to COLREGs.

Information provided in the framework can be used by designers and operators to assess the capability of their vessel with regards to COLREGs and the mission types that they are considering. Designers and operators are free to choose whether a specific capability will be provided onboard, remotely through human oversight, or a combination of both. Where capabilities cannot feasibly be achieved or by preference, then the framework proposes mission constraints which can be implemented to mitigate or eliminate scenario specific risks.

Helpful information on complying with COLREGs

1. Access the COLREGs Operator Guidance Framework annexed to the Code for guidance on the specific requirements that apply to your vessel and proposed operation
2. Helpful general information about COLREGs can be found on the AMSA website here.

What competencies do I need to operate a vessel which is a survey-exempt vessel?

Guidance is available in Chapter 14 of the Code with regards to operator competencies.

As a minimum, the operator should have:

1. Certificate of Competency that would permit the person to operate an equivalent crewed vessel, unless an exemption from AMSA from this requirement has been obtained; and
2. Additional training or certification relevant to monitoring or control of an autonomous or remotely operated vessel; and
3. Vessel specific training.

It may also be necessary for the operator of a Survey Exempt Vessel to have specific Autonomous vessel training, and or a commercial maritime qualification. Your appropriate crewing assessment (described above) will assist you to identify the required competencies.

Once I have compiled my documentation, how do I apply for certification?

Once you have compiled your concept of operations, design record, system design risk assessment, safety management system, appropriate crewing assessment, and confirmed you have complied with applicable chapters of the Code, you will need to apply to AMSA for your certification.

As described earlier in these Guidance Materials, all vessels must have a certificate of operation and certificate of survey, unless an exemption applies. You should consider the regulatory treatment most suitable for your circumstances – for example it could be a specific exemption from

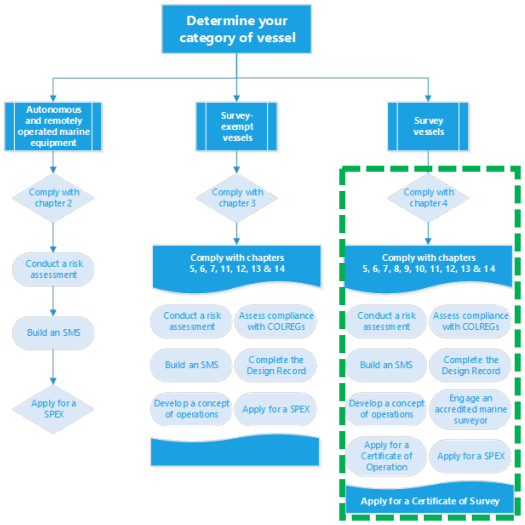
the requirement to have any certification, or it could be having a certificate of operation and certificate of survey, with a specific exemption from the requirement to have a certificate of survey. You can seek advice from AMSA, an accredited marine surveyor, or a Class Society to help determine the best path for you.

Once you have decided which regulatory approach is best for your circumstances, you will need to fill out the relevant application/s and supply your documentation as evidence of compliance with the Australian Code of Practice.

Process:

1. Determine the regulatory approach that is most appropriate for you (with advice from AMSA etc).
2. Submit the relevant application forms with your documentation as supporting evidence
   a. AMSA 547– Application for Specific Exemption
   b. Application for certificate of operation: https://www.amsa.gov.au/forms/application-certificate-operation
   c. Application for certificate of survey: https://www.amsa.gov.au/forms/application-certificate-survey-andor-load-line-certificate-domestic-commercial-vessel

7. SURVEY VESSELS



This section explains the requirements for vessels which are "survey vessels," and provides guidance on how to meet these requirements. It also explains how to apply to AMSA for the necessary certification to enable operation.

Any vessel which is not "autonomous and remotely operated marine equipment" or a "survey-exempt vessel", is likely to be a "survey vessel".

How does my vessel comply with the code?

If you have identified that your vessel falls into the category of "Survey Vessel", then you are obliged to comply with the following requirements in the Code:

- Prepare a **Concept of Operations**
- Prepare a **system design risk assessment**
- Prepare and implement a **Safety Management System**
- Prepare an **appropriate crewing assessment** in accordance with Marine Order 504.
- Ensure that the vessel **complies with applicable COLREGs** requirements. You may wish to complete the **Design Record Template** to assist with this step
- Comply with the Chapters of the Code identified below

A vessel which is a "Survey Vessel" will need to comply with the requirements set out within Chapter 4 of the Code, including those set out in Chapter 4.2, Table 4 of the Code.

Chapters of the Code that apply to me:

1. **Chapter 4 – Vessels in survey**
2. **Chapter 5 – Navigation System and Situational Awareness** covers systems used to acquire information and achieve COLREGS compliance.
3. **Chapter 6 – Control System** provides analysis of the information acquired, decision making and execution.
4. **Chapter 7 – Communication Systems** covers requirements for physical communication and transmitted communication to nearby stakeholders and control stations.
5. **Chapter 8 – Fire Safety Systems**
6. **Chapter 9 – Engineering, Electrical and Auxiliary Systems**
7. **Chapter 10 – Anchor Systems**
8. **Chapter 11 – Contingency Planning and Vessel Recovery** covers contingency plans in the event of vessel malfunction, loss in communication and vessel retrieval.
9. **Chapter 12 – Risk Assessment, Verification, Testing and Certification for Novel Systems** covers risk-based assessment, failure analysis and testing of novel systems OR the vessel may comply with the rules of a Recognised Organisation
10. **Chapter 13 – Surveys and Review of Risk Assessment** covers verification of risk assessments.
11. **Chapter 14 – Operations** covers SMS requirements, minimum crewing, and crew competencies as well as qualification requirements.
12. **ANNEX A – Application of COLREGs Requirements and Evidence of Compliance.**
13. **ANNEX B – Documentation Requirements.**

Guidance on preparing documentation

Please refer to pages 18-24 of these Guidance Materials for information on how to comply with the documentation requirements listed above, including preparation of a **Concept of Operations, System Design Risk Assessment**, **Safety Management System,** and **appropriate crewing assessment**.

Certification requirements

As described earlier in these Guidance Materials, all vessels must have a certificate of operation and certificate of survey, unless an exemption applies. You should consider the regulatory treatment most suitable for your circumstances – for example it could be a specific exemption from the requirement to have any certification, or it could be having a certificate of operation and certificate of survey, with a specific exemption from some applicable requirements of each certificate. You can seek advice from AMSA, an accredited marine surveyor, or a Class Society to help determine the best path for you.

For “Survey Vessels”, a common approach is likely to be applying for a certificate of operation and certificate of survey, with a specific exemption from crewing requirements, and the survey-specific requirements that are not relevant for the vessel. The below guidance is written based on this specific regulatory approach.

Confirm requirements with AMSA early

Early in your planning you should reach out to AMSA to start discussions about the exact requirements and process which will apply to your vessel. This will help to provide certainty in what AMSA will expect to see in your application for a Certificate of Survey, Certificate of Operation, and Specific Exemption.

Applying for a Certificate of Survey (CoS)

If you are carrying out a new design, you can start the application process for a Certificate of Survey whilst undertaking the design. This will give AMSA some time to evaluate your application and provide you a letter that outlines which surveys are required for the application. Obtaining early advice from AMSA will also ensure that the vessel complies with the appropriate design and construction standards.

Who needs to survey my autonomous vehicle and how often?

If you intend to design and build a domestic commercial vessel (DCV), or you intend to undertake significant alterations or additions to a DCV, you may need to contact an accredited marine surveyor or an AMSA recognised organisation to have your vessel surveyed.

Importantly, as autonomous and remotely operated vessels are considered to be ‘novel vessels’, AMSA may require the surveys to be undertaken by an AMSA recognised organisation. If AMSA requires the surveys to be undertaken by a recognised organisation, the recognised organisation may require compliance with their own rules and requirements in addition to, or in lieu of, the requirements contained in the Code of Practice.

For more information visit the AMSA website; Find an accredited marine surveyor:

https://www.amsa.gov.au/vessels-operators/domestic-commercial-vessels/find-accredited-marine-surveyor

For more information, including a list of Recognised Organisations, visit the AMSA website; How flag State administration works in Australia:

https://www.amsa.gov.au/vessels-operators/flag-state-administration/how-flag-state-administration-works-australia

For more information on certificates of survey visit the AMSA website: Certificates of survey:

https://www.amsa.gov.au/vessels-operators/domestic-commercial-vessels/certificates-survey

You will need to also refer to the Code to ensure your vessel complies with the relevant vessel scheme.

Following completion of all required surveys which may include Plan Approval as well as construction and commissioning surveys, your surveyor will submit documentation to AMSA and you will be able to finalise your application form. More information regarding the process can be found here.

Process:

1. Engage a Marine Surveyor or Recognised Organisation
2. Prepare a Concept of Operations
3. Carry out design (where applicable)
4. Assess compliance with COLREGS, supported by filling out the Design Record.
5. Apply for a Certificate of Survey here – AMSA521 Application for a certificate of survey and/or load line certificate for a domestic commercial vessel
6. Submit and upload documentation

Applying for a Certificate of Operation (CoO)

Chapter 14 of the Code outlines the operational requirements for "Survey Vessels", including in relation to the Safety Management System. Following successful completion of your Safety Management System, appropriate crewing evaluation and operational risk assessments, you will be able to apply to AMSA for a Certificate of Operation. There are several declarations that need to be made to obtain a CoO, so it is essential that all documentation required has been completed.

Process:

1. Prepare Risk Assessment
2. Carry out an appropriate crewing evaluation
3. Complete a Safety Management System
4. Apply for a Certificate of Operation here - AMSA504 – Application for Certificate of Operation
5. Submit and upload documentation

Applying for a specific exemption (SPEX)

You should submit your application for a specific exemption at the same time you submit your applications for Certificate of Survey and Certificate of Operation. Prior to submitting you should already have confirmed with AMSA what you will seek exemption from, the type of conditions to propose to ensure operational safety, and the evidence required to support your application.

You will need to state you have complied with the Australian Code of Practice and supply your SMS to AMSA when you submit your SPEX application.

Process for applying for a specific exemption:

1. Use online form AMSA 547– Application for Specific Exemption.
2. Upload your prepared SMS and any other supporting documentation.
3. If you have any questions contact AMSAConnect (amsaconnect@amsa.gov.au)

What competencies do I need to operate a Survey Vessel?

Guidance can be identified within Chapter 14 of the Code with regards to operator competencies.

As a minimum, the operator should have:

1. Certificate of Competency that would permit the person to operate an equivalent crewed vessel.
2. Additional training or certification relevant to monitoring or control of an autonomous or remotely operated vessel; and
3. Vessel-specific operational training.

What do I need to do if I make modifications to my vessel?

If you need to make modifications to your vessel you may need to apply to change the details of your certificate of survey. More information can be found at the AMSA website, Certificates of survey:

https://www.amsa.gov.au/vessels-operators/domestic-commercial-vessels/certificates-survey

You will need to also refer to the Code to ensure your vessel complies with the relevant vessel scheme.

8. Example: Compliance for a small Autonomous Underwater Vehicle (AUV)

This section provides an example of how a small AUV would comply with the requirements in the Australian Code of Practice.

Scenario: A Research Foundation has purchased a REMUS 100 AUV to help them map and monitor the health of a Reef. This section outlines the process needed for the REMUS to be operated by the Reef Foundation in compliance with the Code.

What vessel scheme is this?

The REMUS 100 is a small AUV of approximately 2 metres in length with a top speed of 5 knots and therefore falls within the category of "Autonomous and remotely operated marine equipment" as identified within Chapter 2 of the Code.

Compliance with the requirements of Chapter 2

A **risk assessment has been prepared** (refer Appendix 1)

An **SMS has been prepared** (refer Appendix 6)

A printed copy of the risk assessment and SMS will be located at each operating / monitoring station, with an electronic copy easily accessible.

An **appropriate crewing evaluation** has been carried out:

- For a vessel less than 12 metres, Marine Order 505 requires a minimum of one certified crew member. Under NSCV Part D – Crew Competencies – the minimum qualification for the AUV operator will be a Coxswain Grade 2 NC certificate of competency.
- However, the Code at this stage only calls for a Recreational Boat Licence and additional specialist training in the operation of an AUV from a reputable provider will also be required (noting that a Specific Exemption will need to be sought from AMSA to enable this approach).
- This is due to the operation where the REMUS 100 will be launched, operated, and monitored from a support vessel. The REMUS will remain with 3 nautical miles of this vessel.

REMUS 100 does not contain any **liquid fuel or hazardous materials** that poses a risk to the environment. It will also be operating in waters shallower than 20 metres, and therefore easily retrievable if it stops operating.

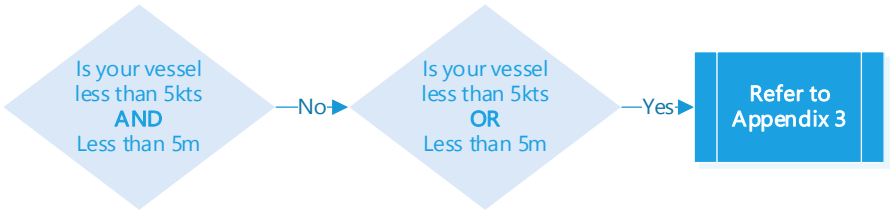
COLREGS: Due to the construction and nature of operation, REMUS is unable to comply with the light and sound signalling requirements of COLREGs. Due to this it will continually have a support vessel displaying Code flag Alpha on station to warn mariners of the underwater operations and ensure other water users keep clear. The support vessels will comply fully with the requirements of COLREGs.

9. Example: Compliance for two medium Autonomous Surface Vessels (ASVs)

This section provides an example of how two medium ASVs would comply with the requirements in the Australian Code of Practice.

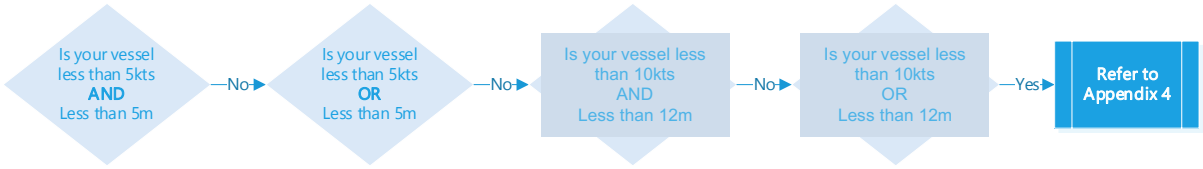
Scenario: A Marine Park Authority have invested in two new autonomous vessels, the 5-metre long WAM-V 16 ASV and 6 metre long WAM-V 20 ASV. They intend to use these ASVs to conduct hydrographic surveys of hard-to-reach areas and carry out research to enhance protection efforts. For this example, both vessels are equipped with the same navigational and sensory equipment.

What vessel scheme is this?



The **WAM-V 16 ASV** has a length of 5m and a top speed of 11kts. The extract above from figure 3, indicates we need to refer to Appendix 3. Appendix 3 has a matrix to help determine whether the ASV can be classed as "autonomous and remotely operated marine equipment", based on the kinetic energy produced.

The WAM-V 16 has a maximum displacement of 320kg and top speed of 11knts, this puts the kinetic energy in the red on the matrix, meaning the vessel's category is a 'survey-exempt vessel'.



The **WAM-V 20 ASV** has a length of 6m and a top speed of 20kts. The extract above from figure 3, indicates we need to refer to Appendix 4. Appendix 4 has another matrix to help determine whether the ASV can be classed as a survey-exempt vessel, based on the kinetic energy produced.

The WAM-V 20 has a maximum displacement of 600kg and top speed of 20knts, this puts the kinetic energy off the chart on the matrix, meaning we need to calculate the kinetic energy ourselves and compare it with the figure in the yellow box. Using the formula provided in appendix 4 the WAM-V 20's kinetic energy is 120000kj, which is lower than 144000kj, therefore the vessel's category is a 'survey-exempt vessel'.

Compliance with the requirements of Chapter 3 of the Code – WAM V 20

The **WAM V 20** must meet the requirements as specified in Table 3 of the Code.

Construction	Yes, complies with the required outcomes of NSCV C3
Floatation	Has two inflatable hulls, each split into two sections, therefore has substantial reserve buoyancy
Stability	The 2:1 length-to-beam ratio along with the articulation and suspension systems make the WAM-V an exceptionally stable and seaworthy platform.
Machinery – fuel tanks, pipes, shafting, etc.	2 x 75 litre fuel tanks, built in to the two hulls meeting the requirements of NSCV Subsection C5A Clause 4.7
Steering	Widely spaced engine pods enable a high degree of manoeuvrability, allowing the vessel to turn 360° within its own length.
Batteries	Batteries are required for engine starting and batteries to power instrumentation are located on the elevated stable platform in a watertight secure location.
Weathertight and watertight integrity	The WAM-V's hulls are each broken down into 3 compartments. Two thirds of the hull are inflatable, and the other portion contains the fuel tank, which is re-enforced to reduce likelihood of penetration. As the hulls are independent from the rest of the vessel, there is minimal risk for water ingress therefore weathertight and watertight integrity is sound.
Electrical	All electronics are protected from the elements and connected to two independent power supplies. The power levels and consumption are monitored from the control station.
Fire equipment	Each 20HP outboard engine has a power of less than 15KW and therefore does not need a fire extinguishing system.
Navigation system and situational awareness	See Chapter 5
Control system	See Chapter 6
Communication system	See Chapter 7
Anchor or station keeping system	The integrated onboard control system includes a station keeping system, allowing the WAM-V to remain in one position. The vessel has two independent means of propulsion and fuel system to meet this requirement.
Contingency planning and vessel recovery	See Chapter 11
Risk analysis, testing, software integrity, and cyber security	See Chapter 12
Surveys and verifications	See Chapter 13
Operations	See Chapter 14

Compliance with Chapter 5

Application with NSCV C7C

The WAM-V fully complies with the required outcomes and deemed to satisfy solutions of this Subsection, apart from the following equipment being located at the vessel control/monitoring system:

- Radar display
- Visual display of 180-degree camera
- Electronic chart display
- AIS monitoring
- Echo sounder / sonar reading
- Speed and distance indicator
- Microphone output with directional reading

WAM-V uses a satellite compass in lieu of a magnetic compass, with a fibre optic gyro as back-up.

Additional navigational and situational awareness systems

- Lidar (Design Record reference (DR) 4.3)
- Omnidirectional microphones (DR 4.6)
- Class A AIS Transceiver (DR 4.5)
- Multi-constellation GNSS receiver (DR 4.10)
- Speaker system capable of making an efficient sound signal as required by Rule 33 and Annex III of COLREGs (DR 6.2)

Limited vessel operations due to compliance with COLREGs:

- No navigation in or near Traffic Separation Schemes.
- Avoid navigating in Narrow Channels or Fairways.
- Two operators on station when the WAM-V is navigating in the two-way route in the Great Barrier Reef.

Compliance with Chapter 6

The WAM-V will follow pre-planned tracks and search patterns during its operation. The vessel monitoring station can take control of the vessel remotely in case of emergency.

Upon detecting a vessel or object, the operator will assess the situation, create an amended mission plan, and send it to the WAM-V to follow. The WAM-V's progress along the track will be

continuously monitored along with the movements of other vessels to ensure COLREGs are always complied with.

Compliance with chapter 7

The WAM-V is not designed for persons to be onboard, therefore does not have any internal communication system, nor does it have the ability to transmit a distress or urgency message due to there being no concern for safety of life onboard.

The WAM-V is equipped with external speakers and microphones, to fully comply with the sound signal requirements of COLREGs.

The WAM-V is also fitted with the relevant navigation lights for her intended operation, with the addition of NUC and RAM lights as required by Rule 27 of COLREGs.

The operating/monitoring station is set up to transmit voice to engage in two-way communications with individuals near the vessel.

WAM-V is fitted with a Class A AIS transceiver.

Compliance with chapter 11

Pre-programmed actions by WAM-V

Loss of communication

- Continue with operation.
- After 10 minutes, if no communication has been made with operating station, the WAM-V will proceed to a pre-programmed designated safe haven.
- Once within Safe Haven, vessel is to remain on position.

Loss of situational awareness sensor/s

- Alert control station.
- Display Not Under Command lights and update AIS.
- Proceed slowly to a pre-programmed safe haven if safe to do so.
- Once within Safe Haven, vessel is to remain on position.

Loss of steering or propulsion

- Alert control station.
- Display Not Under Command lights and update AIS.
- Attempt to remain in position (WAM-V has two independent steering and propulsion systems).
- After analysis by control station, proceed slowly to the closest of four designated safe havens.
- Once at safe haven, remain in position.

Compliance with chapter 12

See example design FMEA analysis for AUV systems within Appendix 9.

Compliance with chapter 13

See example concept of operations structure in Appendix 8

Compliance with chapter 14

See example SMS in Appendix 6 with the following emergency procedures

Emergency Procedures

Collision with another vessel

- Assess damage
- Inform mission controller and DP of situation
- Record incident
- Assess situation
- Contact authorities
- Coordinate all operations
- Contact other vessels in vicinity to assist
- Record the incident as soon as practicable
- Immediate assistance: local VTS (VHF 16) or emergency services (000)

Vessel grounding

- record last reported position and state.
- immediately inform mission controller of situation.
- assess situation then plan and coordinate appropriate action.
- notify DP and relevant maritime authorities

Vessel flooding

- record last reported position and state.
- Inform mission controller of situation.
- assess situation then plan and coordinate appropriate action.

Vessel fire

- record last reported position and state.
- assess immediate risk and take any actions necessary to avoid damage to any other property of risk to other vessels.
- inform mission controller and DP of situation.
- assess situation and plan and coordinate appropriate action.

Loss of position

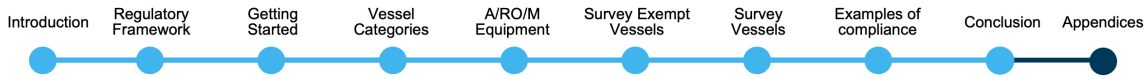
- record last reported position and assess proximity to navigational hazards.
- carry out diagnosis of potential causes.
- assess situation then plan and coordinate appropriate action.
- If position is not re-established, notify relevant maritime authorities

Loss of control or steering

- Inform Mission controller and DP of situation
- Record incident
- Assess location of USV in proximity to other vessels and navigational hazards
- Carry out diagnostics and actions to regain control
- Decide when to communicate situation to relevant authorities.
- Deploy assistance / recovery vessel, if necessary.

Loss of communication

- Inform Mission controller and DP of situation.
- Record incident.
- Assess location of USV in proximity to other vessels and navigational hazards.
- Carry out diagnostics and actions to regain communication.
- Determine the correct date haven, through positional checks or AIS.
- Deploy assistance / recovery vessel.



10. Conclusion

These Guidance Materials aimed to support the use of the Australian Code of Practice, including by operators wishing to demonstrate compliance with the Code to seek certification by AMSA under the Australian maritime regulatory framework.

We welcome your feedback to info@tasdcrc.com.au regrading what you found helpful or unhelpful about these Guidance Materials, and identifying any areas where more support is needed.

APPENDIX 1. GLOSSARY

Actuation

In the maritime context of actuation is used to describe the control of the vehicle's motion. For example, a vehicle with a single propeller and fins can be described as under-actuated because its motion might be driven in more directions that it can provide thrust. Vehicles that have multiple thrusters pointed in different directions, such as most remotely operated vehicles, can move from side to side, forward and back, and up and down. These vehicles are fully actuated. Some AUVs are designed to be fully actuated. An actuator is any part that drives movement in a vehicle, typically some form of electric motor.

AIS (Automatic Identification System)

The AIS is a standard of radio transponders on surface craft that transmits surface craft position, speed, and other navigational safety information. The signals may be received by other surface craft, land- based stations or by satellite.

Autonomy

Autonomy is the ability to self-govern actions. In the robotic sense this relates to the ability to perceive the environment using sensors and to take independent steps to achieve some outcome. For example, a robot mission may illustrate a desired track. The robot uses some location reference, such as GPS to establish its location. The required heading and distance are calculated, and the robot then commands its various control and propulsion systems to move and turn as necessary. The measurements are repeated at regular intervals and the plan of caution is updated as necessary. Autonomous systems range in complexity from simple logic systems that, for example, heat a room to a given temperature, through to complex, multi- layered systems that may navigate through the world, avoid hazards, and perform operations with limited human instruction. It is important to note that there are different levels of autonomy. At the base levels the autonomy exists to aid human performance and reducing cognitive load. Systems that maintain a set depth while a human pilot controls a robot is an example of a low-level autonomous system. High level autonomy may be supervised by humans but typically is performing actions independently.

ASV (Autonomous Surface Vessel)

An Autonomous Surface Vessel is a surface-based craft with no human occupants. The craft may be remotely controlled, driven by autonomous systems or some combination.

AUV (Autonomous Underwater Vehicle)

An Autonomous Underwater Vehicle is a robotic platform that can operate independently of human control in the underwater environments. There is a broad range of hull forms, though the most popular is the torpedo shape, for its hydrodynamic efficiency. Other shapes are more cubic, with propellers pointed in multiple directions. These are less hydrodynamically efficient but are designed to operate in close confines, or with a high degree of freedom to avoid obstacles. AUVs are deployed to undertake a wide range of missions, including scientific observation, mapping, search and recovery, mine detection, etc.

DVL (Doppler Velocity Logger)

A DVL uses a measured Doppler Shift from the pings of multiple beams to build a solution for movement. A DVL is the same physical instrument as an ADCP and has 3-5 beams arranged at defined angles. Each beam gives along-beam velocity, which can then be used to calculate a 3D solution when the beam data are combined. DVLs may provide a reference for movement through

water but reference with respect to a solid seabed is preferred as it is assumed not to be in motion, thus a reference for speed over ground, which can be used to constrain IMU drift errors.

Exemption 07

Exemption 7 is the AMSA Marine Safety Temporary Operations Exemption. This exemption is available for short periods where an owner or surveyors who need to operate temporarily without having the required certificates. This exemption has in the past been used to facilitate the deployment of autonomous vehicles prior to specific exemption availability.

Fibre-Optic Gyro

A fibre-optic gyroscope (FOG) consists of typically sets of looped fibre optic cable, oriented in different axes. The travel time of light passing through the fibre optic cable is impacted by the rotation of that loop, owing to a principal of Special Relativity called the Sagnac Effect. The FOG is at the centre of many high-grade inertial measurement units, where it feeds precise 3D rotation data.

Hydrophone

A hydrophone is a microphone that can be used underwater to detect sound. AUVs often are equipped with fish tags and, in scenarios where a vehicle is missing, a hydrophone with a directional bias can be used to detect the bearing with the strongest signal. This can dramatically reduce search times as an operator can close on a tag by conducting a search pattern and repeating a direction-finding exercise.

Hydrophones are typically sensitive in a nominal frequency band; thus, it is necessary to ensure that the hydrophone selected is appropriate to detect the intended signal.

IMU (Inertial Measurement Unit)

An IMU is an instrument that measures rotation around and acceleration across axes. IMUs use a combination of accelerometers and gyroscopes to provide motion reference, which is then used to feed a navigation solution.

INS (Inertial Navigation System)

An INS is an IMU that also calculates a navigation solution. The acceleration and rotation data from the built-in IMU is integrated over time by a computer and, along with an initial fix, provides an Earth-references position. INS systems are necessary for high-grade positioning underwater as GPS signals are not available. Navigation based on dead- reckoning (acceleration and rotation) is subject to drift and accumulating errors, thus the position fix may need to be updated over time. In addition, technologies, such as DVL, can be used to constrain the drift of the INS and thus ensure more reliable positions over time.

LARS (Launch and Recovery System)

A LARS is used to safely deploy and recover an autonomous marine system. LARS are built to protect sensitive equipment that may be protruding from the hull of the vehicle, such as acoustic modems and sonars. The intention of a LARS is to reduce risk to both the human operators and the vehicle itself. Some LARS are extended from the main deck of a ship and lowered into the water, others may be lowered over the side and form a guided crane lift. LARS design, installation and operation is an essential aspect of large autonomous marine system deployment. Smaller AMS, which may be person-portable, can still be augmented with LARS to reduce the likelihood of injury or equipment damage.

NSCV

The National Standard for Commercial Vessels (NSCV) provides standards for vessel survey, construction, equipment, design, operation, and crew competencies for domestic commercial vessels. (https://www.amsa.gov.au/about/regulations-and-standards/national-standard-commercial-vessels-nscv)

NTM/NOTAM (Notice to Mariners)

A notice to mariners is a bulletin issued by the relevant authority with information on navigational hazards and changes to navigation aids. Notices to mariners are advisable when conducting autonomous marine activity and may be a condition of operation in some jurisdictions.

RAS (Robotics, Autonomous System)

Robotic Autonomous Systems is a catch-all name given to remote and autonomous vehicles. RAS covers aerial, surface and underwater vehicles and include platforms that are either remotely or autonomously controlled.

ROV (Remotely Operated Vehicle)

A Remotely Operated Vehicle is a robotic platform that is tethered to the surface, typically with a cable. The cable provides two-way data. Power may be supplied by a battery in the vehicle or over the cable, which in larger robots it is more common. ROV pilots at the surface directly command the operation of the robotic platform. There are often autonomous systems onboard the ROV, though they are commonly at a low level of autonomy, e.g., keeping depth or orientation. ROVs are extensively used in the oil and gas industry, mine countermeasures, search and rescue, infrastructure inspection and marine science. ROVs are particularly useful for deployments where fine manipulation and human intelligence is desired.

SAFETY MANAGEMENT SYSTEM (SMS)

A safety management system (also referred to as an SMS) is a systematic approach to managing safety. By following established policies, practices, and procedures you ensure the safety of vessels and the people on board. A vessel's SMS should be based on a risk assessment of operations and should describe how safety, maintenance and operation is managed on your vessel. (amsa.gov.au/vessels-operators/domestic-commercial-vessels/safety-management-systems)

Specific Exemption (SPEX)

A specific exemption can be granted by AMSA for operation without meeting specified regulatory requirements under the National Law, such as having a certificate of survey or operation. Specific Exemptions often have conditions imposed on them aimed at providing a minimum level of operational safety, and these are generally determined collaboratively between operators and AMSA. Examples of conditions for a small AUV are:

- The owner and master must ensure that the relevant Port or VTS authority has been advised of the AUV REMUS 100 movements at times of operation. A radio watch on the relevant VHF channel must be maintained at all times during operations.

- The owner must ensure that the AUV REMUS 100 has a unique vessel identifier attached to the vessel at all times.

Whether you have a Specific Exemption or not you will still need a Safety Management System for your vessel and its intended operations.

Specific exemption is on a per-vessel basis. See https://www.amsa.gov.au/forms/application-specific-exemption for more details.

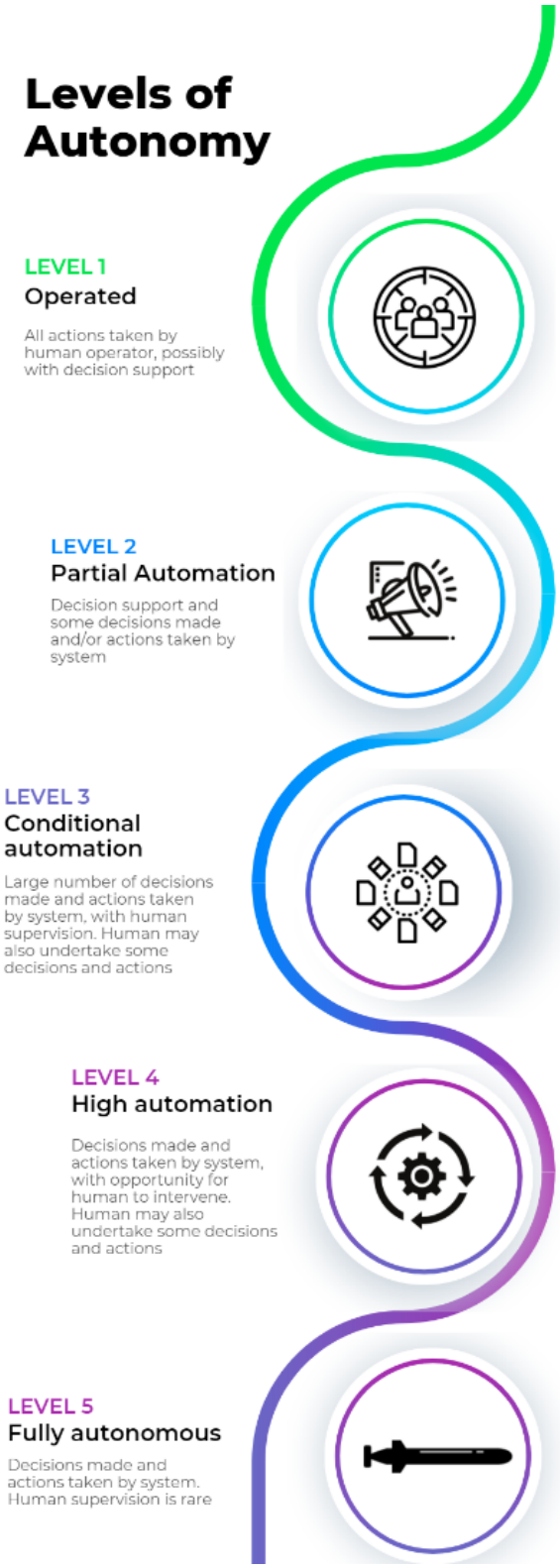
USV (Un-inhabited Surface Vehicle)

An Uninhabited or Unmanned Surface Vehicle or Vessel is a surface-based craft with no human occupants. The craft may be remotely controlled, driven by autonomous systems or some combination.

Levels of autonomy

What are levels of autonomy?

Levels of autonomy describe the decision-making ability of a system. This affects the complexity of its programming and the importance of determining trusted autonomy and assurance of a system's ability to reliably preform. The figure to the right defines the 5 key levels of autonomy.



For example: In a system with a level one of autonomy, all actions are taken by a human operator. While it is possibly this may be from a remote location, it can be expected that in a survey compliant vessel, a competent, trained operator will have the skills and recourses required to negotiate a collision avoidance situation. The skills required to commercially operate an Autonomous or Remotely Operated Vessel are covered in Chapter 14 – Operations.

In a Level 5 system there is no human input at the time of decision making. In a collision avoidance situation, it is necessary to have a sufficiently robust decision-making protocol to ensure a vessel can comply with the COLREGs and the COP. This decision-making protocol relies on the onboard systems, covered by Chapter 5 – Navigation Systems and Situational Awareness and Chapter 6 – Control System.

Section 1.5 of the COP outlines that vessels subject to this COP are expected to have one of these levels of autonomy.

APPENDIX 2. RISK ASSESSMENT EXAMPLE

References: Risk Management in the National System: A Practical Guide – Dec 2020

amsa.gov.au/sites/default/files/risk-management-national-system.pdf

amsa.gov.au/vessels-operators/domestic-commercial-vessels/risk-management-national-system

Example risk assessment

HAZARDS	POTENTIAL CONSEQUENCE	INHERENT RISK			RISK CONTROL MEASURES	RESIDUAL RISK		
		Consequence	Likeli-hood	Risk Rating		Consequence	Likeli-hood	Risk Rating
Manual handling	Injury to personnel Equipment damage	3	3	9	• Two people minimum are used to move equipment >15kg • Operations are planned to minimise manual handling of assembled equipment • Toolbox talk conducted prior to operation	3	1	3
Slips, trips, falls	Injury to personnel Equipment damage	3	3	9	• Launch area clear of obstructions • Avoid operations in adverse weather conditions • Safety boots to be worn	3	1	3
Miscommunication	Injury to personnel Equipment damage	3	3	9	• Clear lines of communication • Reduce background noise • Designate operation leader	3	1	3
Obstructions	Collision Damage to equipment Loss of equipment	4	3	12	• Careful selection of operational area • Inspection of area before first operation • Continuous monitoring of equipment location during operation • Operation plan to be reviewed by another operator	3	2	6
Interaction with other water users including swimmers and vessels	Collision Damage to equipment Injury	4	3	12	• Careful selection of operational area • Inspection of area before first operation • Continuous monitoring of equipment location during operation	3	1	3

	Damage to other vessels Loss of equipment				• Operation plan to be reviewed by another operator • Support vessel to continuously monitor other vessel movements • Broadcast warnings through state/territory/commonwealth maritime authorities • Broadcast safety messages through VHF at start and end of operation • Display Alpha flag for underwater operations			
Operating around cold water	Falling overboard Loss of life hypothermia	5	3	15	• Minimum two trained first aid personnel • All crew to wear lifejackets • Crew to wear sufficient wet/cold weather gear • Spare dry clothing / towels at hand	2	2	4

Risk assessment signed by Designated Person: _____ on _____

Name and position *Date of signing*

Acknowledgment of understanding by crew:

Name	Role	Date	Signature

CONSEQUENCE					
LIKELIHOOD	**1 Insignificant**	**2 Minor**	**3 Moderate**	**4 Major**	**5 Catastrophic**
5 Common	**5**	**10**	**15**	**20**	**25**
4 Likely	**4**	**8**	**12**	**16**	**20**
3 Possible	**3**	**6**	**9**	**12**	**15**
2 Unlikely	**2**	**4**	**6**	**8**	**10**
1 Rare	**1**	**2**	**3**	**4**	**5**

RESIDUAL RISK	Action
Extreme	**Unacceptable risk – Risk control measures required**
High	**Unacceptable risk – Risk control measures required**
Moderate	**Acceptable risk – Additional risk control measures recommended**
Low	**Acceptable risk**

LIKELIHOOD SCALE	
Common	The event is expected to occur in most circumstances / commonly repeating / occurs weekly
Likely	The event will probably occur in most circumstances / known to occur / occurs monthly
Possible	The event might occur, say yearly / has a 1 in 20 chance of occurring
Unlikely	The event could occur at some time, say once in every 10 years / has a 1 in 100 chance of occurring
Rare	Event may only occur in only exceptional circumstances / less than a 1% chance of occurring

APPENDIX 3. APPROPRIATE CREWING EVALUATION TEMPLATE

(NOTE this template has been extracted by the AMSA website in March 22)

Appropriate crewing evaluation—template

Use this appropriate crewing evaluation template to record your crewing assessment and appropriate crewing outcomes in your vessel's safety management system.

Factors to be considered	Evaluation—Consider the following questions
Tasks or activities of the vessel • Demands on the master and crew of each task or activity; and • Safe navigation of the vessel • Mooring arrangements	What tasks will the vessel undertake and what will the crew be required to do?
The number of persons to be carried • Effective monitoring of passengers by the crew	How many persons will the vessel carry and how will they be monitored?
Design characteristics of the vessel • General arrangement • Machinery and equipment	What are the design characteristics of the vessel that may effect crewing numbers?
Competency of master and crew for: • Use of technological aids to safety and navigation in addition to mandatory requirements • Training requirements for use of aids • Familiarisation training	What equipment or aids to navigation are fitted on the vessel and how does that impact on the crew's duties or tasks? What training to the crew require to be able to use such equipment or aids? What should familiarisation training include?

Factors to be considered	Evaluation—Consider the following questions
The area of operation • Expected weather, climate, water temperature, sea conditions. Refer to guidance from the Bureau of Meteorology • Traffic, visibility • Availability of assistance	Where will the vessel operate? What are the expected traffic, weather, sea, and visibility conditions? How will conditions affect the performance or duties of the crew?
Duration of the voyage • Day/night voyages, voyages over 12 hours • Crew required for lookout duties • Sufficient crew to allow adequate rest periods	When will the vessel operate? How long will the vessel operate for? What arrangements are there for the crew to rest?
The risk of fatigue of the master and crew • Fatigue management • Monitoring hours of work and rest • Factors affecting fatigue – refer to fatigue guidelines	How will fatigue affect the crew? How will fatigue be managed? How will hours of work or rest be monitored? What additional duties or conditions could contribute to fatigue? Refer to fatigue guidance
Emergency preparedness • Emergency plan and evacuation arrangements • Emergency equipment fitted and the training required for use of such equipment • Number of crew required to evacuate the vessel • Personnel available to provide first aid • Emergency drills	How will the vessel's crew deal with an emergency? How will they evacuate the vessel if required? What training will be required? At what frequency will training drills be carried out?

Factors to be considered	Evaluation—Consider the following questions
Maintenance requirements • Maintenance tasks • Crew required to complete tasks	What maintenance tasks need to be carried out by the crew? Are the crew trained to carry out maintenance safely?
Risk to the environment and persons on or near the vessel • Consideration of the risks the vessel poses to the environment in various operational circumstances • Consideration of other people in the vicinity	How do the vessel's operations affect the environment? Are people on board or near the vessel impacted by the vessel's operations?
Qualifications and competency of the master and crew • Qualifications and experience of the master and crew • Training requirements • Consideration when only the master holds engineering certification	What are the qualifications and experience levels of the crew? Are their qualifications and experience sufficient to carry out the required duties?
External support available to the vessel • Arrangements in place to seek support • Training requirements to use communications equipment • Contact point for emergency support	What support is available to the vessel if required? Are all crew aware of communications methods? Do they know how to seek help?
Key on board operations • Crew required to carry out routine and non-routine tasks	What are the key operations that need to be carried out?
Any other matters or considerations	

APPENDIX 4. KINETIC ENERGY MATRIX FOR AUTONOMOUS AND REMOTELY OPERATED MARINE EQUIPMENT

This matrix is to be used as a guide to help users determine the category of vessel for the Code. The matrix is based on a 5m long vessel with a mass of 750KG and a speed of 5 knots, which produces 9375 KJ of kinetic energy.

		Weight in Kilograms																						
		50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200
Speed in knots	2.5	156	313	469	625	781	938	1094	1250	1406	1563	1719	1875	2031	2188	2344	2500	2656	2813	2969	3125	3281	3438	3594	3750
	3.0	225	450	675	900	1125	1350	1575	1800	2025	2250	2475	2700	2925	3150	3375	3600	3825	4050	4275	4500	4725	4950	5175	5400
	3.5	306	613	919	1225	1531	1838	2144	2450	2756	3063	3369	3675	3981	4288	4594	4900	5206	5513	5819	6125	6431	6738	7044	7350
	4.0	400	800	1200	1600	2000	2400	2800	3200	3600	4000	4400	4800	5200	5600	6000	6400	6800	7200	7600	8000	8400	8800	9200	9600
	4.5	506	1013	1519	2025	2531	3038	3544	4050	4556	5063	5569	6075	6581	7088	7594	8100	8606	9113	9619	10125	10631	11138	11644	12150
	5.0	625	1250	1875	2500	3125	3750	4375	5000	5625	6250	6875	7500	8125	8750	9375	10000	10625	11250	11875	12500	13125	13750	14375	15000
	5.5	756	1513	2269	3025	3781	4538	5294	6050	6806	7563	8319	9075	9831	10588	11344	12100	12856	13613	14369	15125	15881	16638	17394	18150
	6.0	900	1800	2700	3600	4500	5400	6300	7200	8100	9000	9900	10800	11700	12600	13500	14400	15300	16200	17100	18000	18900	19800	20700	21600
	6.5	1056	2113	3169	4225	5281	6338	7394	8450	9506	10563	11619	12675	13731	14788	15844	16900	17956	19013	20069	21125	22181	23238	24294	25350
	7.0	1225	2450	3675	4900	6125	7350	8575	9800	11025	12250	13475	14700	15925	17150	18375	19600	20825	22050	23275	24500	25725	26950	28175	29400
	7.5	1406	2813	4219	5625	7031	8438	9844	11250	12656	14063	15469	16875	18281	19688	21094	22500	23906	25313	26719	28125	29531	30938	32344	33750
	8.0	1600	3200	4800	6400	8000	9600	11200	12800	14400	16000	17600	19200	20800	22400	24000	25600	27200	28800	30400	32000	33600	35200	36800	38400
	8.5	1806	3613	5419	7225	9031	10838	12644	14450	16256	18063	19869	21675	23481	25288	27094	28900	30706	32513	34319	36125	37931	39738	41544	43350
	9.0	2025	4050	6075	8100	10125	12150	14175	16200	18225	20250	22275	24300	26325	28350	30375	32400	34425	36450	38475	40500	42525	44550	46575	48600
	9.5	2256	4513	6769	9025	11281	13538	15794	18050	20306	22563	24819	27075	29331	31588	33844	36100	38356	40613	42869	45125	47381	49638	51894	54150
	10.0	2500	5000	7500	10000	12500	15000	17500	20000	22500	25000	27500	30000	32500	35000	37500	40000	42500	45000	47500	50000	52500	55000	57500	60000
	10.5	2756	5513	8269	11025	13781	16538	19294	22050	24806	27563	30319	33075	35831	38588	41344	44100	46856	49613	52369	55125	57881	60638	63394	66150
	11.0	3025	6050	9075	12100	15125	18150	21175	24200	27225	30250	33275	36300	39325	42350	45375	48400	51425	54450	57475	60500	63525	66550	69575	72600
	11.5	3306	6613	9919	13225	16531	19838	23144	26450	29756	33063	36369	39675	42981	46288	49594	52900	56206	59513	62819	66125	69431	72738	76044	79350
	12.0	3600	7200	10800	14400	18000	21600	25200	28800	32400	36000	39600	43200	46800	50400	54000	57600	61200	64800	68400	72000	75600	79200	82800	86400
	12.5	3906	7813	11719	15625	19531	23438	27344	31250	35156	39063	42969	46875	50781	54688	58594	62500	66406	70313	74219	78125	82031	85938	89844	93750
	13.0	4225	8450	12675	16900	21125	25350	29575	33800	38025	42250	46475	50700	54925	59150	63375	67600	71825	76050	80275	84500	88725	92950	97175	101400
	13.5	4556	9113	13669	18225	22781	27338	31894	36450	41006	45563	50119	54675	59231	63788	68344	72900	77456	82013	86569	91125	95681	100238	104794	109350
	14.0	4900	9800	14700	19600	24500	29400	34300	39200	44100	49000	53900	58800	63700	68600	73500	78400	83300	88200	93100	98000	102900	107800	112700	117600
	14.5	5256	10513	15769	21025	26281	31538	36794	42050	47306	52563	57819	63075	68331	73588	78844	84100	89356	94613	99869	105125	110381	115638	120894	126150
	15.0	5625	11250	16875	22500	28125	33750	39375	45000	50625	56250	61875	67500	73125	78750	84375	90000	95625	101250	106875	112500	118125	123750	129375	135000

APPENDIX 5. KINETIC ENERGY MATRIX FOR SURVEY-EXEMPT VESSELS

This matrix is to be used as a guide to help users determine the category of vessel for the Code. The matrix is based on a 12m long vessel with a mass of 2000KG and an operational speed of 10 knots, which produces 100000KJ of kinetic energy.

		Weight in Kilograms																						
		800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200	3400	3600	3800	4000	4500	5000	5500	6000	6500	7000	7500
Speed in knots	5.0	10000	12500	15000	17500	20000	22500	25000	27500	30000	32500	35000	37500	40000	42500	45000	47500	50000	56250	62500	68750	75000	81250	87500	93750
	5.5	12100	15125	18150	21175	24200	27225	30250	33275	36300	39325	42350	45375	48400	51425	54450	57475	60500	68062	75625	83188	90750	98313	105875	113438
	6.0	14400	18000	21600	25200	28800	32400	36000	39600	43200	46800	50400	54000	57600	61200	64800	68400	72000	81000	90000	99000	108000	117000	126000	135000
	6.5	16900	21125	25350	29575	33800	38025	42250	46475	50700	54925	59150	63375	67600	71825	76050	80275	84500	95062	105625	116188	126750	137313	147875	158438
	7.0	19600	24500	29400	34300	39200	44100	49000	53900	58800	63700	68600	73500	78400	83300	88200	93100	98000	110250	122500	134750	147000	159250	171500	183750
	7.5	22500	28125	33750	39375	45000	50625	56250	61875	67500	73125	78750	84375	90000	95625	101250	106875	112500	126562	140625	154688	168750	182813	196875	210938
	8.0	25600	32000	38400	44800	51200	57600	64000	70400	76800	83200	89600	96000	102400	108800	115200	121600	128000	144000	160000	176000	192000	208000	224000	240000
	8.5	28900	36125	43350	50575	57800	65025	72250	79475	86700	93925	101150	108375	115600	122825	130050	137275	144500	162562	180625	198688	216750	234813	252875	270938
	9.0	32400	40500	48600	56700	64800	72900	81000	89100	97200	105300	113400	121500	129600	137700	145800	153900	162000	182250	202500	222750	243000	263250	283500	303750
	9.5	36100	45125	54150	63175	72200	81225	90250	99275	108300	117325	126350	135375	144400	153425	162450	171475	180500	203062	225625	248188	270750	293313	315875	338438
	10.0	40000	50000	60000	70000	80000	90000	100000	110000	120000	130000	140000	150000	160000	170000	180000	190000	200000	225000	250000	275000	300000	325000	350000	375000
	10.5	44100	55125	66150	77175	88200	99225	110250	121275	132300	143325	154350	165375	176400	187425	198450	209475	220500	248062	275625	303188	330750	358313	385875	413438
	11.0	48400	60500	72600	84700	96800	108900	121000	133100	145200	157300	169400	181500	193600	205700	217800	229900	242000	272250	302500	332750	363000	393250	423500	453750
	11.5	52900	66125	79350	92575	105800	119025	132250	145475	158700	171925	185150	198375	211600	224825	238050	251275	264500	297562	330625	363688	396750	429813	462875	495938
	12.0	57600	72000	86400	100800	115200	129600	144000	158400	172800	187200	201600	216000	230400	244800	259200	273600	288000	324000	360000	396000	432000	468000	504000	540000
	12.5	62500	78125	93750	109375	125000	140625	156250	171875	187500	203125	218750	234375	250000	265625	281250	296875	312500	351562	390625	429688	468750	507813	546875	585938
	13.0	67600	84500	101400	118300	135200	152100	169000	185900	202800	219700	236600	253500	270400	287300	304200	321100	338000	380250	422500	464750	507000	549250	591500	633750
	13.5	72900	91125	109350	127575	145800	164025	182250	200475	218700	236925	255150	273375	291600	309825	328050	346275	364500	410062	455625	501188	546750	592313	637875	683438
	14.0	78400	98000	117600	137200	156800	176400	196000	215600	235200	254800	274400	294000	313600	333200	352800	372400	392000	441000	490000	539000	588000	637000	686000	735000
	14.5	84100	105125	126150	147175	168200	189225	210250	231275	252300	273325	294350	315375	336400	357425	378450	399475	420500	473062	525625	578188	630750	683313	735875	788438
	15.0	90000	112500	135000	157500	180000	202500	225000	247500	270000	292500	315000	337500	360000	382500	405000	427500	450000	506250	562500	618750	675000	731250	787500	843750
	15.5	96100	120125	144150	168175	192200	216225	240250	264275	288300	312325	336350	360375	384400	408425	432450	456475	480500	540562	600625	660688	720750	780813	840875	900938
	16.0	102400	128000	153600	179200	204800	230400	256000	281600	307200	332800	358400	384000	409600	435200	460800	486400	512000	576000	640000	704000	768000	832000	896000	960000
	16.5	108900	136125	163350	190575	217800	245025	272250	299475	326700	353925	381150	408375	435600	462825	490050	517275	544500	612562	680625	748688	816750	884813	952875	########
	17.0	115600	144500	173400	202300	231200	260100	289000	317900	346800	375700	404600	433500	462400	491300	520200	549100	578000	650250	722500	794750	867000	939250	########	########
	17.5	122500	153125	183750	214375	245000	275625	306250	336875	367500	398125	428750	459375	490000	520625	551250	581875	612500	689062	765625	842188	918750	995313	########	########

APPENDIX 6. EXAMPLE SPEX CERTIFICATE FOR REMUS 100

Australian Government
Australian Maritime Safety Authority

SPECIFIC EXEMPTION

Marine Safety (Domestic Commercial Vessel) National Law Act 2012, Schedule 1

Approval Number: SPEX-XXX

Name of Approval Holder: Ningaloo Research Foundation
ACN: 123 456 789

Name of Vessel	Type of Vessel	Unique Vessel Identifier	Service Category
REMUS 100	Submersible - Autonomous	123456	2C

Approved specific exemption:
The vessel is exempt from the requirement to comply with:

- Marine Safety (Domestic Commercial Vessel) National Law Act 2012 only to the extent that it requires the vessel to have a certificate of survey.
- Marine Safety (Domestic Commercial Vessel) National Law Act 2012 only to the extent that it requires the vessel to have a certificate of operation.

Exemption granted:

- This vessel is exempt from the requirement to have a certificate of survey.
- The vessel is exempt from the requirement to have a certificate of operation.

Conditions:

- The owner and master must ensure that the relevant Port or VTS authority has been advised of the AUV REMUS 100 movements at times of operation. A radio watch on the relevant VHF channel must be maintained at all times during operations.
- The owner must ensure that the AUV REMUS 100 has a unique vessel identifier attached to the vessel at all times.
- The owner must ensure that the AUV REMUS 100 is maintained in accordance with the Hydroid REMUS 100 Operations and Maintenance Manual.
- The owner and master must ensure the parent vessel is in close proximity to the AUV REMUS 100 whilst on the surface and maintains a visual lookout for marine vessel traffic.
- The owner and master must ensure specific location-based operational plans are developed and complied with as part of the safety management system that considers any potential risks associated with operating the vessel unmanned for each individual area of operation.
- Note: The watch officer (WO) is considered the master of the vessel with respect to any master-related obligations of Marine Order 504 not covered by this specific exemption.
- The owner and master must ensure the vessel has and complies with a safety management system that addresses the operation requirements in Schedules 1 and 2 of Marine Order 504 that apply for the vessel, excluding minimum crewing requirements contained in Marine Order 504, schedule 1 section 6, subsection 4 and section 5.
- The owner and master must ensure the vessel is monitored at all times from one or more remote control stations and crewed by competent personnel.
- Note: this exemption is only valid while the AUV is operated by Ningaloo Research Foundation
- Please note: This decision does not relieve any person from the general safety duties, which arise under Part 3 of the National Law.

Unless revoked, this approval is valid from 13 January 2021 to 12 January 2026.

DELEGATE OF THE NATIONAL REGULATOR
PO Box 2181, Canberra ACT 2601
p 1800 627 484
w www.amsa.gov.au

APPENDIX 7. EXAMPLE SAFETY MANAGEMENT SYSTEM FOR A SMALL AUV

This Appendix will be available to download with the Guidance Materials.

APPENDIX 8. EXAMPLE OF CONCEPT OF OPERATIONS STRUCTURE

1. INTRODUCTION

2. GENERAL VESSEL OVERVIEW & CONCEPT OF OPERATIONS

2.1 OPERATIONAL CONCEPT OF THE VESSEL

(OPERATIONAL INTENT, OPERATIONAL SCENARIOS, TASKS COVERED BY AUTONOMOUS SYSTEMS/OPERATORS NOT ONBOARD)

2.2 MAIN PARTICULARS OF VESSEL

(VESSEL TYPE, LENGTH, BREADTH, DEPTH, WEIGHT/DISPLACEMENT, SPEED ETC)

2.3 OPERATING CONDITIONS

(OPERATING AREA, ENDURANCE, AMBIENT CONDITIONS, SEASTATES ETC)

2.4 GENERAL VESSEL OVERVIEW

(PROPULSION TYPE, ELECTRICAL PLANT, FIREFIGHTING SYSTEMS, BALLAST SYSTEM, NAVIGATION AND COLLISION AVOIDANCE, COMMUNICATION SYSTEMS, VESSEL MONITORING SYSTEMS)

3. BASIS OF DESIGN, VESSEL TAILORING AND CERTIFICATION MATRIX

3.1 CLASS NOTATION (IF APPLICABLE)

3.2 STATUTORY ASPECTS AND TAILORING

3.3 RULES AND STANDARDS

3.4 GENERAL DESIGN STATEMENTS

3.5 STRUCTURAL DESIGN STATEMENTS

3.6 PROPULSIONS DESIGN STATEMENTS

3.7 AUXILARY DESIGN STATEMENTS

3.8 ENVIRONMENTAL PROTECTION DESIGN STATEMENTS

RECOVERY PLAN

4. SURVEY PLAN

5. MAINTENANCE PLAN

APPENDIX 9. FMEA EXAMPLES

The FMEA tables within this appendix are intended to provide examples on the expected detail required when doing FMEA analysis, and are not meant as exhaustive representations of the required extent expected for FMEA documents. The systems fitted to maritime autonomous systems (MAS) are expected to vary between manufacturers, operators and applications of individual MAS platforms, and as such will have different FMEA. To aid in developing comprehensive FMEA for the primary MAS platform types, the lists below have been generated to form a starting point:

- Power management system
- Command and Control (Communications, UI, HMI, etc.)
- Situational awareness systems (LiDAR, Radar, etc.)
- Navigation Systems (INS, GPS, Speed through water sensors, etc.)
- Integration Units (For vessels that integrate combustion engine and are optionally manned)
- Propulsion and Steering systems (If fully electronically controlled)
- Emergency response systems (fire suppression, bilge pumps, etc.),
- SOLAS equipment (VHF, smoke and flares, etc.)
- Software decision making and AI systems (Control software, software tests, etc.)
- Mooring and anchor systems.
- Auxiliary systems (Such as any towed array machinery, hydraulics, etc.)
- Hull and structure

EXAMPLE PARTIAL FMEA OF AUV

Equipment	Function	Failure Mode	Failure Cause	Failure Effect		Failure Detection	Corrective Action
				Local Effect	End Effect		
Novel System Example							
Obstical Avoidance Sonar (OAS)	Provides forward looking obstical avoidance, ice avoidance and slop	Incorrect or lack of data being provided	Mechanical connection of signal/ power or hardware failure	Vehicle unable to navigate obsticals and ice as well as pre-emtively	vehicle collides with underwater object or terrain	Over Depth Alarm Obstical avoid	FRT will result will suitable action for operating environment as defined by user.
ACE (Automated Control Engine)	Overarching control system of vehicle	Unresponsive or misguided control of vehicle	Frozen software, corrupted control software, broken connection or hardware failure.	Vehicle is uncontrolable	vehicle collides with underwater object or terrain	Over Depth Alarm	Automated timer will try to restart ACE. If in acoustic or wifi then manual control can be requested
Battery System Example							
Battery management system	Monitors battery usage, balancing and charging	serial communication issue or canbus interface issue	wiring, electrical connection or parsing error	no health or capacity feedback	energy usage might be higher than anticipated and mission may not abort due to no feedback supplying low energy alarm with information	Battery Timeout	FRT will result will suitable action for operating environment as defined by user.
Battery management system	Monitors battery usage, balancing and charging	ammeter reading high current draw from batteries	device drawing too much current	possible electrical connection issue, motor movement being obstructed or mechanical failure	Might cause AUV fault and cause mission to end	Battery Current High	FRT will result will suitable action for operating environment as defined by user.
Battery management system	Monitors battery usage, balancing and charging	battery monitor showing low energy	battery capacity drops below pre-defined threshold	likely some of the battery banks have comeoff-line or mission limits set low enegery warning limit incorrectly	Might cause AUV fault and cause mission to end	Energy Remaining Low Warning	FRT will result will suitable action for operating environment as defined by user.
Battery management system	Monitors battery usage, balancing and charging	battery monitor showing low energy	battery capacity drops below pre-defined threshold	likely some of the battery banks have comeoff-line or mission limits set low enegery alarm limit incorrectly	Might cause AUV fault and cause mission to end	Energy Remaining Low Alarm	FRT will result will suitable action for operating environment as defined by user.

EXAMPLE PARTIAL FMEA OF WAMV USV

Equipment	Function	Failure Mode	Failure Cause	Failure Effect		Failure Detection	Corrective Action
				Local Effect	End Effect		
Novel System Example							
AIS	To report vessel location to other nearby watercraft.	Inability to send or receive AIS data.	(1) Loss of power, (2) connections lose or incorrect	Reduction of situational awareness for USV, and other AIS enabled vessels.	Vessel collides with another vessel.	AIS Alarm (Software), Loss in connection	Attempt AIS power cycle, Restart software control process.
Obstacle avoidance cameras	Detect obstacles and report to pilot, or control system for avoidance.	Incorrect or lack of data being provided to operator or control system.	(1) Loss of power, (2) connections lose or incorrect, (3) physical obstruction of cameras.	Inability for remote pilot, or on0board control system to observe and avoid obstacles.	Collision with moving or stationary object.	Loss in Camera Feed, Various Alarms (Software)	Attempt power cycle of device, restart software processes responsible, restrict speed of vessel.
Mast Lights	Provide various light configurations for achievement of COLREG and operational requirements.	Inability to modify lights depending on requirements.	(1) Loss of power, (2) connections lose or incorrect, (3) physical obstruction of device.	Cannot achieve COLREGs compliance, causing other vessels and masters to make incorrect decisions.	Disruption of navigation of other vessel, collisions and mis-informed actions of other vessels.	Light Alarm (Software),	Attempt power cycle of control device, restart software processes responsible, restrict speed of vessel
Propulsion System Example							
Steering Gear	Aids in Steering the vessel.	Inability, or reduction in ability to steer and manoeuvre vessel.	(1) Physical failure (2) Electronic failure, (3) Loss of control.	Reduction/Loss of ability to steer or manoeuvre the vessel.	Collision with moving or stationary object.	Steering Gear Failure Alarm, loss of control	Attempt power cycle of device, restart software processes responsible, restrict speed of vessel to hold position until rectification. Steering system to default to straight ahead, system to use thrust variation to navigate to safe haven.
Propulsion Unit	Propels Vessel and aids in steering the vessel.	Inability, or reduction in ability to steer and manoeuvre vessel.	(1) Physical failure (2) Electronic failure, (3) Loss of control.	Reduction/Loss of ability to move, steer or manoeuvre the vessel.	Collision with moving or stationary object.	Propulsion Failure Alarm, loss of control	Attempt power cycle of device, restart software processes responsible, restrict speed of vessel to hold position until rectification if some propulsion ability remains. After 5 min without rectification of at least 50%, request help.
Command and Control (C2) System Example							
Primary communications	Sends and receives Data between vessel and remote command station/unit.	Inability to control or receive situational awareness data from vessel.	(1) Physical failure (2) Electronic failure.	Reduction or complete loss in ability to control or monitor the vessel.	Collision with moving or stationary object, loss of system.	Loss in Communications Alarm on Ground Station (Through signal strength indicator)	Attempt power cycle of device, restart software processes responsible (automatic). Vessel automatically attempts to hold position as best it can, lights display not under command until connection re-established.
Ground Station/Hub	Allows Pilot to control, monitor and command vessel(s) under their control.	Inability to control and monitor the vessel remotely.	(1) Physical failure (2) Electronic failure, (3) Software freeze.	Reduction or complete loss in ability to control or monitor the vessel.	Collision with moving or stationary object, loss of system.	Ground station shuts down, or stops responding.	Attempt power cycle of device, restart software processes responsible (automatic). Vessel automatically attempts to hold position as best it can, lights display not under command until connection re-established.