Standardisation Proposal for Launch and Recovery of Any Vehicle from Naval Platforms

Generic craft / launch and recovery-equipment interface and process

Version 4.2 May 2020

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Reviewed By: Dan Smith (for Naval Design Partnering update task)

Document History

Version	Date	Author	Notes
V1	2013-02-11	SK	Original outline.
V1	2013-02-11	SK	Original outline.
V1.x	2013-03-/	SK/RJP/DJA	Notes and discussion.
V2	2013-04-29	RJP	Changed structure, added figures, ID unknowns.
V2.1	2013-06-17	RJP	Placed comments in-line with text, distributed for discussion.
V2.2	2013-10-18	RJP	Changes following feedback, deliverable version for Oct 2013.
V2.3 (Point hoist)	2014-06-12	RJP	Further changes following feedback, narrative and questions added in comments, split into concept families, distribution to WPL for comment and population.
V3	2014-07-24	EHT	Addition of generic mechanical craft launch and recovery equipment interface.
V3.1	2014-10-02	EHT	Comments included from WPL / SC meeting Amsterdam Sep. '14.
V3.2	2014-10-29	EHT	Includes comments McTaggart-Scott.
V3.3	2015-03-23	RJP	Combined hook and cradle versions.
V3.4	2015-04-15	RJP	Incorporated changes from FK and ET, re-arranged structure to represent GIS-FCD-Cradle/Planars hierarchy.
V3.5	2020-01-03	RJP	Incorporated revision to class structure & common applicability description. Discussed at UCL 2020-Jan.
V4.0	2020-03-02	RJP	Revisions based on UCL workshop, trials reports and design documents (under NDP TOF217 tasking).
V4.1	2020-03-26	RJP	Revisions based on feedback from LAURA consortium (under NDP TOF217 tasking).
V4.2	2020-03-26	FK	Small editorial corrections

Contents

1 Nomenclature

FCD Floating Capture Device

GIS Generic Interface System

LARS Launch And Recovery System

L&R Launch and Recovery

LAURA LAUnch and Recovery of Any small navy craft

RHIB Rigid Hull Inflatable Boat (also RIB)

USV Uncrewed Surface Vehicle

UUV Uncrewed Underwater Vehicle

UXV Uncrewed Vehicle

2 Aim

2.1 The aim of this standardisation proposal document is to provide guidance and recommendations on a standard set of Launch and Recovery Systems (LARS), equipment and operational procedures to support the handling, launch and recovery of a range of surface and sub-surface craft from a range of host vessels.

2.2 This standardisation proposal document was developed by the JIP LAURA consortium and includes lessons learnt from simulation, model and full scale testing of a range of prototype LARS solutions.

3 Standard Structure

3.1 Figure 1 outlines the broad structure of the standard.

3.2 This standard is designed to be extensible, in that additional entries can be added at each level of the hierarchy shown in Figure 1.

3.3 The standard is composed of multiple families. Each family is described in the same way, with an outline of the system, associated procedure, and a list of the components in the system. Each component is described using requirements and specifications as defined above. Requirements and specifications are categorised into: geometry, mass, interfaces and general.

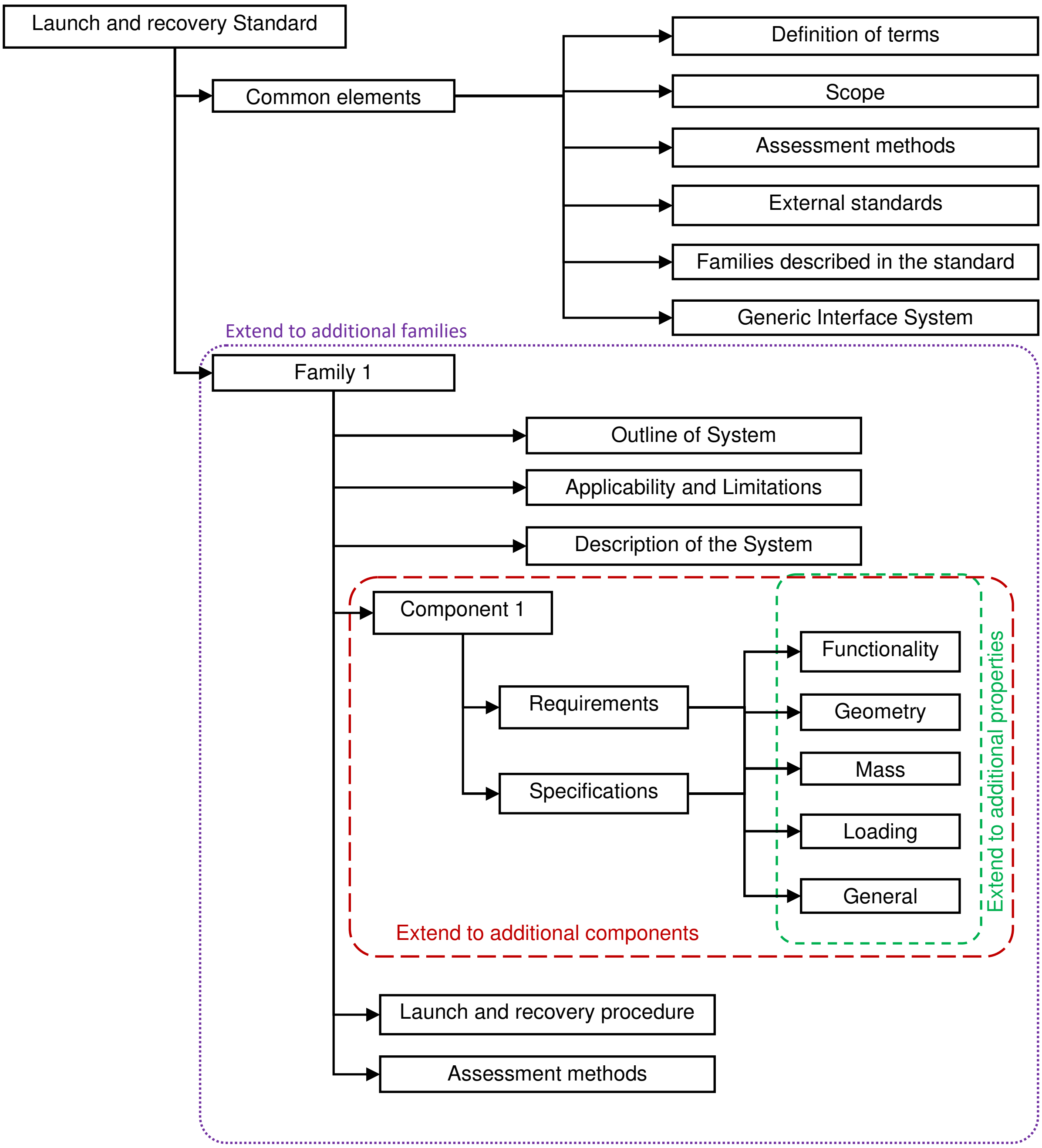

Figure 1: The hierarchical structure of the launch and recovery standard, showing extensibility

4 Definition of Terms

4.1 This section defines a common set of terms used throughout the standard document.

4.2 Craft

4.2.1 Within this document, the term craft is used to refer to the vehicle which is being launched and recovered. e.g. a RIB, USV or UUV.

4.3 Family

4.3.1 A family is a method of launch and recovery. Families may be detailed and highly specified, or they may be loosely defined. They may including existing systems.

4.3.2 Families are differentiated from one another by using distinguishable physical methods to launch and recover craft. Specific families may however contain common components.

4.3.3 All families incorporate a generic mechanical craft launch and recovery system interface used described in this standard.

4.4 Component

4.4.1 A component is a constituent part or element of a launch and recovery system. This includes the craft itself and any of its required features.

4.4.2 Interfaces in the system may be divided into components, which have interfacing with another component as a function.

4.5 Specifications

4.5.1 Specifications are a detailed exact statement of particulars prescribing materials, dimensions, mechanical and physical properties etc. of a component or system.

4.6 Requirements

4.6.1 Requirements are compulsory properties of components which have to be met.

4.6.2 Some requirements may be less prescriptive in nature and may only partially prescribe a solution.

4.7 Shall, Should and May

4.7.1 This document provides general guidance for L&R equipment and procedures. Within this general guidance, specific items are described using three levels of application:

4.7.2 Shall expresses a mandatory requirement of the specification.

4.7.3 Should expresses a recommendation on implementation which is expected to be met, but may be subject to design or procurement trade-offs.

4.7.4 May expresses a permissible practice but is not necessarily a requirement of the specification.

4.8 Applicability

4.8.1 The words “applicable” and “applicability” do not constitute a guarantee that the so described system or component will meet a given operational or performance requirement.

4.8.2 The words “applicable” and “applicability” instead mean that sufficient analysis and testing has been carried out to provide confidence that a solution could be developed, for the combination of LARS and craft, within the requirements and specifications in this document.

4.9 Geometry

4.9.1 The vertical axis is defined as perpendicular to the still water plane.

4.9.2 The horizontal plane is defined as the still water plane.

5 Scope

5.1 This standard has been developed for application to a wide range of combinations of host vessels and deployed craft, operational speeds and environmental conditions.

5.1.1 The limits on overall characteristics of host vessels, craft and systems are summarised here for the purpose of identification of appropriate applications.

5.1.2 Some systems are not applicable to all combinations or conditions, and this is stated in the sections on the LAR families.

5.2 This standard is primarily concerned with the act of achieving a physical connection between the craft and host vessel, but als describes the corresponding launch and recovery proces. Where other aspects such as davit design are referenced, it is to capture the main impacts the LARS may have on these.

5.3 Where "capability" is used, it refers to the act of achieving a physical connection between the craft and host vessel.

5.4 Where operational procedures are described, these are for example only and may be adapted, including the addition of technological aids such as quiescent period prediction, if appropriate.

5.5 Host vessel

5.6 This standard has been developed for application to naval combatant host vessels within combinations of the dimensional ranges shows in the table below. These are for guidance only and are not absolute limits.

Table 1: Key characteristics of host vessels

		Minimum Value	Maximum Value
4.2.1.a	Displacement [tonnes]	700	8000
4.2.1.b	Length overall [m]	60	150
4.2.1.c	Length – Beam ratio	5.5	9.9
4.2.1.d	Beam – Draft ratio	2.5	3.5
4.2.1.e	Transom immersion – draft ratio	0.00	0.15
4.2.1.f	Metacentric height [m]	0.90	1.60
4.2.1.g	Speed for launch & recovery [kts]	5	15

5.7 Deployed craft

5.7.1 This standard has been developed for application to the launch and recovery of a range of sizes and types of craft.

5.7.2 The systems described in the standard are applicable to crewed and uncrewed craft. Where the provisions of the standard only apply to one or the other, this is stated.

5.7.3 Placeholder Values: This is a draft document and placeholder values are indicated by curly brackets {}. These values are subject to confirmation.

5.7.4 Surface craft are classified into six classes, based on displacement, with associated ranges of dimensions for each displacement class shown in the table below.

Table 2: Surface craft classes

Surface Craft Class	Mass Range (Denominator of Class)	Length Range	Beam Range
SC-I	25kg – 500kg	<3.0m	0.5m – 1.5m
SC-II	500kg – 1200kg	3.0m – 6.0m	1.0m – 2.5m
SC-III	1200kg – 2000kg	5.0m – 7.0m	1.5m – 3.0m
SC-IV	2000kg – 5500kg	6.0m – 9.0m	2.0m – 3.5m
SC-V	5500kg – 10000kg	9.0m – 12m	2.5m – 4.0m
SC-VI	> 10000kg	>12m	> 4.0m

5.7.5 Figure 2 illustrates the range (from smallest to largest) of dimensions for each class of craft, including overlaps.

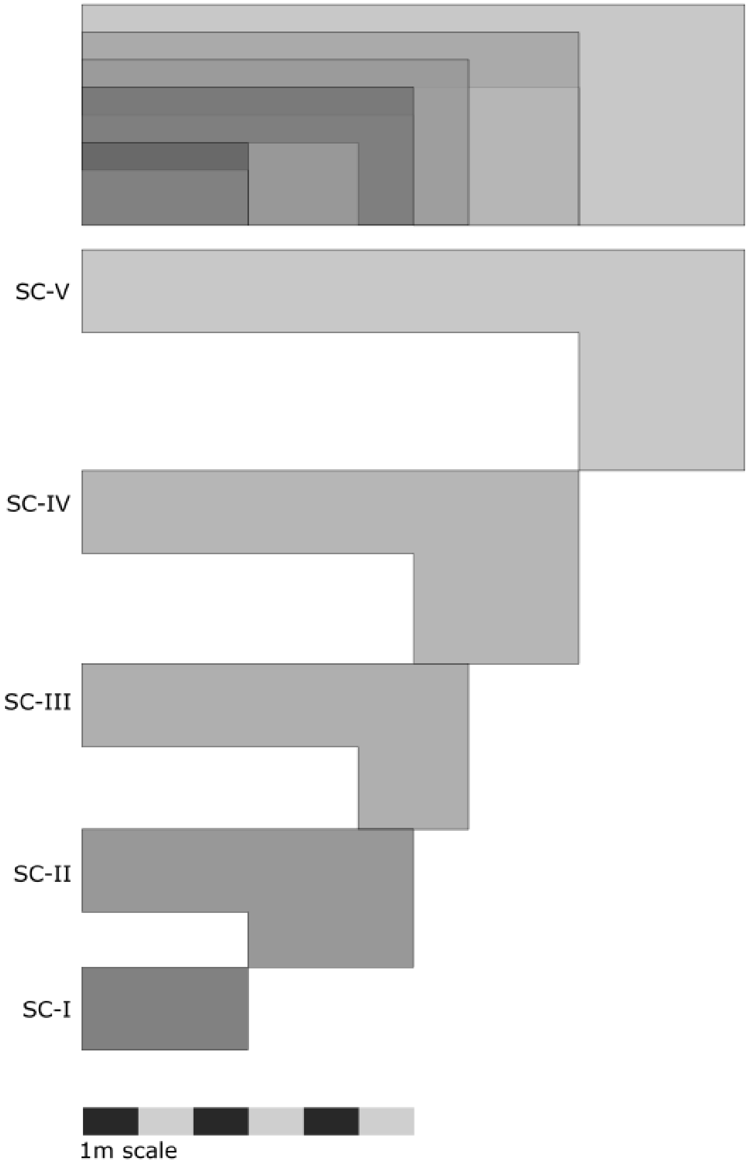

Figure 2 Comparison of SC categories, showing scope of length and beam for each

5.7.6 Within these classes, surface craft are also identified by further features. The class and features are used to identify if a LARS family is suitable for the craft.

Table 3: Surface craft features

Feature	Options
Topology	Monohull, catamaran, trimaran
Hull underwater shape	V-shaped, flat bottom, round bilge
Propulsion	Waterjet(s), propeller(s) (inboard motor), propeller(s) (outboard motor)
Inflatable collar	Present / absent
Performance	Capable / not capable of exceeding host vessel speed during launch and recovery
Human occupied	Crewed / Uncrewed

5.7.7 Sub-surface craft are classified into four classes, based on displacement, with dimensions shown in Table 4.

Table 4: Sub-surface craft classes

Sub-Surface Craft Class	Mass Range (Denominator of Class)	Length Range	Beam or Diameter Range	Height Range
UC-I	<50 kg	1.0 m – 2.0 m	<1.0 m	<0.50 m
UC-II	50 kg – 250 kg	1.5 m – 3.5 m	0.25 m – 1.10 m	0.25 m – 0.75 m
UC-III	250 kg – 1350 kg	2.0 m – 6.0 m	0.30 m – 2.50 m	0.50 m – 1.50 m
UC-IV	>1350 kg	>4.0 m	0.50 m – 3.00 m	> 0.6 m

5.7.8 Within these classes, sub-surface craft are also identified by further features. The class and features are used to identify if a LARS family is suitable for the craft. These are summarised in Table 5.

Table 5: Sub-surface craft features

Feature	Options
Hull cross section	(Referring to overall cross section if multiple hulls are used) circular; rectangular
Free-flooding	Presence or absence of free-flooding volumes that will drain after removal from the water
Propulsion	Stern propeller(s), ducted thrusters, podded thrusters
Performance	Capable / not capable of exceeding host vessel speed during launch and recovery

5.7.9 Certain systems have further limitations on their applicability to deployed craft and these are described in Section 7.

5.8 Launch and Recovery Methods

5.8.1 The systems described in this standard are intended to be utilised within two main launch and recovery methods: lifting appliances (e.g. davits or cranes), and stern ramps.

5.8.2 The standard covers the process of achieving a connection between the deployed craft and host vessel; the full process of launch and recovery will be affected using cranes, davits etc. which are outside the scope of this document.

5.9 Launch and Recovery Location

5.9.1 Those options compatible with davits or cranes are suitable for launch and recovery over the side of the host vessel, or from its stern.

5.9.2 The location of capture (when the craft becomes attached to the deployed component of the LARS) may be different from the location of recovery by crane, davit etc.

5.10 Launch and Recovery Conditions

5.10.1 This section summarises the objective range of launch and recovery conditions for the applicability of the standard. This is only a summary and attention must be paid to the specific limitations included in the technical descriptions in sections specific to each family.

5.10.2 Launch and recovery operations take place at speeds between 5 and 15 knots for the host vessel.

5.10.3 Required deployed craft speeds relative to the host vessel are dependent on the launch and recovery system and are described in Section 7.

5.10.4 Launch and recovery operations take place at sea states between 0 and 6. Sea state being defined as per STANAG 4194 and ANEP 14 (for littoral environments).

6 Assessment Methods

6.1 Aim

6.1.1 This section does not prescribe a particular set of numerical assessment methods to be used. Rather, it captures lessons learnt and best practice to be applied in development, analysis and assessment of LARS designs to meet this standard.

6.1.2 The described assessment methods may be used to:

a) Demonstrate the performance of proposed designs (where none are specified) to meet specified operational / functional characteristics.

b) Demonstrate compliance with external standards.

c) Develop operator guidance and instruction.

6.1.3 Individual families may also include discussion of considerations for assessment methods specific to the family.

6.2 Numerical Methods: Applicability

6.2.1 Numerical methods such as Computational Fluid Dynamics (CFD) may be used to assess the local wave system around the host ship and its effect on the craft, including diffraction and radiation of incoming waves and the wake astern of the host vessel.

6.2.2 This analysis should examine conditions at both connection and lifting locations.

6.2.3 Zero speed frequency domain codes will only provide useful results {very close} to the host vessel hull or at {very low} speed.

6.2.4 Exact forward speed codes will be required to deliver results that can be used for evauation of LARS concepts at representative distances from the host vessel or with forward speed.

6.2.5 CFD codes may be used to obtain an understanding of specific aspects of the host-surface craft interactions. For example, FREDYN has shown a good match with model tests for determining deployed craft heave, but not for horizontal movement.

6.3 Numerical Methods: Recommended Approach

6.3.1 The recommended approach to numerical analysis of a proposed LARS solution within the bounds of limited computing capacity or time is a hybrid approach. In this approach, numerical tools are used to investigate specific aspects of the dynamic system, such as the local wave system. These results can then be used in database form by time-domain software modelling the complete system.

6.3.2 This hybrid approach should be reviewed as computing power develops over time, or where additional resource has been made available, with a preference for more complete computational assessment where possible.

6.4 Model Testing: General

6.4.1 Attention must be paid to different scaling regimes that may be present in a scale model LARS system, in particular those concerning: resistance, mass and stiffness of cables; stiffness of compliant structures; contact and impact accelerations.

6.4.2 Wave profiles used in testing should include short crested seas, to capture the increased sensitivity of small craft and LARS devices to these conditions.

6.4.3 Powered and unpowered models may be used for the host vessel for the LAR speeds considered by this standard.

6.5 Model Testing: Autopilots

6.5.1 The use of autopilots with positon and heading control is recommended for model tests investigating craft docking with LARS such as cradles or FCD. This ensures repeatability between runs.

6.5.2 Where such autopilots are used, the state or intent of the autopilot should be recorded to allow the estimation of LAR procedure durations.

6.5.3 Maintaining correct scale mass and trim should be considered when using tracking markers on models of LARS equipment such as cradles and craft.

6.6 Safety Assessment

6.6.1 Established processes of safety assessment for davits etc. are applicable to the LARS concepts described in this standard.

6.6.2 Failure Mode and Effects Analysis (FMEA) is recommended for application to both LARS system design and operational processes.

6.6.3 Link Analysis may be appropriate to analyse crew-intensive operations and communications during L&R.

6.7 Communicating to Operators

6.7.1 The use of decision support aids such as the Ships Helicopter Operational Limit (SHOL) diagram and "traffic light" systems should be considered.

6.7.2 Performance of a LARS solution may be described in terms of a probability of success per attempt and an associated cycle time.

7 External Standards

7.1 Aims

7.1.1 This section has two aims; firstly to highlight certain considerations regarding the application of existing standards to the systems described in this document; and secondly to list external standards of relevance.

7.1.2 All proposed solutions should comply with these standards where applicable.

7.2 Considerations

7.2.1 Ontology: To fit within existing classification society rules, LARS need to be categorised in some way. Consideration should be given as to whether the deployed LARS are a type of hook; a type of craft; or something different.

7.2.2 Ontology: Although the LARS so far developed could be placed under the category of “loose gear” usually applied to lifting equipment, there may be a need for a new sub-category. This would be to allow identification and designation of what is to be assessed by the classification society.

7.2.3 Skills and domains: Review of rules for lifting appliances indicates that the analysis and certification skillsets they represent are primarily structural analysis under static load, with dynamic loading addressed with factors of safety. As such they can be assessed with relatively straightforward numerical analysis.

7.2.4 Skills and domains: LARS as described in this standard currently fall outside existing equipment rules in that their performance and loading is derived from the interaction of lifting forces, buoyancy and hydrodynamics.

7.3 Using Standards with this Document

7.3.1 Where proposed solutions do not fall under explicit classification society rules, Alternative Design arrangements should be used to allow classification.

7.3.2 Components such as ropes and hooks may be designed entirely to classification society standards once suitable SWL are defined for the LARS use case.

7.4 List of External Classification Standards of Relevance

7.4.1 This is not an exhaustive list.

7.4.2 Lifting appliances

- Lloyds: Lloyd’s register Classification Society Code for Lifting Appliances in a Marine Environment.
- DNV GL-ST-0498; Launching Appliances for Work Boats and Tender Boats
- ABS Rules for the Certification of Lifting Appliances onboard Ships and Offshore Units

7.4.3 International Safety Standards:

- NATO Naval Ship Code – ANEP 77 – Chapter 7
- HSC 2000 Code - International Code of Safety for High-Speed Craft, 2000 – Chapter 8

7.4.4 National Health and Safety Standards:

- UK – LOLER, Lifting Operations and Lifting Equipment Regulations

7.4.5 National Military Design Regulations:

- UK – JSP 467 The Specification of Power Driven Lifting Appliances used for Handling Conventional and Nuclear Armaments
- UK – Def Stan 02-113: Requirements for Mechanical Handling
- NL – Civil standard: NEN 2017 up to and including NEN 2024
- AUS - DEF(AUST)5000 ADF Maritime Materiel Requirements Set, Vol 4. Propulsion and Auxiliary Systems Requirements, Part 8. Shipboard Boat Lifting Appliances

7.4.6 National Military User Documents:

- UK - BR 3027 Manual of Safe Use, Examination & Testing Of Lifting Plant.
- NL - ACZSK 121.1 Directie Operaties, Handboek Zeemanschap deel 1
- UK – Admiralty Manual of Seamanship

7.4.7 Standards describing the operational environment

- NATO STANAG 4154 Common Procedures for Seakeeping in the Ship Design Process

8 Families Described in the Standard

8.1 This standard describes several different families. Not all families are uniformly compatible with all host vessel and deployed craft defined by the limits stated in Section 4. This Section lists the families included in the standard and summarises the limits on their applicability to host vessels and craft.

8.2 Determination of applicability of LARS families to surface and subsurface craft has considered the following aspects:

1) Relative mass of craft and LARS device
2) Speed and seakeeping capabilities of the deployed craft, particularly with reference to operations in the host vessel's wake
3) Geometric limitations such as incompatable draft

8.3 Where a LARS family has been declared as applicable to a range of craft sizes, the use of modular LARS may be required to respect considerations (1) and (2) above.

8.4 Generic Interface System

8.4.1 This standard describes a mechanical Generic Interface System (GIS) between craft and host vessel. The GIS is itself used as a component in the other families described in this standard.

8.4.2 The GIS is applicable to both crewed and uncrewed craft in the classes shown in Table 6.

8.4.3 Applicability of the GIS to craft features is summarised in Table 7.

8.4.4 The GIS is applicable to all launch and recovery locations and methods.

Table 6: Applicability of GIS to surface and sub-surface craft classes

<table>
<tr><th>Surface Craft Class</th><th>Applicability and Notes</th><th>Sub-Surface Craft Class</th><th>Applicability and Notes</th></tr>
<tr><td>SC-I</td><td>Not applicable due to small size of craft</td><td>UC-I</td><td>Not applicable due to small size of craft</td></tr>
<tr><td>SC-II</td><td rowspan="5">Applicable</td><td>UC-II</td><td rowspan="3">Applicable</td></tr>
<tr><td>SC-III</td><td>UC-III</td></tr>
<tr><td>SC-IV</td><td>UC-IV</td></tr>
<tr><td>SC-V</td><td></td><td></td></tr>
<tr><td>SC-VI</td><td></td><td></td></tr>
</table>

Table 7: Applicability of GIS to surface and sub-surface craft features

Surface Craft Feature	Applicability & Notes
Topology	Applicable to all
Hull underwater shape	
Propulsion	
Inflatable collar	
Performance	Only applicable when the speed of the deployed craft is at least 4 knots greater than that of the host vessel during launch and recovery.
Sub-Surface Craft Feature	**Applicability & Notes**
Hull cross section	Applicable to all
Free-flooding	
Propulsion	
Performance	Only applicable when the speed of the deployed craft is at least 4 knots greater than that of the host vessel during launch and recovery.

8.5 Floating Capture Device

8.5.1 This standard describes a launch and recovery family and associated procedure using a deployed device known as a Floating Capture Device (FCD).

8.5.2 The FCD is applicable to both crewed and uncrewed craft in the classes shown in Table 8.

8.5.3 Applicability of the FCD to craft features is summarised in Table 9.

8.5.4 The FCD shall make use of the GIS as a component.

8.5.5 The FCD may be used as a component in the other families.

Table 8: Applicability of FCD to surface and sub-surface craft classes

Surface Craft Class	Applicability and Notes	Sub-Surface Craft Class	Applicability and Notes
SC-I	Applicable when using stern ramp or two-point lift via side davit.	UC-I	Not applicable due to small size of craft relative to FCD
SC-II		UC-II	Applicable when using stern ramp only, due to need to attach lifting lines in davit application.
SC-III		UC-III	
SC-IV		UC-IV	
SC-V	Possibly applicable, due to small size of FCD relative to craft.		
SC-VI			

Table 9: Applicability of FCD to surface and sub-surface craft features

Surface Craft Feature	Applicability & Notes
Topology	Applicable to monohull and trimaran hulls. Catamarans unsuitable due to blunt bow shape.
Hull underwater shape	Applicable to all
Propulsion	
Inflatable collar	
Performance	Only applicable when the speed of the deployed craft is at least 4 knots greater than that of the host vessel during launch and recovery.
Human occupied	Crewed (recovery only), Uncrewed (launch and recovery)
Sub-Surface Craft Feature	**Applicability & Notes**
Hull cross section	Applicable to all
Free-flooding	
Propulsion	
Performance	Only applicable when the speed of the deployed craft is at least 4 knots greater than that of the host vessel during launch and recovery.

8.6 Cradles

8.6.1 This standard describes a launch and recovery family and associated procedure using a deployed device known as a Cradle.

8.6.2 The Cradle is applicable to both crewed and uncrewed craft in the classes shown in Table 10.

8.6.3 Applicability of the Cradle to craft features is summarised in Table 11.

8.6.4 The cradle shall make use of the GIS as a component.

8.6.5 The cradle may make use of the FCD as a component.

8.6.6 When using the GIS in the cradle, connection success rate is expected to be {90%} of individual attempts.

8.6.7 Recovery of a RHIB is expected to take approximately {1 minute +/- 30 seconds}.

Table 10: Applicability of cradle to surface and sub-surface craft classes

<table>
<tr><th>Surface Craft Class</th><th>Applicability and Notes</th><th>Sub-Surface Craft Class</th><th>Applicability and Notes</th></tr>
<tr><td>SC-I</td><td>Applicable when using stern ramp or side davit, if cradle is designed to prevent beaching before GIS contact.</td><td>UC-I</td><td rowspan="2">Applicable when using stern ramp or side davit, if cradle is designed to prevent beaching before GIS contact.</td></tr>
<tr><td>SC-II</td><td rowspan="5">Applicable when using stern ramp or side davit.</td><td>UC-II</td></tr>
<tr><td>SC-III</td><td>UC-III</td><td rowspan="2">Applicable when using stern ramp or side davit, if cradle has sufficient draft.</td></tr>
<tr><td>SC-IV</td><td>UC-IV</td></tr>
<tr><td>SC-V</td><td></td><td></td></tr>
<tr><td>SC-VI</td><td></td><td></td><td></td></tr>
</table>

Table 11: Applicability of cradle to surface and sub-surface craft features

Surface Craft Feature	Applicability & Notes
Topology	Applicable to all
Hull underwater shape	
Propulsion	
Inflatable collar	
Performance	Only applicable when the speed of the deployed craft is at least 4 knots greater than that of the host vessel during launch and recovery.
Human occupied	Crewed and Uncrewed
Sub-Surface Craft Feature	**Applicability & Notes**
Hull cross section	Applicable to all
Free-flooding	
Propulsion	
Performance	Only applicable when the speed of the deployed craft is at least 4 knots greater than that of the host vessel during launch and recovery.

9 Generic Interface System (GIS)

9.1 Outline of System

9.1.1 The generic mechanical Generic Interface System (GIS) described in this standard is responsible for establishing the physical connection between craft and the launch and recovery system of the host vessel.

9.1.2 The GIS enables the craft to establish a connection with, and be towed, by the host vessel.

9.1.3 The connection may require different implementations for different families and/or craft, given the different types of hull shapes. The specification in this document ensures physical interoperability between families of craft and/or launch and recovery systems.

9.2 Applicability and Limitations

9.2.1 The GIS is intended to be applied as a component within another launch and recovery family. It is applicable to those families described in this standard and also to other options.

9.2.2 Application of the GIS within the various families is associated with certain unique requirements and specifications and these are provided in the relevant sections of this standard.

9.2.3 Applicability of the GIS to craft features is summarised in Table 15.

9.2.4 The GIS is applicable to all launch and recovery locations and methods.

Table 14: Applicability of GIS to surface and sub-surface craft classes

<table>
<tr><th>Surface Craft Class</th><th>Applicability and Notes</th><th>Sub-Surface Craft Class</th><th>Applicability and Notes</th></tr>
<tr><td>SC-I</td><td>Not applicable due to small size of craft</td><td>UC-I</td><td>Not applicable due to small size of craft</td></tr>
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<tr><td>SC-VI</td><td></td><td></td></tr>
</table>

Table 15: Applicability of GIS to surface and sub-surface craft features

Surface Craft Feature	Applicability & Notes
Topology	Applicable to all
Hull underwater shape	
Propulsion	
Inflatable collar	
Performance	Only applicable when the speed of the deployed craft is at least 4 knots greater than that of the host vessel during launch and recovery.
Sub-Surface Craft Feature	**Applicability & Notes**
Hull cross section	Applicable to all
Free-flooding	
Propulsion	
Performance	Only applicable when the speed of the deployed craft is at least 4 knots greater than that of the host vessel during launch and recovery.

9.3 Description of the System

9.3.1 The GIS is composed of a horizontal capture bar on the LARS-side and a vertical hook on the craft side. The hook has a load-bearing catch or gate which allows it to create a secure attachment to the LARS.

9.3.2 Figure 3 depicts the different components of the GIS, including the two significant variants of the craft-side hook.

9.3.3 Functionality: The GIS is engaged by the following actions:

1. Craft enters LARS
2. Craft drives forwards until capture bar passes over catch
3. Craft reduces power
4. Catch sectures capture bar

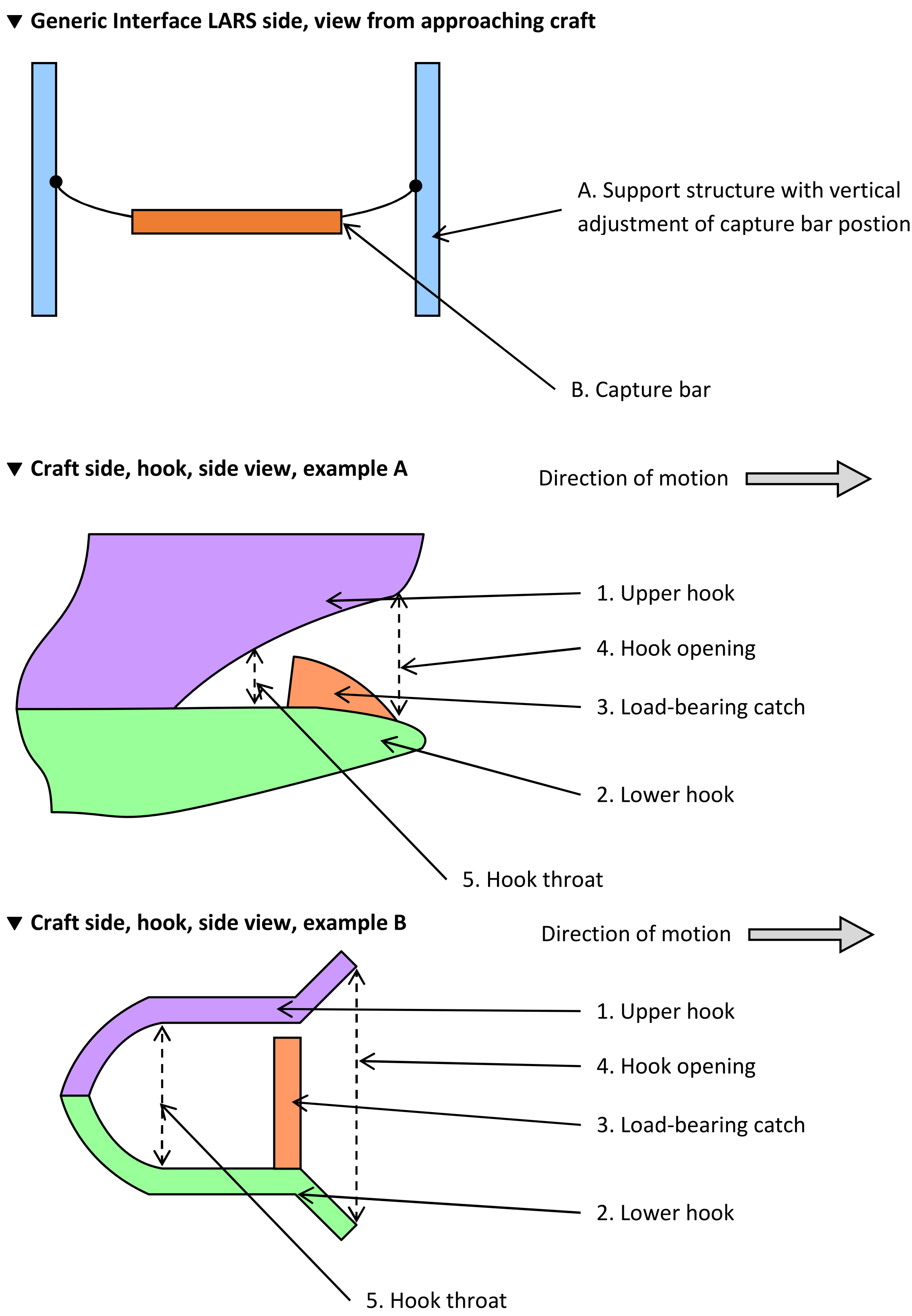


Figure 3: Components of the mechanical Generic Interface System

9.4 LARS Side: Support Structure

9.4.1 Functionality: This component shall allow the vertical position of the capture bar above the waterline to be adjusted.

9.4.2 Geometry: The horizontal spacing of the support structure shall be not less than the capture bar width.

9.4.3 Loading: This support structure shall be designed to withstand a total load at least equal to the resistance of the craft at the maximum speed for launch and recovery, plus appropriate safety factors.

9.4.4 Loading: The support structure shall have sufficient mechanical strength to survive unintentional collisions during launch and recovery operations.

9.5 LARS Side: Capture bar

9.5.1 General: The capture bar should be a tensioned rope or a rope with a rigid sleeve.

9.5.2 Functionality: A means for adjusting the tension whilst aboard the host vessel shall be provided.

9.5.3 Geometry: The width of the capture bar shall be derived from two considerations: the ratio of craft width to LARS width (FCD or cradle); and the steering ability / accuracy of the craft.

9.5.4 Geometry: The height of the capture bar above the waterline shall be adjustable. The required height above the waterline should be derived from: the class of craft; trim due to speed at recovery; the choice of LARS (FCD or Cradle).

9.5.5 Loading: The capture bar shall be designed to withstand a static towing load at least equal to the resistance of the craft at the maximum speed for launch and recovery, plus appropriate safety factors.

9.5.6 Loading: The capture bar shall have sufficient mechanical strength to survive unintentional collisions during launch and recovery operations. Transient collision loads should be considered at least equal to the weight of the craft.

9.5.7 General: The stiffnes of the capture bar shall be chosen with consideration of the resistance of the craft-side load bearing catch, to ensure the catch can be triggered.

9.6 Craft Side: Hook (general)

9.6.1 Geometry: The craft side hook shall be positioned on the upper surface of the craft, above any inflatable collar etc., to prevent the hook under-running the capture bar.

9.6.2 Geometry: The craft side hook may be symmetric or asymmetric in profile, as illustrated by optons A or B.

9.6.3 Loading: The hook shall have sufficient mechanical strength to survive unintentional collisions during launch and recovery operations.

9.6.4 Hook opening geometry: The width of the hook opening shall be be sufficient to accommodate relative vertical movement between craft and LARS. The width required will depend on LARS method adopted.

9.7 Craft Side: Upper hook

9.7.1 Geometry: The upper hook shall have a height and shape that guides the LARS side capture bar into the hook throat.

9.7.2 Mass: Mass should be as low as possible within the geometric and strength requirements.

9.7.3 General: The contact surface of the upper hook may be protected with rubber sheathing etc.

9.8 Craft Side: Lower hook

9.8.1 Geometry: The lower hook shall have a height and shape that guides the LARS side capture bar into the hook throat.

9.8.2 Mass: Mass should be as low as possible within the geometric and strength requirements.

9.8.3 General: The contact surface of the upper hook may be protected with rubber sheathing etc.

9.9 Craft Side: Load bearing catch

9.9.1 Functionality: The catch shall automatically close and lock on entry of the capture bar into the hook throat, without the need for an external command.

9.9.2 Functionality: The catch shall be positively retained in position once closed, without the use of an external power source.

9.9.3 Functionality: The catch shall have a release mechanism on the craft side, allowing it to be released whilst under load. This should be under the control of the coxswain in a crewed craft or operator in the case of an uncrewed craft.

9.9.4 Functionality: The catch shall be fitted with a resetting mechanism so it can be primed for a repeated attempt at connecting with the LARS.

9.9.5 Functionality: A visual indicator of the status of the catch should be provided to the operator.

9.9.6 Loading: When in the closed position, the catch shall be designed to withstand a total load at least equal to the resistance of the craft at the maximum speed for launch and recovery, plus appropriate safety factors.

9.9.7 General: The material selection for the catch should consider the need to withstand frequent metal-on-metal impacts with the capture bar.

9.9.8 General: The resistance of the gate or catch to opening shall be chosen with consideration of the propulsive power of the craft, specifically the ability of the craft to accelerate at the speeds intended for recovery.

9.9.9 General: The resistance of the gate or catch to opening and the stiffness of the capture bar shall be chosen to be consistent with one another.

9.9.10 General: The resistance of the gate or catch to opening may be estimated as {}% of the craft propulsive thrust at the recovery speed.

10 Floating Capture Device (FCD)

10.1 Outline of System

10.1.1 This standard describes a launch and recovery family and associated procedure using a deployed device known as a Floating Capture Device (FCD).

10.1.2 This FCD provides a means to connect a tow line to a deployed craft, to winch it up a stern ramp or hold in position for subsequent connection of lifting lines for davit lift.

10.1.3 The FCD makes use of the GIS, as a component, as the mechanism for the capture of the craft and connection to the FCD.

10.1.4 The FCD may be used as a planar.

10.1.5 Planars may be added to the system in side davit operation to pull the FCD to a position further outboard of the host vessel.

10.2 Applicability and Limitations

10.2.1 Tables 16 and 17 summarise the applicability of the FCD.

10.2.2 The FCD is not suitable for single-point side lift, due to the additional mass of the FCD moving the combined centre of gravity of craft and FCD and potentially causing a bow-down pitch moment.

Table 16: Applicability of FCD to surface and sub-surface craft classes

Surface Craft Class	Applicability and Notes	Sub-Surface Craft Class	Applicability and Notes
SC-I	Applicable when using stern ramp or two-point lift via side davit.	UC-I	Not applicable due to small size of craft relative to FCD
SC-II		UC-II	Applicable when using stern ramp only, due to need to attach lifting lines in davit application.
SC-III		UC-III	
SC-IV		UC-IV	
SC-V	Possibly applicable, due to small size of FCD relative to craft.		
SC-VI			

Table 17: Applicability of FCD to surface and sub-surface craft features

Surface Craft Feature	**Applicability & Notes**
Topology	Applicable to monohull and trimaran hulls. Catamarans unsuitable due to blunt bow shape.
Hull underwater shape	Applicable to all
Propulsion	
Inflatable collar	
Performance	Only applicable when the speed of the deployed craft is at least 4 knots greater than that of the host vessel during launch and recovery.
Human occupied	Crewed (recovery only), Uncrewed (launch and recovery)
Sub-Surface Craft Feature	**Applicability & Notes**
Hull cross section	Applicable to all
Free-flooding	
Propulsion	
Performance	Only applicable when the speed of the deployed craft is at least 4 knots greater than that of the host vessel during launch and recovery.

10.2.3 Table 18 summarises the operational capabilities and limitations of the FCD. These recommendations have been determined from simulation, and full-scale trials.

Table 18: Summary of craft types, sea states and host vessel speeds for the FCD

	UC-I UC-II	UC-III UC-IV	SC-I SC-II SC-III	SC-IV SC-V	Crewed RIB up to 3500Kg	Crewed RIB up to 10000 Kg
Less than Sea State 3	Up to 6 knots all headings	Up to 6 knots all headings	Up to 6 knots all headings	Up to 6 knots all headings	*no data*	*no data*
Sea State 3	Up to 6 knots all headings	Up to 6 knots all headings	Up to 6 knots all headings	Up to 6 knots all headings	*no data*	*no data*
Sea State 4	*no data*	*no data*	*no data*	*no data*	*no data*	*no data*
Sea State 5	Not advised	*no data*	*no data*	*no data*	*no data*	*no data*
Sea State 6	Not advised	Not advised	Not advised	Not advised	Not advised	Not advised

10.3 Description of the System

10.3.1 Figure 4 illustrates an FCD used in a stern ramp system.

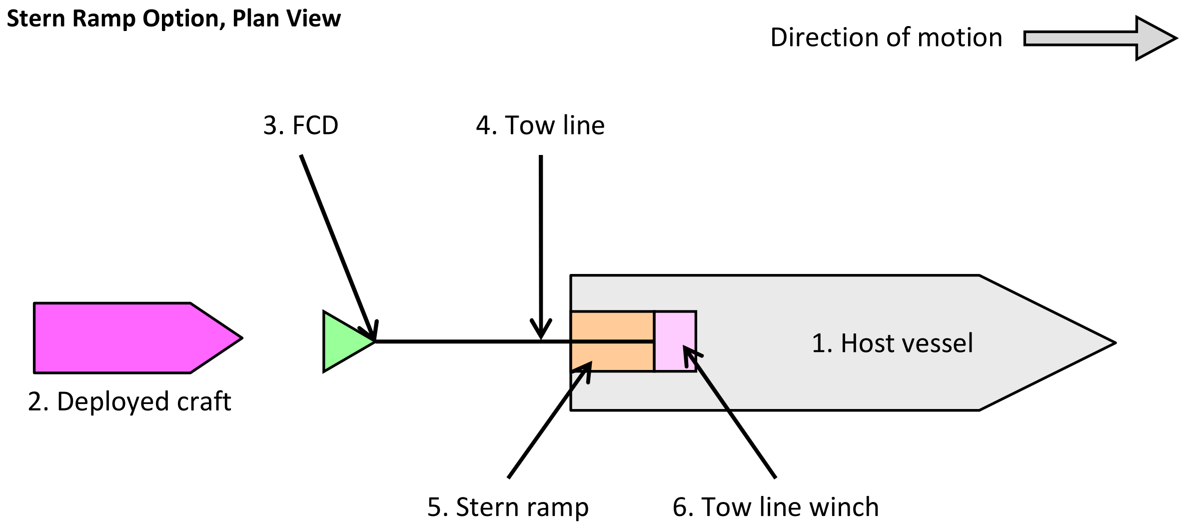


Figure 4: FCD used in a stern ramp system

10.3.2 Figure 5 illustrates an FCD used in a side davit system.

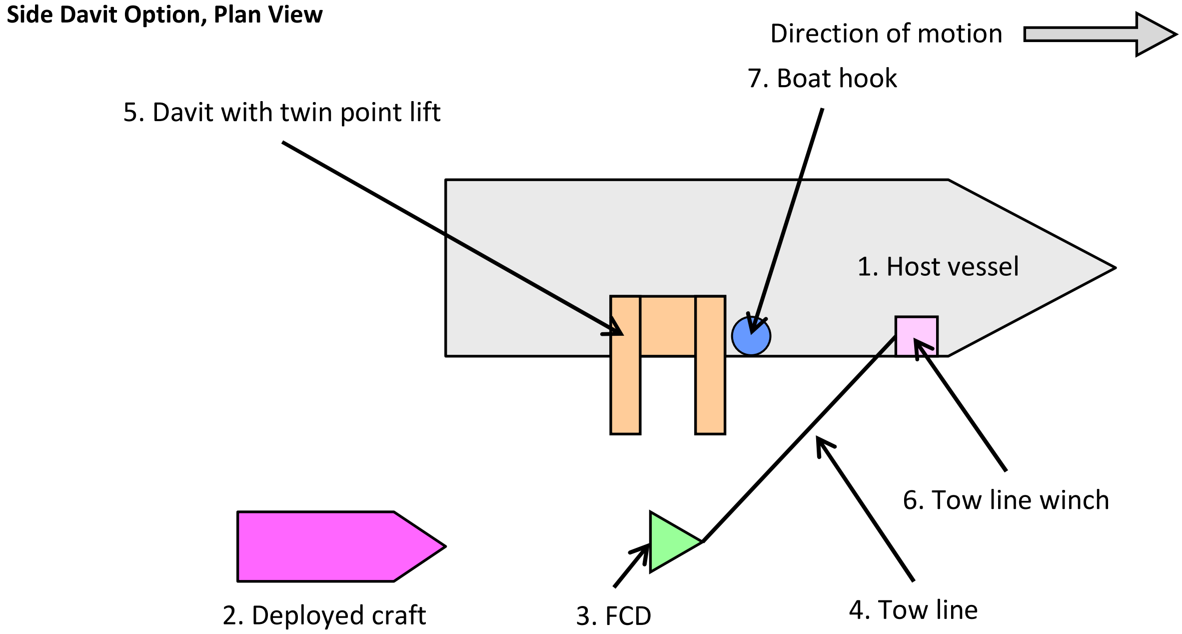


Figure 5: FCD used in a side davit system

10.4 Floating Capture Device

10.4.1 Description: The FCD is a re-useable device that presents a "V" shaped interface to the bow of the deployed craft, with the generic interface system at the apex of the "V" as shown in Figure 6.

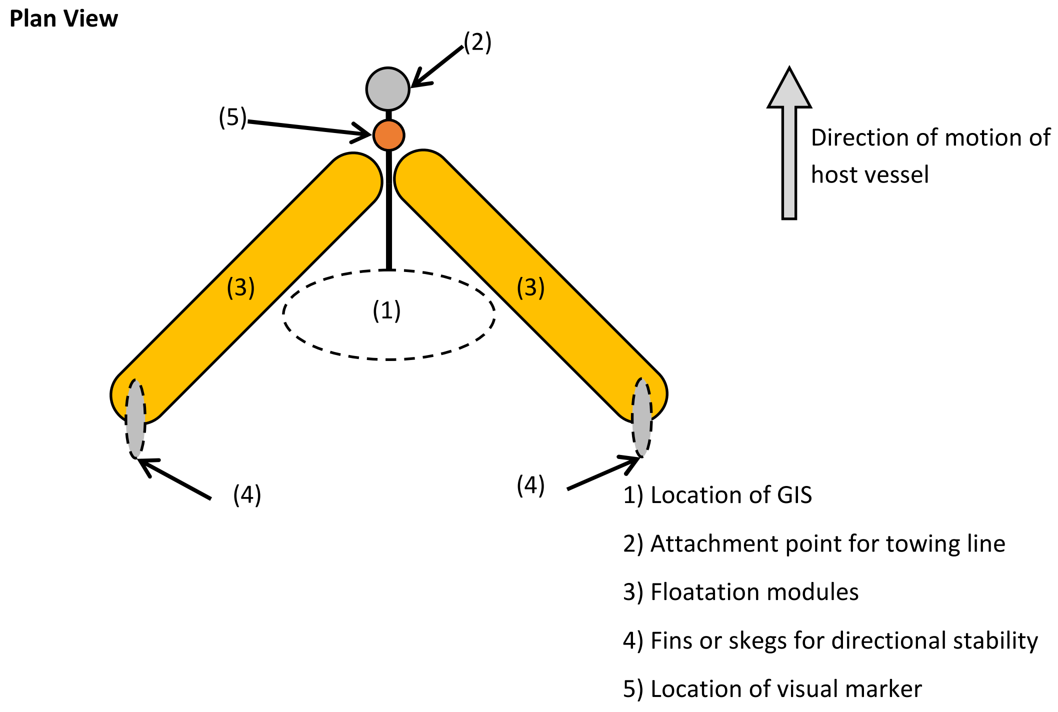


Figure 6: Main components of the FCD

10.4.2 Functionality: The V-shaped interface forms two functions: it guides the bow of the craft into the GIS, and provides directional stability through hydrodynamic resistance.

10.4.3 Geometry: The internal geometry of the FCD shall ensure that the GIS is the first part of the system to contact the craft. This is illustrated for the generic case in Figure 7. In this simple case, the internal angle of the FCD, defined by the ratio of dimensions y1:x1, should be greater than the internal angle of the craft bow, defined by the ratio of dimensions y2:x2.

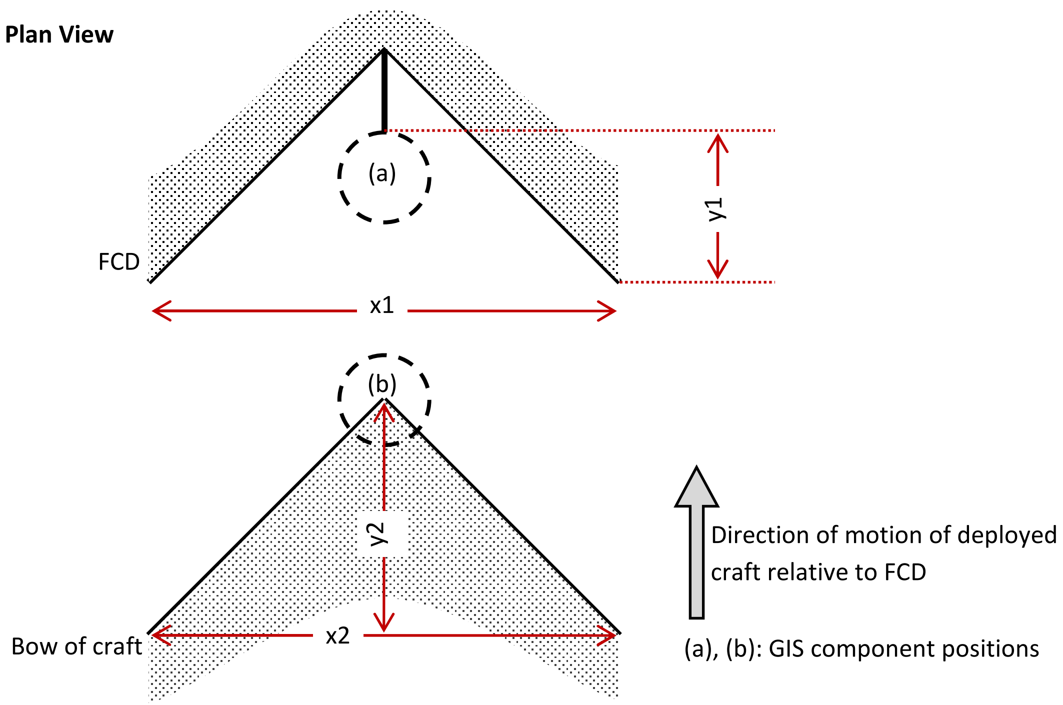


Figure 7: Deployed Craft envelope requirements

10.4.4 Mass: FCD mass shall be no more than {1/20th (5%)} of the craft mass and ideally should be no more than 35kg.

10.4.5 Mass: Where the FCD can be broken into modules, each module shall not exceed: 75kg and be suitable for a two person lift.

10.4.6 Loading: The FCD shall be designed to withstand a total load at least equal to the resistance of the craft at the maximum speed for launch and recovery, plus appropriate safety factors.

10.4.7 Loading: The FCD shall have sufficient mechanical strength to survive unintentional collisions during launch and recovery operations. Transient collision loads should be considered at least equal to the weight of the craft.

10.4.8 Loading: The FCD shall be sufficiently rigid to maintain the shape and height above water of the capture interface whilst under tow. Rigid or semi-compliant FCD structures are permissible if they meet this local geometric requirement.

10.4.9 General: The FCD may be supported by a combination of static and dynamic lift. The dynamic pitch adopted and subsequent GIS vertical location should be the main design criteria. Devices such as fins and sea anchors may be used to control trim angle.

10.4.10 General: The FCD should not be designed for minimum hydrodynamic resistance, as a combination of hydrodynamic drag and FCD mass is required to provide sufficient inertia to ensure functioning of the GIS catch.

10.4.11 Surge stability and inertia should be considered with respect to the required force for GIS function. Drag generating devices such as sea anchors may be used to ensure sufficient stability in this direction.

10.4.12 Yaw stability should be considered with respect to the likelihood of the bow of the craft impacting the sections of the FCD outboard of the GIS, to ensure a rapid return of the FCD to a stable orientation.

10.4.13 General: The FCD shall be fitted with a visual reference to allow determination of craft alignment in the transverse (port-stbd) direction. This may consist of a triangular marker flag in International Orange or another high visibility colour.

10.4.14 General: When used with a side davit, the FCD should be fitted with a locking mechanism to secure it in position before lifting.

10.5 Tow Line:

10.5.1 Functionality: The tow line may be either fixed length, variable length, or deployed via a self-tensioning winch. Different requirements and specifications may apply to each option.

10.5.2 General: The tow line may be attached directly to the winch via a fairlead or bollard, or a boom may be used. The boom should be a minimum of {50%} of the distance between the side of the ship and the centreline of the FCD in the deployed position

10.5.3 General: The choice of material for the tow line shall consider those requirements, such as elasticity, applied by the responsible authority to bow and painter lines for small craft.

10.5.4 Geometry: The attachment point to the host vessel, or end of the boom, shall be chosen so that the tow line does not have an angle greater than {20} degrees from horizontal, and ideally the angle should be no more than {10} degrees from the horizontal.

10.5.5 Mass: The tow line shall be neutrally or positively buoyant.

10.5.6 Loading: The tow line shall be selected to withstand both the hydrodynamic resistance of the FCD at the required launch and recovery speeds and conditions, and the dynamic loads due to wave impacts.

10.6 Boat Hook

10.6.1 A boat hook may be used to lower lifting lines to the craft.

10.6.2 The boat hook may be fixed length or extendable.

10.7 Stern Ramp

10.7.1 Geometry: The FCD cross section shall be designed to fit within the V-shape of a stern ramp. As the FCD is used to winch the craft up the ramp, the effect of the FCD drooping from the craft bow need not be considered.

10.8 Side Davit

10.8.1 Functionality: When the FCD is used in combination with davit or crane lifts over the side or stern, a separate mechanism and procedure is required to attach the lifting line to the craft. Telescopic boat hooks may be used.

10.8.2 Geometry: The length of the FCD shall be considered with respect to the length of boat bay side doors, including additional space allowance for craft and FCD motion during lifting.

10.9 Generic Interface System

10.9.1 Geometry: In the FCD application the GIS should be at a height of at least {300mm} above the waterline.

10.9.2 Geometry: In the FCD application the GIS support structure should permit a vertical range of adjustment of at approximately {1000mm} to support craft in sizes SC-II to SC-IV.

10.9.3 Geometry: In the FCD application the width of the FCD-side capture bar shall be the greater of; {500mm}; or the difference in craft beam and maximum internal width of the FCD.

10.9.4 General: For recovery of uncrewed craft, additional indication of successful GIS connection should be included. A camera fixed to observe the GIS may be suitable.

10.10 Launch and Recovery Procedure

10.10.1 The FCD is applicable to recovery of crewed and uncrewed craft, and launch of uncrewed craft where it is desirable to start up the craft after deployment but before release (e.g. for in-water pre-launch checks).

10.10.2 An example launch and recovery process for side launch via lifting appliances is described in the flow charts in Figure 8 and 9. This process is an example for information only.

10.10.3 It is assumed that for a crewed craft in side launch the minimum personnel requirements are one craft pilot/operator, two davit/crane operators, one supervisor and one tow line operator.

10.10.4 It is assumed that for an uncrewed craft in side launch the minimum personnel requirements are as for a crewed operation minus the craft pilot.

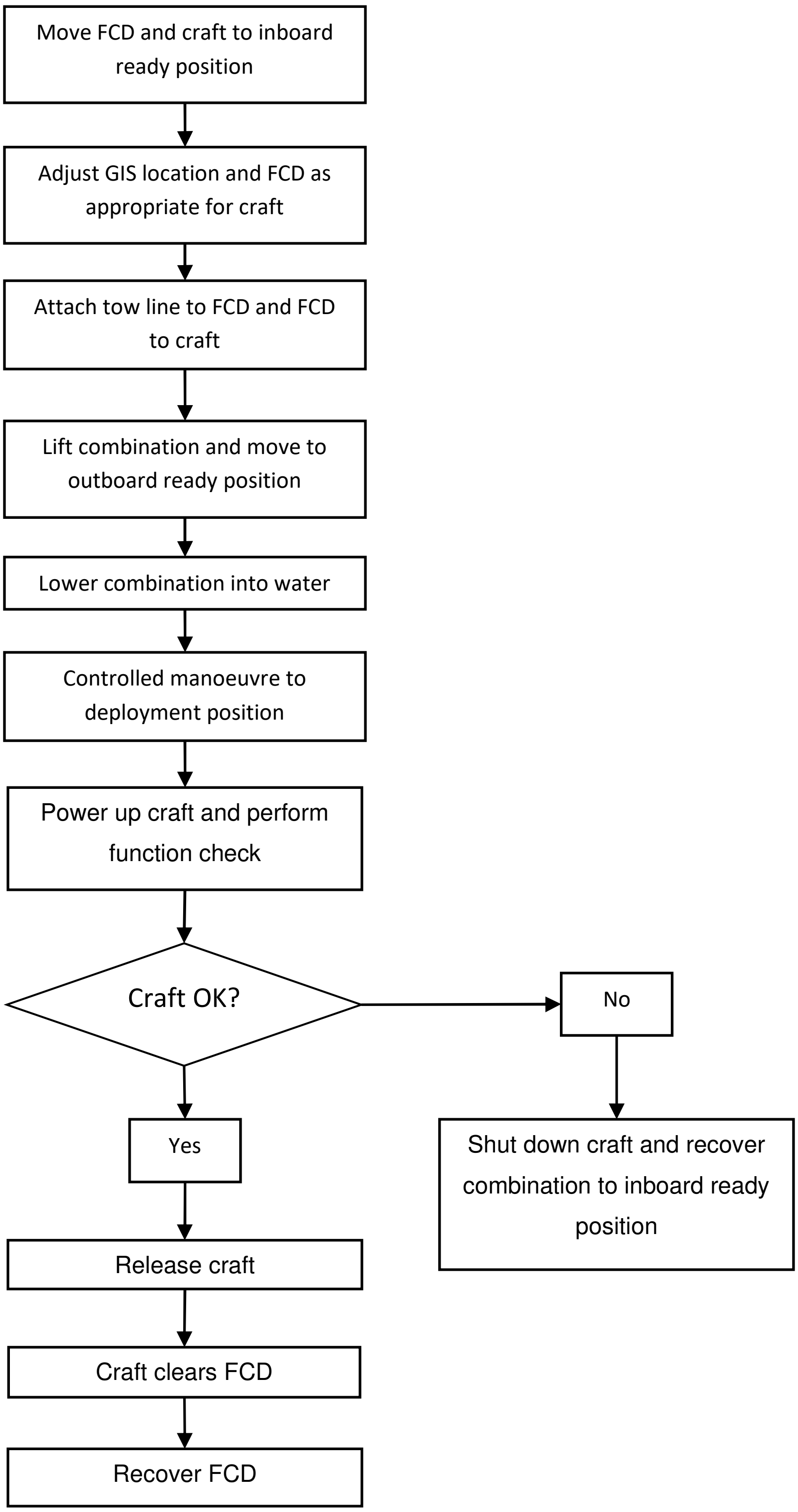


Figure 8: Launch Procedure using the FCD (uncrewed craft)

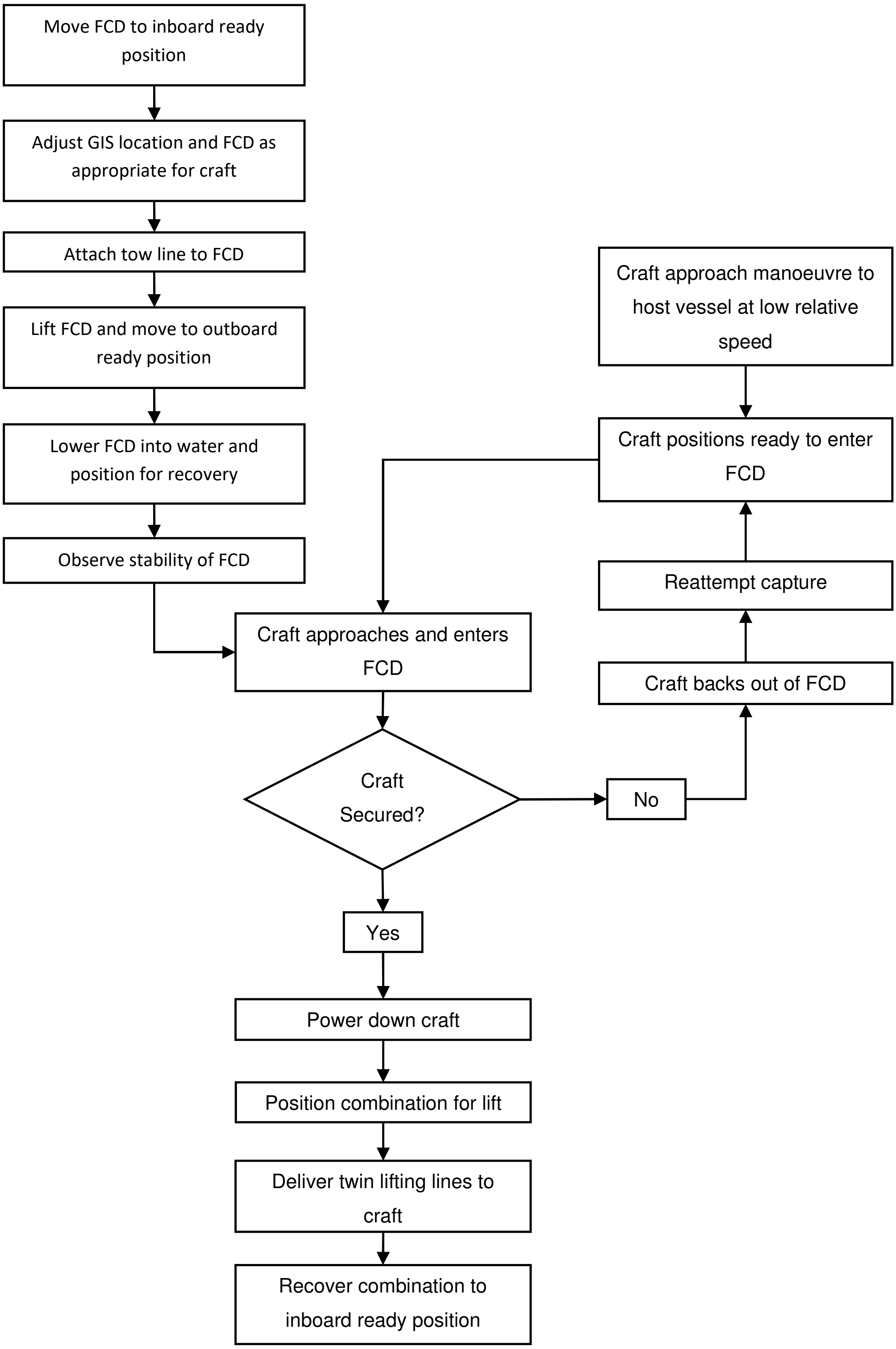


Figure 9: Recovery Procedure using the FCD (crewed or uncrewed craft)

10.11 Assessment Methodology

10.11.1 Sea trials will be required to determine the GIS vertical position for each craft and recovery speed. Extrapolation from other craft shall not be applied, as small craft can adopt extreme angles of trim at slow speeds and the trim of the FCD will vary with speed.

11 Cradles

11.1 Outline of System

11.1.1 The cradle concept family is characterised by a cradle, or frame, containing the craft which is deployed and recovered via davit, crane or stern ramp. The cradle is towed by a tow line secured to the host vessel. During launch, the combination of craft and cradle are deployed from the host vessel, the craft is then released from the cradle. During recovery, the craft docks with the cradle and the combination is recovered to the host vessel.

11.1.2 The Cradle shall make use of the GIS as a component.

11.1.3 The Cradle may make use of the FCD as a component, with the FCD forming the nose of the cradle.

11.1.4 The Cradle is differentiated from the FCD in that the Cradle may be used to lift the craft and support it when stowed.

11.2 Applicability and Limitations

11.2.1 Tables 19 and 20 summarise the applicability of the cradle.

Table 19: Applicability of cradle to surface and sub-surface craft classes

<table>
<tr><th>Surface Craft Class</th><th>Applicability and Notes</th><th>Sub-Surface Craft Class</th><th>Applicability and Notes</th></tr>
<tr><td>SC-I</td><td>Applicable when using stern ramp or side davit, if cradle is designed to prevent beaching before GIS contact.</td><td>UC-I</td><td rowspan="2">Applicable when using stern ramp or side davit, if cradle is designed to prevent beaching before GIS contact.</td></tr>
<tr><td>SC-II</td><td rowspan="5">Applicable when using stern ramp or side davit.</td><td>UC-II</td></tr>
<tr><td>SC-III</td><td>UC-III</td><td rowspan="2">Applicable when using stern ramp or side davit, if cradle has sufficient draft.</td></tr>
<tr><td>SC-IV</td><td>UC-IV</td></tr>
<tr><td>SC-V</td><td></td><td></td></tr>
<tr><td>SC-VI</td><td></td><td></td></tr>
</table>

Table 20: Applicability of cradle to surface and sub-surface craft features

Surface Craft Feature	**Applicability & Notes**
Topology	Applicable to all
Hull underwater shape	
Propulsion	
Inflatable collar	
Performance	Only applicable when the speed of the deployed craft is at least 4 knots greater than that of the host vessel during launch and recovery.
Human occupied	Crewed and Uncrewed
Sub-Surface Craft Feature	**Applicability & Notes**
Hull cross section	Applicable to all
Free-flooding	
Propulsion	
Performance	Only applicable when the speed of the deployed craft is at least 4 knots greater than that of the host vessel during launch and recovery.

11.2.2 Table 21 summarises the operational capabilities and limitations of the Cradle. These recommendations have been determined from simulation, large-scale model testing and full-scale trials.

11.2.3 In practice, maximum recovery speed will potentially be limited by cradle trim.

11.2.4 In the side launch application, maximum sea state will be limited by wavelength rather than wave height, due to differential roll between the cradle and host vessel.

11.2.5 When using the GIS in the cradle, connection success rate is expected to be {90%} of individual attempts.

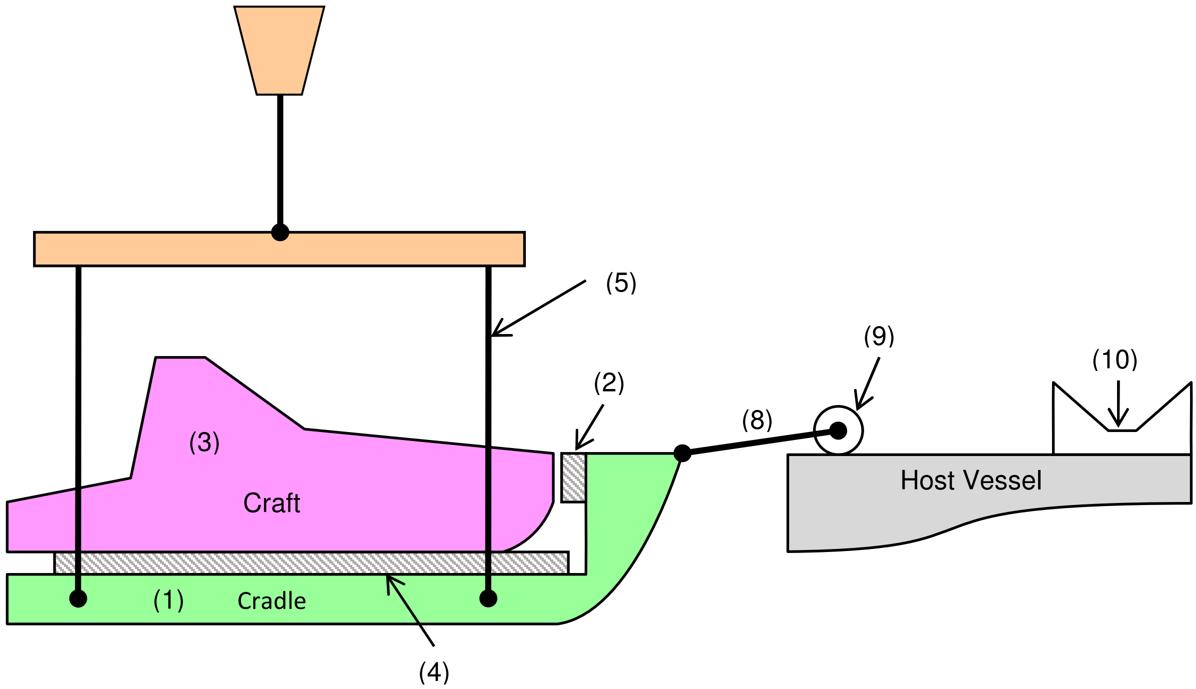
11.2.6 Recovery of a RHIB is expected to take approximately {1 minute +/- 30 seconds}.

Table 21: Summary of craft types, sea states and host vessel speeds for the cradle

	UC-I UC-II	UC-III UC-IV	SC-I SC-II SC-III	SC-IV SC-V	Crewed RIB up to 3500Kg	Crewed RIB up to 10000 Kg
Less than Sea State 3	Up to 3 knots all headings	Up to 5 knots all headings	5 to 12 knots all headings	5 to 12 knots all headings	5 to 12 knots all headings	5 to 12 knots all headings
Sea State 3	Up to 3 knots all headings	Up to 5 knots all headings	5 to 12 knots all headings	5 to 12 knots all headings	5 to 12 knots all headings	5 to 12 knots all headings
Sea State 4	*no data*	*no data*	*no data*	*no data*	*no data*	*no data*
Sea State 5	Not advised	*no data*	*no data*	*no data*	*no data*	*no data*
Sea State 6	Not advised	Not advised	Not advised	Not advised	Not advised	Not advised

11.3 Description of the System

11.3.1 Figure 10 illustrates the components of the cradle in a davit system using a single point lift with a spreader bar.



1) Cradle
2) Bow capture mechanism between craft and cradle (GIS)
3) Example craft envelope
4) Cradle inserts
5) Hoisting bars attached to cradle
6) Spreader
7) Single point lift
8) Cradle tow line (Painter Line)
9) Tow line winches
10) Stowage onboard ship

Figure 10: Components of the cradle in a single-point davit launch system

11.4 Cradle:

11.4.1 Functionality: The cradle should be capable of accommodating varying longitudinal centre of gravity positions to allow different craft to be operated. This may be achieved through a combination of a modular cradle and removable inserts.

11.4.2 Functionality: The cradle may utilize buoyancy and ballast modules to achieve correct waterline and trim.

11.4.3 Functionality: The cradle shall be designed to avoid stagnant flow in the cradle. Internal flow is needed to permit the craft to launch, and prevent surging during recovery.

11.4.4 Functionality: Modular cradles designed for multiple classes shall include arrangements to change the attachement points of hoisting lines or bars.

11.4.5 Geometry: The cradle should not exceed the largest craft recovered +{1.5}m in Length and +{1}m in width.

11.4.6 Geometry: The cradle draught shall be suitable for craft entry.

11.4.7 Geometry: The cradle shall be designed to reduce turbulence in the internal flow. The three main areas of design consideration are: Bow shape; nose shape of buoyancy or ballast modules; openings in the nose and side.

11.4.8 Mass: the cradle should be designed to achieve a mass as low as possible so as to avoid impacting the lifting capacity of current lifting systems. Recommended maximum mass values are shown in Table 22 below.

Table 22: Target maximum cradle mass (dry)

Surface Craft Class	Target Mass
SC-I	1 tonne
SC-II	1 tonne
SC-III	1 tonne
SC-IV	1.8 tonnes
SC-V	3 tonnes
SC-VI	3.3 tonnes

11.4.9 Entrained Water Mass: During the recovery process, entrained water in the craft, cradle and inserts should not exceed {5%} of the total mass (craft, cradle and inserts) and should drain within {2} seconds to within a maximum of {1%} of the total mass.

11.4.10 Loading: The cradle may be rigid or semi-rigid, incorporating flexible sections. If a semi-rigid option is used, the forces exerted on the deployed craft during launch and recovery shall be evaluated with regards to craft strength. In the semi-rigid configuration, the craft may be supported by lifting strops within the cradle.

11.4.11 Loading: The cradle structure shall be designed to withstand the loads induced by its lifting arrangement. The design case shall include the worst possible load case, including the case of breakage of one lifting line for multiple point lifting arrangements.

11.4.12 Loading: Additional loads that should be considered are: impacts with the side of the host vessel or a stern ramp; snatch loads due to wave impacts. Transient collision loads should be considered at least equal to the weight of the craft.

11.4.13 General: The cradle shall be fitted with a visual reference to allow determination of craft alignment in both the transverse (port-stbd) and longitudinal (fwd-aft) directions. This may consist of a triangular marker flag in International Orange or another high visibility colour.

11.4.14 General: The cradle shall be fitted with fenders to avoid damage to the host vessels hull. These may be combined with buoyancy modules.

11.4.15 General: Cradle fender design and material selection should consider the effect of longer periods in contact with the host vessel than would be the case for a typical RIB fender.

11.5 Generic Interface System (GIS)

11.5.1 Functionality: The craft side hook should permit vertical movement so that, when the combination of craft and cradle is lifted, the craft is fully in contact with the load-bearing component of the cradle (e.g. strops or inserts). This may be enabled by the choice of hook throat dimensions, or by the use of mechanisms to allow the hook to move in the vertical plane.

11.5.2 Geometry: GIS to be positioned at least; {300mm} above still water line at regarded launch or recovery speed for craft smaller than Class III; {450mm} above still water line at launch or recovery speed for craft of Class III.

11.5.3 Geometry: To be adjustable to accommodate a {20} degree range of relative pitch angle between the craft and the cradle.

11.5.4 Geometry: Where the craft-side capture hook does not permit vertical movement, the vertical location of the capture bar shall be chosen so that, when the combination of craft and cradle is lifted, the craft is fully in contact with the load-bearing component of the cradle (e.g. strops or inserts).

11.5.5 Hook Opening Geometry: The hook opening geometry should be chosen to accommodate differential movement between the craft and cradle. Typical maximum values for vertical differentials with the craft in the cradle but not connected are shown in Table 23 below.

Table 23: Typical vertical differentials between craft and cradle at GIS

Surface Craft Class	Vertical Differential	Sub-Surface Craft Class	Vertical Differential
SC-I	*No data*	UC-I	*No data*
SC-II	*No data*	UC-II	*No data*
SC-III	0.4m	UC-III	*No data*
SC-IV	*No data*	UC-IV	*No data*
SC-V	*No data*		
SC-VI	*No data*		

11.5.6 Geometry: In the cradle application the width of the cradle-side capture bar shall be the greater of; {500mm}; or the difference in craft beam and maximum internal width of the cradle.

11.6 <u>Craft Envelope</u>

11.6.1 Functionality: A craft envelope should be developed for any cradle design, describing the range of craft it can launch or recover.

11.6.2 Geometry: The craft envelope provides a volume, described by section views in plan, elevation and profile, of a craft that will be accommodated by the cradle.

11.6.3 Mass: The craft envelope describes the range of locations of longitudinal centre of mass for each of the craft size classes that can be supported by the cradle.

11.6.4 General: Multiple envelopes may be developed for modular cradles.

11.7 Cradle Inserts

11.7.1 Functionality: Inserts may be used to achieve the following aims: Allow the cradle to be adapted to smaller classes of craft; Centreing the craft such that the bow capture mechanism can be activated.

11.7.2 General: The inserts may be solid, static inflatable (e.g. compressed air), or dynamic inflatable (e.g. incoming water flow). Dynamic inflatable inserts are only suitable for L&R operations with positive forward speed.

11.7.3 General: Inserts shall be positively secured to the cradle when in use.

11.7.4 General: Inserts design and location shall be considered with regards to the use of rigid or compliant cradle designs and the subsequent changes in geometry during lift.

11.8 Hoisting Bars

11.8.1 Functionality: When a spreader is used, rigid hosting bars shall be be used.

11.8.2 Geometry: The length of the hoisting bars shall be chosen to avoid collision between the craft and spreader. This should consider both the craft envelope and motions of the cradle during recovery.

11.8.3 Geometry: Where a spreader bar is not used, rigid hoisting bars or flexible hoisting lines may be used.

11.8.4 Geometry: Where a spreader bar is not used, the length of the hoisting lines shall be chosen to ensure an internal angle providing sufficient internal width to prevent interference with the craft envelope. This is illustrated in Figure 11.

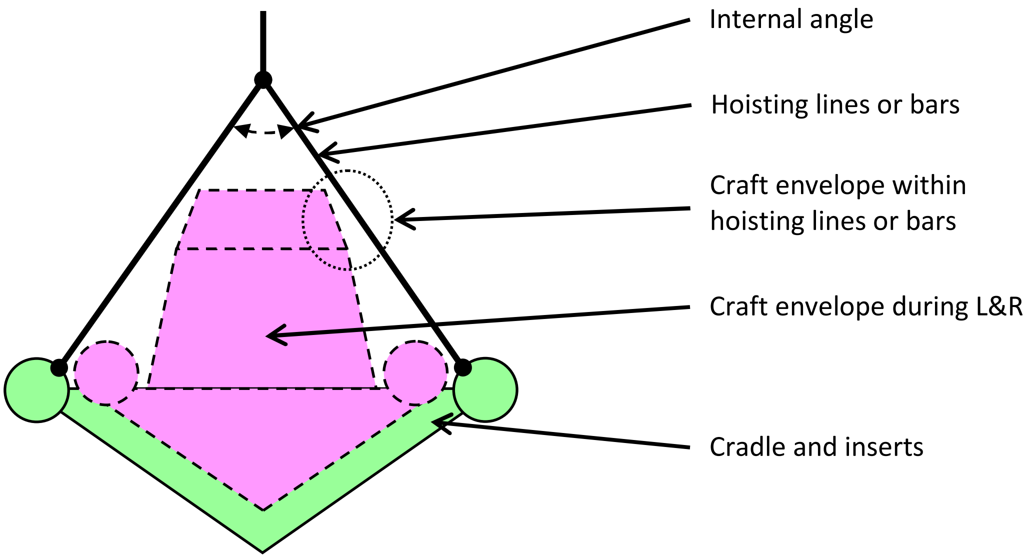


Figure 11: Section of cradle showing importance of internal ange between lines

11.8.5 Loading: Strength calculation for the hoisting lines or bars shall consider: static load due to the mass of craft, cradle and entrained water; dynamic loads due to pendulation of craft cradle and entrained water; snatch loads following wave contact with a partially-hoisted craft and cradle combination.

11.9 Spreader

11.9.1 Functionality: The spreader shall ensure that the hoisting bars meet the cradle at an angle of not more than 10 degrees from the vertical (in a static situation).

11.9.2 Geometry: The span of the spreader should be equal to the width of the cradle.

11.9.3 Loading: Strength calculation for the spreader shall consider; static load due to the mass of craft, cradle and entrained water; dynamic loads due to pendulation of craft cradle and entrained water; snatch loads following wave contact with a partially-hoisted craft and cradle combination.

11.9.4 General: The use of a spreader may be considered for twin-point lifts, to meet the hoist line geometry requirements described in 11.8.

11.9.5 General: The spreader shall be a rigid structure.

11.10 Davit

11.10.1 Functionality: The davit or crane should be fitted with a self-tensioning winch.

11.10.2 The winch speed in self-tensioning mode shall be selected to accommodate the worst possible operational conditions.

11.10.3 Loading: Davit, lines and hook design and selection shall consider; static load due to the mass of craft, cradle and entrained water; dynamic loads due to pendulation of craft cradle and entrained water; snatch loads following wave contact with a partially-hoisted craft and cradle combination.

11.10.4 General: Where a single-point lift is used, bow and stern painters may be required on the cradle to prevent rotation.

11.11 Tow Line:

11.11.1 General: Figure 12 shows the generalized geometry of the tow line.

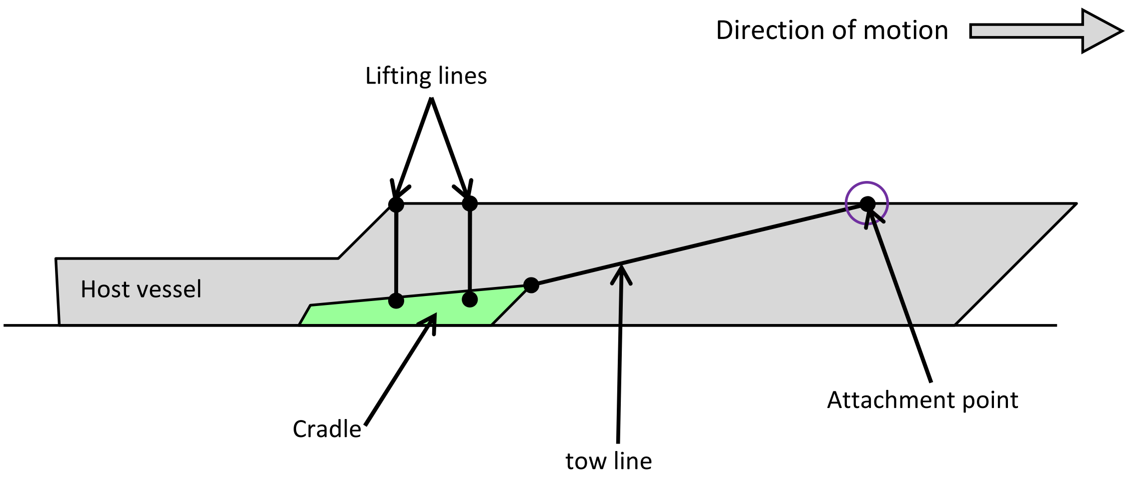


Figure 12: Profile view showing the generalized geometry of the tow line

11.11.2 Functionality: The tow line may be either fixed length, variable length, or deployed via a self-tensioning winch. Different requirements and specifications may apply to each option.

11.11.3 General: The tow line may be attached directly to the winch via a fairlead or bollard, or a boom may be used. The boom should be a minimum of {50%} of the distance between the side of the ship and the centreline of the cradle in the deployed position

11.11.4 General: The choice of material for the tow line shall consider those requirements, such as elasticity, applied by the responsible authority to bow and painter lines for small craft.

11.11.5 Geometry: The attachment point to the host vessel, or end of the boom, shall be chosen so that the tow line does not have an angle greater than {20} degrees from horizontal, and ideally the angle should be no more than {10} degrees from the horizontal.

11.11.6 Mass: The tow line shall be neutrally or positively buoyant.

11.11.7 Loading: The tow line shall be selected to withstand both the hydrodynamic resistance of the cradle at the required launch and recovery speeds and conditions, and the dynamic loads due to wave impacts.

11.12 Stowage

11.12.1 Functionality: The cradle may be used as the stowage for the craft, or it may be stowed separately.

11.13 Launch and Recovery Procedure

11.13.1 Davit Launch and Recovery is described by Figures 13 and 14. This is an example for information only.

11.13.2 It is assumed that for a crewed craft the minimum personnel requirements are one craft pilot/operator, two davit/crane operators, one supervisor and one tow line operator.

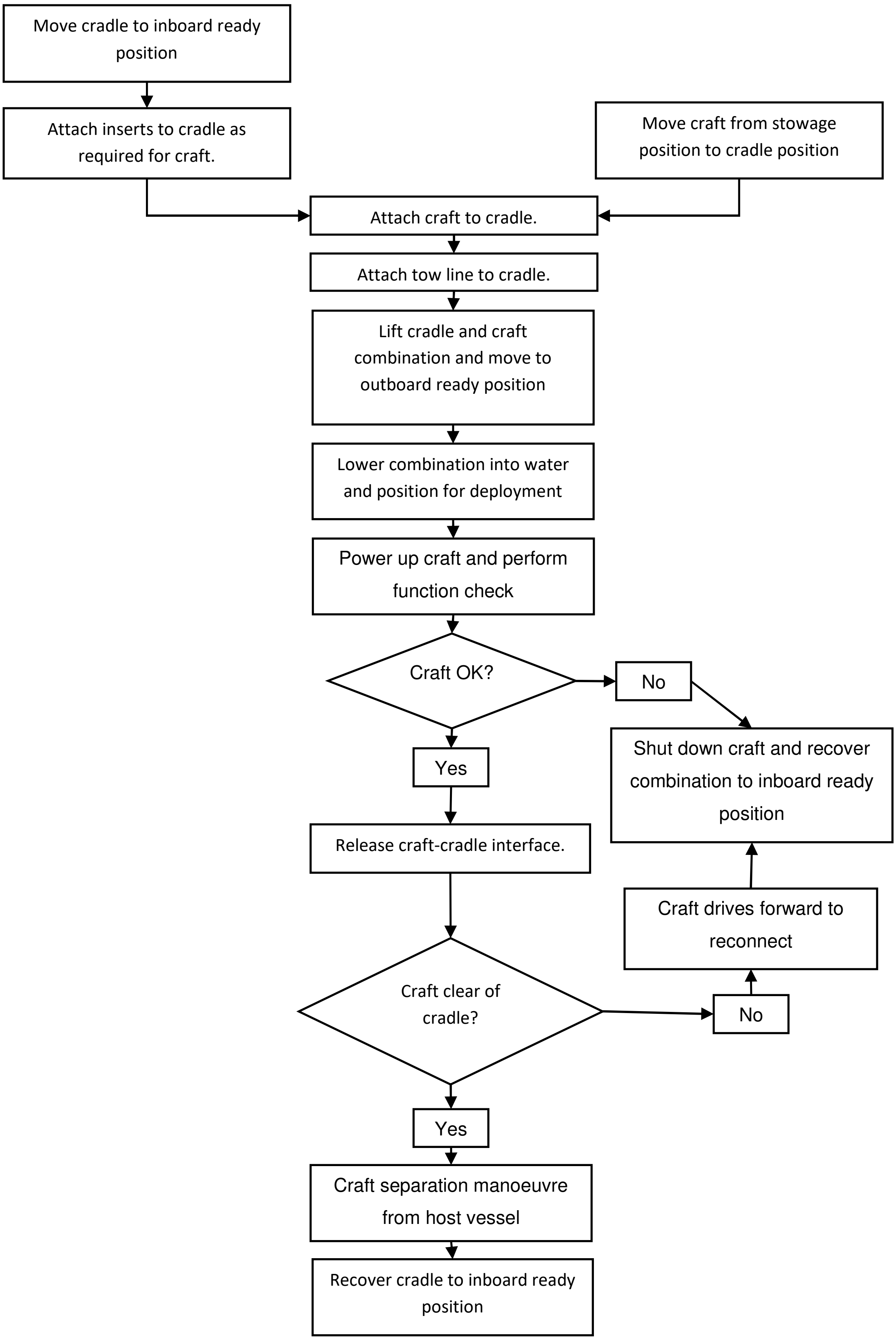


Figure 13: Launch procedure for the cradle using a davit

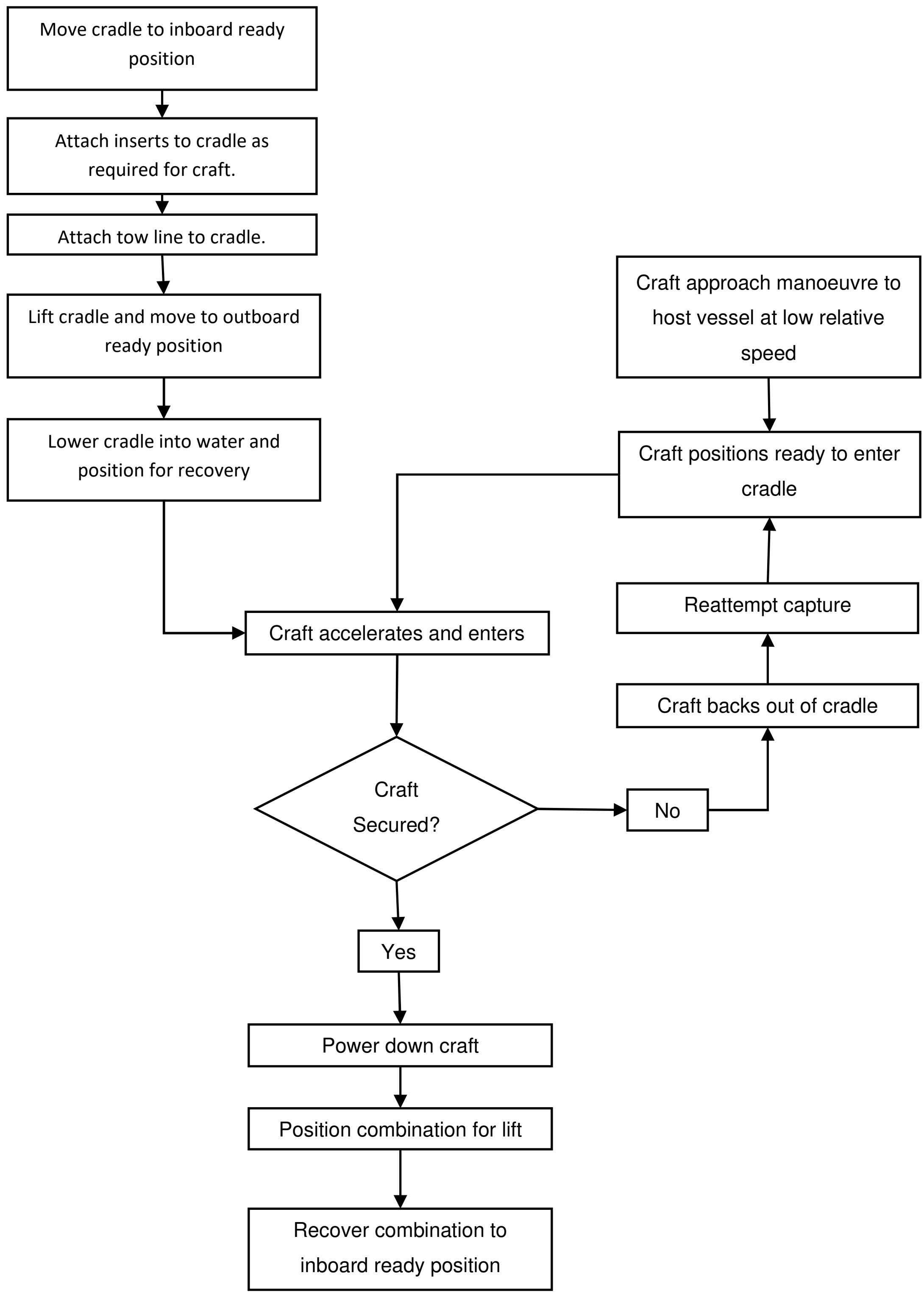


Figure 14: Recovery procedures for the cradle using a davit

11.14 Assessment Methodology

11.14.1 Model tests may be used to predict and sea trials shall be used to confirm the GIS vertical position for each craft and recovery speed. Extrapolation from other craft shall not be applied, as small craft can adopt extreme angles of trim at slow speeds.

11.14.2 Model tests may be used to predict and sea trials shall be used to confirm that the flow inside the cradle is sufficiently steady to permit craft recovery.

11.14.3 Model tests and sea trials shall include; both entering and leaving the cradle, for both launch and recovery processes, to accommodate abort options.