Guidance Notes on

The Use of Remote Inspection Technologies

December 2022

GUIDANCE NOTES ON

THE USE OF REMOTE INSPECTION TECHNOLOGIES
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Foreword *(1 December 2022)*

Suitable means of access to structures is required for surveys to be carried out safely, effectively, and efficiently. Currently, Surveyors use a combination of permanent, temporary (e.g., staging, scaffolding, rafting, and ladder), and alternative (e.g., rope access) means of access to conduct class surveys. Remote inspection technologies (RITs) are considered an alternative means of access. These technologies can help reduce safety risks to the Surveyor (e.g., working at heights and working in enclosed and confined spaces). In contrast to Remote Survey, which is for non-attended verification of select surveys, remote inspection techniques are performed in the presence of the Surveyor on-site and directed by the attending Surveyor during class-related surveys and, when approved by the flag State, statutory activities.

There are different remote inspection technologies (RITs) that can assist the attending Surveyor in evaluating a structure's condition. These RITs may be installed on remote inspection vehicles or robotic arms. Vehicles and robotic arms allow for collecting digital data to support an assessment of the structure's condition and identify anomalies. This data may include photos, videos, light detection and range (LiDAR) data, and other NDE data. The remote inspection vehicle (RIV) is a remotely controlled vehicle operating in the air, underwater, or on structures. Some common types of RIV include Unmanned Aerial Vehicles (UAVs), Remotely Operated Underwater Vehicles (ROVs), and robotic crawlers. These RITs also benefit the asset Owner/Operator by reducing operational intrusiveness.

These Guidance Notes offer best practices for class surveys and non-class inspections using RITs. These best practices include recommendations and guidance on applications of RITs, technology qualification, and proficiency of the remote inspection Service Suppliers, RIV operation, data handling, and data analysis. These best practices are intended to facilitate a safer, more effective, and efficient survey. The following IACS Recommendations and Requirements were considered in the development of these Guidance Notes:

- IACS Recommendations No. 42, Guidelines for Use of Remote Inspection Techniques for Surveys
- IACS UR Z7, Hull Classification Surveys 1.6 Remote Inspection Techniques
- IACS UR Z17, Procedural Requirements for Service Suppliers

These Guidance Notes address UAVs, ROVs, robotic crawlers, and remote cameras and robotic arms. This document references the relevant industry standards and ABS Guides and Guidance Notes. These Guidance Notes supersede the ABS *Guidance Notes on the Use of Unmanned Aerial Vehicles*, which has been retired.

The May 2022 version updated these Guidance Notes based on ABS/industry experience, including RIT procedure or Survey, field tests on UAV thickness measurement, UAV autonomous inspection, Artificial Intelligence (AI) software to detect coating breakdown, and Other Remote Camera systems.

The December 2022 version reorganizes Section 2, Tables 2 and 3 into one table grouped by inspection area instead of RIT method.

These Guidance Notes become effective on the first day of the month of publication.

Users are advised to check periodically on the ABS website www.eagle.org to verify that this version of these Guidance Notes is the most current.

We welcome your feedback. Comments or suggestions can be sent electronically by email to rsd@eagle.org.

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GUIDANCE NOTES ON

THE USE OF REMOTE INSPECTION TECHNOLOGIES

CONTENTS

SECTION 1
Introduction

1 General (1 May 2022)

Remote inspection technologies (RITs) may be installed on remote inspection vehicles or robotic arms. A remote inspection vehicle (RIV) is a remotely controlled vehicle operating in the air, underwater, or on structures (e.g., ship, mobile offshore unit, pipeline, and mooring line/chain). In these Guidance Notes, three RIV types are discussed: Unmanned Aerial Vehicles (UAVs), Remotely Operated Underwater Vehicles (ROVs), and robotic crawlers. These Guidance Notes also discuss robotic arms. The use of RIVs can reduce risk to Surveyors and inspectors by reducing the need for Surveyors/inspectors to access potentially hazardous locations at height, in confined spaces, or other hazardous inspection areas. RITs can be used to reduce the amount of preparation and time required for inspections, thereby also reducing operating expenses for operators. These Guidance Notes provide best practice recommendations on using RITs to facilitate safer, more effective, and efficient inspections.

1.1 Unmanned Aerial Vehicles (UAVs) (1 May 2022)

An unmanned aerial vehicle (UAV), commonly known as a drone, is an aircraft without a human pilot onboard. A UAV can be a tethered or wireless vehicle designed to fly in or around a structure. The UAV can be remotely controlled or programmed to fly a predetermined route using the information on a specific asset's condition to target known areas of concern. It can collect visual data (e.g., still images, live-stream, and recorded video), perform Nondestructive Testing (NDT), and measure plate thickness from difficult-to-reach structures and areas.

1.3 Remotely Operated Underwater Vehicles (ROVs) (1 May 2022)

An ROV is an unmanned unit designed for underwater observation, survey, inspection, construction, intervention, or other tasks. Like UAVs, an ROV can be remotely controlled or programmed to travel a predetermined route using the information on a specific asset's condition to target known areas of concern. It can collect visual data, perform Nondestructive Testing (NDT), and measure plate thickness in difficult-to-reach areas.

1.5 Robotic Crawlers (1 May 2022)

A robotic crawler, commonly referred to as a "crawler", is a tethered or wireless vehicle designed to "crawl" along a structure using wheels or tracks. Crawlers are often equipped with magnets to operate on a vertical or inclined surface or hull structures in air or underwater.

1.7 Remote Cameras and Robotic Arms (1 May 2022)

A remote camera can be installed on a robotic arm. There are several types of robotic arms, which can serve many uses. For example, a robotic arm can be inserted through deck openings in pre-planned locations, and the camera lowered into position on a robotic manipulator. The remote camera can collect visual data of compartments normally inaccessible for physical inspection.

3 Scope *(1 May 2022)*

The purpose of these Guidance Notes is to provide information to the marine and offshore industries on:

i) The use of RITs in conjunction with class surveys

ii) The use of RITs in conjunction with non-class-related inspections (i.e., pre-approved by each appropriate flag State for statutory surveys and inspections)

If RITs are used in conjunction with class-related surveys and, when approved by the flag State, statutory activities, it is considered an alternative means of access to assist the attending Surveyor in performing an examination of hard-to-reach structures. RITs should be considered in advance and incorporated into the survey planning phase. Acceptance of the inspection results is at the discretion of the attending Surveyor. The Surveyor may require additional inspections using other alternative or traditional inspection techniques depending on the conditions found and results of the remote inspection.

These Guidance Notes are intended for pilot-operated RIT applications only. Local (Port and/or Country) requirements and regulations for the use of RIVs should be verified and complied with.

These Guidance Notes cover:

- Applications of Remote Inspection Technologies (Section 2)
- Guidance for Service Supplier Selection (Section 3)
- Survey/Inspection Process (Section 4)

5 Associated Documents *(1 May 2022)*

- ABS *Rules for Survey After Construction, Part 7*
- ABS *Rules for Building and Classing Mobile Offshore Units, Part 7, "Surveys"*
- ABS *Guidance Notes on Job Safety Analysis for the Marine and Offshore Industries*
- ABS *Guidance Notes on the Development of Procedures and Technical Manuals*
- ABS *Guidance Notes on Risk Assessment Applications for the Marine and Offshore Industries*
- ABS *Guidance Notes on the Investigation of Marine Incidents*
- ABS *Guide for Means of Access to Tanks and Holds*
- ABS *Guide for Nondestructive Inspection*
- ABS *Guide for Dropped Object Prevention on Offshore Units and Installations*

7 Terminology and Abbreviations *(1 May 2022)*

ABS Recognized Service Supplier Program: An ABS program to certify Service Suppliers who perform services on behalf of an equipment manufacturer, shipyard, vessel's owner or other clients in connection with classification and/or statutory services.

Autonomous UAV Scan: A UAV with autopilot and anti-collision capabilities which use Artificial Intelligence (AI) technology to recognize and avoid objects in real-time and make intelligent flight decisions. Before scanning, the Remote Pilot in Command (RPC)/Service Supplier should define the distances of scanning scope (i.e., the distance to surface and Ground Sample Distance (GSD) in millimeter/pixel) for each scan.

Beyond Visual Line of Sight (BVLOS) Operation: Operations where the UAV is not within the visual line of sight of the operator at all times.

Civil Aviation Authority (CAA): The statutory corporation that oversees and regulates all aspects of civil aviation in the United Kingdom. The use of UAVs within the United Kingdom is subject to CAA regulations.

Close-up Survey: A survey where details of structural components are within close visual inspection range of the Surveyor (i.e., normally within hand's reach), which is defined in the ABS *Rules for Building and Classing Marine Vessels (MVR)*. The offshore industry may refer to a Close-up Survey as "Close Visual Inspection" (CVI), which is defined in the ABS *Rules for Building and Classing Mobile Offshore Units (MOU Rules)*.

Digital Data: Visual data (e.g., still images, live-stream video, and recorded video), gauging data, and data from other emerging technologies.

Distance to surface: A distance between the UAV and structural surface per the types of inspection (i.e., GVI/overall or CVI/close-up survey). This distance should be defined by the remote pilot in command (RPC) /Service Supplier for an autonomous flight.

ESP: Enhanced Survey Program.

Extended Visual Line of Sight (EVLOS) Operation: Operations that rely on one or more remote observers to keep the UAV in visual sight at all times. These remote observers relay critical flight information via radio and assist the pilot in maintaining safe separation from other aircraft.

Federal Aviation Administration (FAA): The national aviation authority of the United States, with powers to regulate all aspects of American civil aviation. The use of UAVs within the United States is subject to FAA regulations.

FAA Part 107 Certificate (FAA107): An active FAA certificate to operate UAVs in the US. Outside the US, similarly applicable certificates are required to use UAVs.

Flight Control Modules: An onboard system that can control a UAV's direction in flight.

Global Positioning System (GPS): A satellite navigation system used to determine the global position of an object.

Ground Sample Distance (GSD): A distance from UAV to ground surface used for a 3D autonomous flight plan.

Hazardous Areas: Areas where flammable or explosive gases, vapors, or dust usually are present or likely to be present.

Hazardous Area Plan: An arrangement plan indicating hazardous areas with classification levels. It may also be referred to as an "Area Classification Plan".

High-Definition (HD) Resolution: Video/Image of substantially higher resolution and quality than standard-definition (e.g., 720P, 1080P, 4K).

Job Safety Analysis (JSA): A technique that focuses on job tasks to identify hazards. It focuses on the relationship between workers, tasks, tools, and the work environment. It also includes steps to eliminate or reduce the hazards to an acceptable level. JSAs can be performed formally, with requisite subject matter experts. They may be performed immediately before beginning a work activity at the job site.

Light Detection and Ranging (LiDAR): A remote sensing method using light in the form of a pulsed laser to measure ranges to structures/objects.

Machine Learning (ML): The study of computer algorithms that can improve automatically through experience and data.

Metadata: Data that provides information about other data. The metadata collected with still imagery and video can include but is not limited to time/date stamps, GPS location, camera orientation, focal length, shutter speed, aperture setting, ISO level, camera type, and lens type.

Nondestructive Testing (NDT): A broad group of analysis techniques used in the science, technology, and engineering industry to evaluate the properties of a material, component, or system without causing damage. NDT is sometimes referred to as nondestructive examination (NDE), nondestructive inspection (NDI), and nondestructive evaluation (NDE).

Notice to Airman: A statement filed with an aviation authority to alert aircraft pilots of potential hazards along a flight route or at a location that could affect the safety of the flight.

Overall Survey: A survey intended to report on the hull structure's general condition and determine the extent of additional Close-up Surveys. An Overall Survey, which is defined in the ABS *Rules for Survey After Construction (Part 7),* may be referred to by the offshore industry as "General Visual Inspection" (GVI), which is defined in the ABS *Rules for Building and Classing Mobile Offshore Units (MOU Rules)*.

Original Equipment Manufacturer (OEM): The original equipment manufacturer of a RIV or robotic arm.

Payload: The carrying capacity of a RIV in terms of weight. It usually refers to the reserved lifting ability of the RIV to perform additional operations, excluding the basic systems required for moving (e.g., flying, swimming, or crawling).

Payload Operator: An operator who only controls the onboard modules of the RIV.

Personal Protection Equipment (PPE): Protective clothing, helmets, goggles, and other garments or equipment designed to protect a person from an injury or hazard.

Photogrammetry: A 3D coordinate measuring technique using photographs as the fundamental medium for measurement.

Pilot: An operator who directly controls the RIV (e.g., UAV, ROV, or robotic crawler).

Point Cloud: A 3D coordinate measuring technique utilized by Photographs and LiDAR (Light Detection and Ranging) as the fundamental medium for measurement.

Quality Management System (QMS): A set of policies, processes, and procedures required for planning and execution (production/development/service) in the core business area of an organization.

Receiver Autonomous Integrity Monitoring (RAIM): A technology developed to assess the integrity of Global Positioning System (GPS) signals in a GPS receiver system.

Remote Camera and Robotic Arm: A remotely controlled camera installed on a robotic arm. The robotic arm is a type of mechanical arm with similar functions to a human arm. The links of such a manipulator are connected by joints allowing either rotational motion or translational displacement.

Remote Inspection Technique: Remote inspection techniques may include the use of:

- Divers
- Unmanned robot arm
- Remote Operated Vehicles (ROV)
- Climbers
- Drones
- Other means accepted.

Surveys carried-out by Remote Inspections Techniques are to be carried out in the presence of the Surveyor.

Remote Inspection Technology (RIT): A technology installed on remote inspection vehicles or robotic arms that is used by a remote inspection technique. These vehicles and robotic arms allow for collecting digital data to support an assessment of the structure's condition and identify anomalies. This data may include photos, videos, light detection and range (LiDAR) data, and other NDE data.

Remote Inspection Vehicle (RIV): A remotely-controlled vehicle (e.g., UAV, ROV, or robotic crawler) often equipped with a remote camera and connectivity equipment. A control station and a platform to display visual data and to operate the RIV.

Remotely Operated Underwater Vehicle (ROV): An unmanned unit designed for functions such as underwater observation, survey, inspection, construction, intervention, or other underwater tasks.

Remote Pilot in Command (RPC): A person responsible for the planning and operation of the work scope. The RPC has the final authority and responsibility for the operation and safety.

Remote Piloted Aircraft (RPA): A UAV controlled remotely by a pilot.

Safety Assurance (SA): A key component of the SMS used to evaluate the continued effectiveness of applied risk control strategies and support identifying new hazards.

Safety Management System (SMS): A systematic approach to managing safety, including the necessary organizational structures, accountabilities, policies, and procedures.

Safety Risk Management (SRM): A key component of the SMS intended to determine the need for and adequacy of new or revised risk controls based on the assessment of acceptable risk.

Service Supplier: A company that provides specialized inspection services using RITs.

SOLAS: International Convention for the Safety of Life at Sea.

Standard Operation Procedure (SOP): A set of step-by-step instructions created by the organization to assist workers in carrying out routine operations.

Survey Planning Document: A document prepared by the Owner/Operator to support the survey pre-planning requirements for carrying out class-related surveys.

Tether Management System (TMS): Acts as an ROV's "garage". It is a device in which the ROV is contained during launch and recovery for its protection or sits on top of a larger working-class ROV. The purpose of the TMS is to lengthen or shorten the tether to eliminate the drag of the umbilical attached to the ROV.

Underwater Inspection in Lieu of Drydocking (UWILD): The underwater inspection that may be carried out as an alternative to Drydocking Surveys.

Unmanned Aerial Vehicle (UAV): An aircraft with no pilot on board that is controlled remotely or can fly autonomously based on a predefined flight route and/or using dynamic automation systems. The industry may refer to Unmanned Aerial Vehicles as "drones", Remotely Operated Aerial Vehicles (ROAVs), or Unmanned Aircraft Systems (UASs).

Ultra-short Baseline (USBL), also known as Super Short Baseline (SSBL): A method of underwater acoustic positioning. A complete USBL system consists of a transceiver mounted on a pole under a ship and a transponder or responder on the seafloor or an ROV. A computer is used to calculate a position from the ranges and bearings measured by the trans-receiver.

Visual Line of Sight (VLOS) Operation: Operations that always keep the UAV in the visual line of sight of the pilot. For example, UAVs are not flown into clouds, fog, or behind structures.

Work Permit/Permit-to-Work (PTW): A formal, documented safety protocol that individuals complete when conducting high-risk jobs. A PTW is not a replacement for a JSA. Many companies require that a PTW may not be authorized unless accompanied by a task-specific JSA for the job.

SECTION 2

Application of Remote Inspection Technologies

1 General *(1 May 2022)*

Remote inspection technologies (RITs) are typically equipped with a camera and remote control modules capable of collecting visual data in the form of still images, live-stream videos, or recorded videos of difficult-to-reach structures and areas.

Below are a few examples of where RITs can be used to aid/assist in inspection-related activities:

i) *Working at Heights:* RITs can reduce the need for personnel to work at heights using conventional means of access (e.g., staging, scaffolding, or rafting).

ii) *Underwater Inspection:* RITs can carry out underwater tasks and reduce or eliminate the need for human divers.

iii) *Confined Space Entry:* RITs can carry out tasks in areas with limited or restricted means of entry or exit, such as tanks, vessels, and pipelines.

iv) *Preliminary Condition Assessment:* RITs can be used as a screening tool to quickly collect visual data at specified locations for preliminary condition assessments.

v) *Known Condition Assessment Monitoring:* RITs can be used to periodically monitor temporary repairs in hard-to-reach areas. Additionally, known damage that does not require immediate repair can be monitored using photographic evidence or other data collected by RITs.

vi) *Damage Assessment for Rapid Response:* RITs can be used to assist rapid and timely damage assessment following certain situations (e.g., collision or grounding of vessels, structure failure, etc.).

vii) *Data Collection for 3D Model:* RITs can be used to collect a point cloud or photogrammetry data to generate a 3D Model.

RITs are an evolving technology. Additional applications for RITs may become available in the future.

3 Application to Survey *(1 May 2022)*

RITs are tools that may be used to assist the attending Surveyor with class surveys and, when approved by the flag State, statutory activities where visual examination of the structure is required. In general, remote inspection techniques can be used as an alternative means for the close-up survey of marine and offshore structures in compliance with IACS UR Z17. Additional Rule and Regulatory requirements are to be considered and incorporated into Survey Planning Documents for other inspection methods such as hull gauging and nondestructive testing (NDT). The remote inspection techniques related to survey activities are described in Subsection 2/7. Due to rapidly evolving technologies, RIT applications and inspection methods in addition to those discussed in these Guidance Notes may become available in the future. ABS should be contacted for details on the acceptance of these evolving technologies. The process is discussed in Subsection 2/9.

If an owner or operator intends to incorporate RITs into an ABS class or statutory survey, the local ABS office should be advised in advance for consideration. The intended use of the RITs should be incorporated into the Survey Planning Document.

Flag Administrations may have additional requirements or restrictions for using RITs during statutory surveys and these should be considered during the survey planning.

The role of the Owner/Operator, Service Supplier, and ABS are outlined in 2/3 TABLE 1, “Roles and Responsibilities”. The local ABS survey office should be contacted for details on survey planning, scheduling, and execution.

TABLE 1
Roles and Responsibilities *(1 May 2022)*

Activity	*Role of the Owner/Operator*	*Role of the Service Supplier*	*Role of ABS*
Planning	Determine, in consultation with ABS, if the use of RIT is appropriate Select an ABS Recognized Service Supplier as the Service Supplier Provide supporting information to the Service Supplier about the asset's condition and drawings related to the work scope Review and accept the remote inspection plan proposed by the Service Supplier Provide Survey Planning Documentation, with inspection plan incorporated, to the attending Surveyor Coordinate logistical aspects of the inspection, such as obtaining work/ site permits, onboarding crews, inspection preparation, etc.	Develop an inspection plan which includes, but is not limited to: • Determining the appropriate type of RIT to be used • Performing a risk assessment and developing the remote inspection plan based on the work scope Create an operation plan for RITs. This operation plan should be developed based on the proposed inspection.	Review the proposed Survey Planning Document to verify the survey plan satisfies the applicable ABS Rules, ABS Guides, and other requirements while employing the RIT as an inspection technique Accept Survey Planning Document
Operation	Initiate the remote inspection Coordinate survey and remote inspection activity with the Surveyor and the Service Supplier	Execute the remote inspection by the agreed Survey Planning Document, RIT operation plan, and to the satisfaction of the ABS Surveyor Perform a JSA during the kick-off meeting	Conduct the survey in compliance with applicable ABS Rules, ABS Guides, and other requirements. The remote inspection will be carried out in the presence of the attending Surveyor or as detailed otherwise in the Survey Planning Document. The Surveyor will direct the RIV or robotic arm operations team, as needed, regarding the survey requirements.
Reporting	Review the inspection results provided by the Service Supplier	Provide inspection results and data to the Owner/ Operator and ABS, as applicable. Inspection results should include the identification of any limitations of the process.	Evaluate the results of the remote inspection for credit towards the class survey. Determine any additional inspections that may be required to further examine or validate the RIT results.

For all surveys accepted for using RITs, acceptance of the remote inspection results is at the discretion of the attending Surveyor. The Surveyor may require additional inspections using other alternative or traditional inspection techniques depending on the conditions found and results of the remote inspection.

Additional conditions for using RITs during surveys are discussed in Section 4.

5 Owner Self-Inspection *(1 May 2022)*

RITs may be used to assist owners with various assessment and self-inspection purposes. Potential applications for owner self-inspection include:

Survey and Drydock Preparation: Owners may use RITs to prepare for periodic surveys and related drydock activities. Identifying any new damages and checking the condition of any existing damage promotes effective preparation.

Asset Management/Maintenance Programs: With safer and potentially quicker or less intrusive methods available for accessing heights, enclosed and confined spaces, and other hazardous areas, owners may establish asset management and/or maintenance programs to regularly perform preventative maintenance.

Emergency Response: Owners may use RITs to respond to emergencies (e.g., ship grounding, man overboard, structural failure) safely and efficiently.

Platform for Emerging Technologies: RITs may be used as a platform for piloting emerging technologies (e.g., image comparison, gaugings, lasers for coating assessment). This promotes collaboration among owners, Service Suppliers, vendors, and class societies to explore safer, more efficient inspection technologies.

The owner may own the platform or perform the inspection through a Service Supplier. All inspections should be carried out by qualified personnel.

7 Remote Inspection Techniques in Survey Activities *(1 December 2022)*

RIT can be considered to assist the attending Surveyor during survey activities. The RIT should perform the requirements specified in the ABS *Rules for Survey After Construction (Part 7)* for marine vessels, Part 7 of the ABS *Rules for Building and Classing Floating Production Installations (FPI Rules)* for floating installations, or Part 7 of the ABS *Rules for Building and Classing Mobile Offshore Units (MOU Rules)* for offshore units.

The remote inspection techniques are a means to enable examination of any part of the structure without the need for direct physical access during the survey by the Surveyor. The Service Supplier may need the remote inspection techniques certification for the engagement in the survey using remote inspection techniques as an alternative means for a survey of the structure of ships and mobile offshore units.

When a UT probe takes thickness measurements from a RIV (e.g., UAV, ROV, and robotic crawler), a hull gauging certification, specified in Subsection 1/5 of the ABS *Guide for Nondestructive Inspection (NDI Guide)*, is recommended for the Service Supplier. The Service Supplier should demonstrate the full scope of the required thickness measurements for the vessel or offshore unit, including the final gauging report. The calibration of the UT probe, specified in 3/3.5 of the *NDI Guide*, should be performed every time the battery on the RIV is changed. The UT probe on RIV should be in steady contact with the steel surface for at least five seconds. If the thickness measurement cannot be performed in the areas not accessible by the RIV, manual thickness measurement should cover these areas.

2/7 TABLE 2 provides recommendations for the use of remote inspection techniques in the specified inspection areas and types for the survey of marine vessels and offshore units.

TABLE 2
Remote Inspection Techniques for Marine Vessels and Offshore Units
(1 December 2022)

Inspection Areas	*Inspection Types*	*Recommendations*
Internal Inspection (Any Type of Tanks/Spaces)	Overall Survey or General Visual Inspection (GVI)	Notes 1, 3
	Close-up Survey or Close Visual Inspection (CVI)	Notes 1, 3
	Thickness Measurement	Notes 2, 3
	Nondestructive Testing (NDT)	Note 3
In-Water Inspection	Overall Survey or General Visual Inspection (GVI)	Note 1
	Close-up Survey or Close Visual Inspection (CVI)	Note 1
	Thickness Measurement	Note 2
	Nondestructive Testing (NDT)	-----
Inspection of Structures at Height	Overall Survey or General Visual Inspection (GVI)	Notes 1, 3
	Close-up Survey or Close Visual Inspection (CVI)	Notes 1, 3
	Thickness Measurement	Notes 2, 3
	Nondestructive Testing (NDT)	Note 3

General Notes:

- A Remote Inspection Techniques certificate(s) should be verified by ABS for all Recognized Service Suppliers who perform remote inspection techniques.
- Any restrictions of the assigned Service Supplier Certification should be included in the inspection plan and presented to the attending Surveyor prior to the commencement of the survey(s).
- The application of Remote Inspection Techniques may also be utilized if the technique or method has proven to be effective and the restrictions/limitations are noted in the Service Supplier Recognition Certification.
- If the Remote Inspection Techniques cannot be used to perform all the necessary survey requirements, traditional survey methods are to be applied.
- For NDT application, the Service Supplier should perform the requirements specified in ABS Guide for Nondestructive Inspection (NDI Guide)

Notes:

1 Spaces to be internally examined should have their inspection plan approved by ABS. Also, the subject spaces should be:

- Cleaned as specified in 7-3-1/3.5 of the ABS Rules for Survey After Construction (Part 7),
- Light colored coating and in GOOD condition,
- Free of scale, and
- Free of obstruction.

2 Thickness measurements should be taken in conjunction with the close-up survey or CVI.

3 Remote Inspection Techniques used in hazardous areas should be certified safe as defined in International Standards IEC 60079 (or other applicable recognized standards).

9 Process to Accept RIT *(1 May 2022)*

When the survey is not carried out by traditional practices (e.g., staging) to allow survey where the details of structural components are within the close visual inspection range of the Surveyor (i.e., normally within hand’s reach), the examination using RIT may be carried out by a certified ABS Service Supplier. The recommended process to accept RIT are summarized below.

i) Proposals (including selected equipment, procedures, and survey scope) of pilot initiatives should be submitted to ABS in advance of the survey to agree on satisfactory arrangements with ABS.

ii) The capabilities of the specific RIT should be defined in the proposal to identify defects/conditions, for example:

a) Coating condition

b) Thickness of scale

c) Thickness measurement of steel

d) Depth of pitting

e) Fractures

f) Deformation

g) Leaks

h) Anode condition

i) Piping and other outfitting condition

j) Condition of plating under suction bell mouths

k) Welding defects

l) Missing structures

iii) In the proposal, ABS, IACS, IMO, flag Administration, and Coastal State requirements should be identified.

iv) Visibility should be sufficient to allow for a meaningful examination.

v) The ABS Surveyor should be satisfied with the methods of orientation on the structure.

vi) The ABS Surveyor should be satisfied with the method of data presentation and good two-way communication between the Surveyor and RIV or robotic arm operator.

vii) Blind tests for the validation should be performed by RIT and the current traditional survey.

viii) The outcomes of blind tests should be reviewed and evaluated to the satisfaction of the ABS Surveyor, where the results by RIT are confirmed to be equivalent to those by the current traditional survey. The results should also clearly state any limitations or conditions that may be needed to support the proposed RIT process.

SECTION 3

Guidance for Service Supplier Selection (1 May 2022)

1 General (1 May 2022)

When RIT is used for an inspection, the asset Owner/Operator is responsible for:

i) Selecting a remote inspection Service Supplier whose qualifications and capabilities are appropriate for the intended application

ii) Verifying the inspection can be conducted safely, effectively, and efficiently

If the RIT is used for close-up examination associated with surveys, the remote inspection Service Supplier is to be an ABS Recognized Service Supplier in compliance with IACS UR Z17.

The following recommendations can be used as guidance for the Owner/Operator to assess the qualifications of the remote inspection Service Supplier.

3 Regulations (1 May 2022)

For UAVs, the remote inspection Service Supplier should obtain all applicable certificates of authorization from recognized national/local authorities or according to an equivalent industrial standard where the inspection is to be performed. Where no national/local requirements are applicable for UAVs, it is recommended to follow the criteria implemented by recognized aviation authorities such as the FAA's Title 14 Code of Federal Regulations (CFR), Part 107 requirements, and the CAA's CAP 722 guidance.

5 Quality Management System (1 May 2022)

A Quality Management System (QMS) is a formalized system that documents processes, procedures, and responsibilities for achieving quality policies and objectives. A QMS helps coordinate and direct an organization's activities to meet customer and regulatory requirements and improve effectiveness and efficiency continually. The Service Supplier should have an internal QMS that:

i) Demonstrates the ability to consistently provide services that meet customer and applicable statutory and regulatory requirements

ii) Enhances customer satisfaction through the practical application of a management system, including processes for continual improvement of the system and conformity to customer and applicable statutory and regulatory requirements

It is recommended that the remote inspection Service Supplier obtain ISO 9001 certification or equivalent third-party vetting credentials. At a minimum, the following should be included as part of the QMS:

- Operating instructions, maintenance logs, and reference calibration of all equipment
- Training program to provide relevant training based on the job description and individual qualifications

- Policies and procedures regarding the recording and reporting of information
- Policies and procedures regarding operating preparations
- Process for reviewing procedures, complaints, corrective actions, and issuance, maintenance, and control of documentation
- Code of conduct for the use of RITs for inspection

7 Safety Management System *(1 May 2022)*

A Safety Management System (SMS) provides a systematic approach to managing safety. The SMS should emphasize safety management as a fundamental business process to be considered in the same manner as other aspects of business management. For example, in the United States, the US FAA/Coast Guard suggests that the SMS for product/Service Supplier integrate modern safety risk management and safety assurance concepts into repeatable, proactive systems.

The SMS of the Service Supplier should be evaluated for its fitness-for-service based on the aspects of the following paragraphs.

7.1 Safety Policy *(1 May 2022)*

The remote inspection Service Supplier should establish their senior management's commitment to continually improve safety and define the methods, processes, and organizational structure required to meet safety goals. The Service Supplier should have written policies, processes, and procedures to address:

i) Safety commitment

ii) Safety objectives

7.3 Safety Risk Management *(1 May 2022)*

Safety Risk Management (SRM) determines the need for and adequacy of new or revised risk controls based on the assessment of acceptable risks. The Service Supplier should incorporate system descriptions, risk assessment, and risk controls in their service planning documents.

7.5 Safety Assurance *(1 May 2022)*

Safety Assurance (SA) evaluates the continued effectiveness of implemented risk control strategies and supports the identification of new hazards. It is recommended that the Service Supplier maintain organizational procedures that address compliance with SMS requirements and standards, policies, directives, and any requirements applicable to the technology being used, such as aviation orders. Actions to demonstrate safety assurance include, but are not limited to:

i) Internal audits and evaluations

ii) Reporting culture and incident reporting system, including near-miss reporting

iii) Safety data analysis and assessment

iv) Safety oversight and improvement

7.7 Safety Promotion *(1 May 2022)*

The Service Supplier should promote a positive safety culture through training, communications, and other actions within all levels of the workforce in the company. Further guidance on safety culture can be found in the ABS *Guidance Notes on Safety Culture and Leading Indicators of Safety*.

9 Management of Change *(1 May 2022)*

If modifications to equipment, operational policies, and organization's or personnel are necessary, then an effective Management of Change (MoC) system is critical. A MoC system is a combination of policies and procedures used to evaluate the potential impacts of a proposed change so that it does not result in the introduction of new hazards or increase the risk of existing hazards or threats. Developing an effective MoC strategy requires establishing, documenting, and successfully implementing formal policies to evaluate and manage temporary and permanent modifications. Whenever a change is made, the potential consequences of that change should be assessed before implementation. It is recommended that the Service Supplier have a MoC strategy in place as part of their quality and safety management system. Further guidance on MoC can be found in the ABS *Guidance Notes on Management of Change for the Marine and Offshore Industries*.

11 Recommendations for Service Supplier Selection *(1 May 2022)*

When selecting a remote inspection Service Supplier, it is recommended that the asset Owner/Operator review the QMS (Subsection 3/5) and SMS (Subsection 3/7) of the Service Supplier for the aspects provided in the following Paragraphs.

11.1 Equipment *(1 May 2022)*

The remote inspection Service Supplier can be an Original Equipment Manufacturer (OEM) of the RIV or robotic arm capable of providing inspection services to the asset Owner/Operator. The remote inspection Service Supplier can also be an inspection service firm that utilizes a RIV or robotic arm manufactured by others. In either case, the quality standards of the equipment, including hardware and software, should be maintained through equipment selection and maintenance.

11.1.1 Equipment Selection *(1 May 2022)*

Based on the intended application of the RIT (e.g., external offshore structure inspection, internal marine vessel cargo tank/hold/ballast/void inspections, wind turbine inspection, dropped objects inspection, Underwater Inspections in Lieu of Drydocking (UWILD)), the specifications and capabilities of the hardware and software equipment may be different. When selecting a remote inspection Service Supplier, RIV, or robotic arm and associated equipment, the following should be considered.

i) *Safety:*

a) The RIV or robotic arm and any onboard inspection modules should be rated for their intended operational environment (e.g., certified safe type for use in hazardous areas as defined in IEC 60079, operational wind speed, temperature, humidity, etc.).

b) The materials of the RIV or robotic arm and onboard inspection modules should be non-hazardous to the structure and the operational environment during normal operations or in the instance of a malfunction or failure.

c) For internal structure inspections, it is recommended that the RIV or robotic arm possess a protection component to minimize damage to the structure and coatings (e.g., propeller guards).

d) The RIV or robotic arm should have critical component redundancy in the case of a malfunction or failure (e.g., motor, battery, controller, etc.).

e) The RIV or robotic arm should have multiple operational modes (e.g., GPS mode, height mode, and manual mode) in the case of a malfunction or failure.

f) For UAVs, the propeller mounting method should prevent accidental detachment.

g) The UAV should have an emergency landing capability, returning to its recovery zone and keeping the same location after losing the communication link.

h) The remote inspection Service Supplier should have a fatigue management program for its pilots. It is recommended that the daily operating time for each pilot be limited to eight hours, and the continuous operating time for each task be limited to three hours.

ii) *Operability:*

a) The RIV or robotic arm should have a control station that allows the pilot to operate the RIV or robotic arm easily.

b) The RIV or robotic arm should have onboard localization and navigation modules (e.g., GPS for external inspection).

c) The RIV or robotic arm should provide sufficient lighting, especially for internal tank inspection and/or during night time operation.

d) The RIV or robotic arm should be capable of operating for an amount of time adequate to conduct the inspection (e.g., sufficient battery life).

e) The maximum operating range of the RIV or robotic arm should be accurately defined (e.g., flight height/tether length/depth rating, distance from the pilot).

f) The OEM should have previously tested the functionality of the selected RIV or robotic arm type.

g) Dimensions of the RIV or robotic arm should allow for access and navigation within the intended space (e.g., manhole, opening to small or confined spaces, size of the openings, structural limitations within the space, etc.).

h) The RIV or robotic arm should provide and maintain an interference-resistant communication channel.

i) The RIV or robotic arm should include reliable connectivity to equipment to maintain constant communication among team members during operations.

j) The UAV has onboard flight control modules that allow for maintaining stable and accurate positions.

iii) *Acquisition, Review, and Security of Remote Inspection Technology Data:*

a) Integrity of the raw data should be maintained during the data storage process.

b) Related metadata of the raw data should be captured and stored properly.

c) The raw data and related metadata should be stored separately from post-processed data.

d) The RIV or robotic arm should have an onboard camera that provides adequate visual quality of still images, live-stream videos, and recorded videos. It is recommended the camera possess High-Definition (HD) resolution (e.g., 4K resolution for still images).

e) If applicable, the RIV or robotic arm may have onboard sensors that can provide additional information such as geotag information, anomaly measurement (e.g., crack length measurement and coating breakdown area measurement), thermal imaging, and 2D/3D modeling.

f) The RIV or robotic arm should include an appropriate platform to display and replay visual data on location for the owner/Surveyor, including still images, live-stream videos, and recorded videos.

g) All frequencies used to support safety-critical functionality should be coordinated and licensed by the appropriate licensing regime, as applicable.

h) The remote inspection Service Supplier should have data security policies and procedures to verify that the data collected during the inspection and any data analyses are captured, transmitted, and stored in a secure way that has minimum vulnerability to unauthorized manipulation and distribution.

11.1.2 Battery Handling *(1 May 2022)*

If a battery powers the RIV, the remote inspection Service Supplier should have procedures in place for the proper handling of RIV batteries, including the following:

- Battery tracking system identifying the batteries' use, replacement, and performance.
- Battery transportation and storage, including safe charging and safe disposal.

11.1.3 Tether Handling *(1 May 2022)*

If a tether/cable powers the RIV, the remote inspection Service Supplier should have procedures in place for the proper handling of tethers/cables, such as:

- ABS recommends that the Service Supplier arranges for additional cameras for monitoring tethers/cables.
- A plan should be in place to address tangled tethers/cables.

11.1.4 Maintenance *(1 May 2022)*

It is recommended that the Service Supplier provides maintenance training to their designated personnel. Adequate knowledge of pre-operation assembly and checkup, post-operation disassembly, handling, transport, and storage are essential to delivering safe, effective, and efficient service.

It is recommended that the Service Supplier follows the OEMs' maintenance processes and procedures. Where no maintenance guidance is available from the OEMs, the following criteria should be considered:

i) *Calibration:* Equipment should be calibrated regularly for its fitness-for-service and in accordance with the OEM instructions.

ii) *Hardware Check:* Blades, motors, wires, and other fixed components should be checked, cleaned, and renewed/replaced if needed.

iii) *Software Check:* Any software updates or changes should be documented as part of the maintenance procedures.

iv) *Swappable Payload Check:* Swappable modules should be checked for loose connections. Module functions should be checked and calibrated.

v) *Battery:* Inspections for capacity and thermal runaway should be conducted regularly.

A logbook (or log entries) should be maintained for each type of maintenance activity. The logbook is recommended to include all pre-operation and post-operation inspection records. A description of any malfunctions (e.g., loss of link), anomalies, and parts needing replacement.

11.3 Personnel *(1 May 2022)*

The remote inspection Service Supplier should utilize competent personnel to perform remote inspection related services.

Depending on the nature of the job, different training programs should be provided by the remote inspection Service Supplier to their operators. If recognized national/local authorities have qualification and training requirements, these should be considered minimum standards. In addition to the applicable statutory and regulatory requirements, the remote inspection Service Supplier is recommended to have mandatory standard requirements for personnel qualification and training/re-training.

When the RIV is equipped with a Nondestructive Examination (NDE) tool, the operator should be qualified and certified as described in the ABS *Guide for Nondestructive Inspection*.

11.3.1 Safety Awareness *(1 May 2022)*

Safety awareness training should be part of the Service Supplier's SMS. The objective of this training should be to confirm that the personnel in the field can execute the inspection safely, not only regarding themselves but also to the asset and the environment, and should also include any national, local, or industry-recognized requirements (e.g., Safety and Environmental Management Systems (SEMS) from Bureau of Safety and Environmental Enforcement (BSEE)). Where no such requirements are applicable, the Service Supplier should provide safety training to the designated personnel including, as applicable:

i) Personal protective equipment (PPE) training

ii) Dropped object awareness training

iii) Confined space entry and safety practice

iv) Hazardous area identification and safety practice

v) Maritime emergency response and evacuation training

vi) Basic Offshore Safety Induction and Emergency Training (BOSIET)

11.3.2 Supervisor Proficiency *(1 May 2022)*

A supervisor is the person who oversees the pilot, who controls the RIV or robotic arm. The supervisor should be certified according to the recognized national requirements or an equivalent standard and has a minimum of two years' experience in inspecting marine and/or offshore structures.

11.3.3 Pilot Proficiency *(1 May 2022)*

A pilot is the person in direct control of the RIV or robotic arm. Pilot proficiency in remote inspection operations can affect the safety of onsite personnel and the asset that is being inspected. If applicable, the pilot should meet statutory and regulatory operation training requirements to maintain their pilot license.

In addition to the statutory and regulatory requirements, the Service Supplier should place a high level of emphasis on pilot proficiency through training. The following are recommended:

i) The pilot should have formal training in the minimum Rule requirements for the structure of relevant ships or asset types, the recognition of structural deterioration (including corrosion, buckling, and deteriorated coatings), and the use of the reporting system.

ii) The pilot should have sufficient flight/ground/underwater experience so that expected or observed extreme scenarios (i.e., weather condition changes, functional loss, operation with extra PPE, etc.) can be foreseen and accounted for.

iii) The pilot is qualified and licensed under applicable national requirements or an equivalent industrial standard and has at least one year's experience as an assistant in the inspection of marine and/or offshore structures (including participation in a minimum of five different assignments).

11.3.4 Inspection Knowledge *(1 May 2022)*

Training should be provided for remote inspection Service Supplier's personnel to familiarize them with basic maritime and/or offshore asset designs and terminology. This training should include maritime and/or offshore nomenclatures to communicate effectively with the asset Owner/ Operator and the attending Surveyor during the inspection.

Personnel should have working knowledge of applicable Rules, Guides, and guidelines (such as the ABS *Rules for Survey After Construction (Part 7)*, Part 7 of the ABS *Rules for Building and Classing Mobile Offshore Units*, the ABS *Guide for Means of Access to Tanks and Holds for Inspection*, and IACS Recommendation No. 42, UR Z7, and UR Z17.

11.3.5 Fatigue Management *(1 May 2022)*

It is recommended that the Service Supplier have a Fatigue Management System to help prevent fatigue-related work incidents. The Fatigue Management System should aim to:

- Increase the personnel's understanding of the need to be fit for duty.
- Create safe working environments and operations by eliminating or minimizing hazards associated with fatigue.
- Utilize fatigue avoidance and mitigation strategies or countermeasures for identified hazards to be implemented, where possible, to help manage fatigue risk and related issues.
- Incorporate fatigue management in the Service Supplier's ongoing risk assessment and hazard monitoring processes.

11.5 Documentation *(1 May 2022)*

The remote inspection Service Supplier should have an organized documentation system to confirm that service-related records are well maintained. It should include, but is not limited to:

i) Documentation of the organizational and management structure.

ii) *Statutory and Regulatory Certificates:* Required certificate of authorization from recognized national/local authorities or according to an equivalent industrial standard.

iii) *Equipment Registry:* The Service Supplier should obtain a registry of each operational device with OEM specifications, serial number, technical bulletins, software versions, and hardware alteration and customization history.

iv) *Training/Retraining Record:* The training/retraining record should include all applicable information of personnel in terms of personal portfolio, training hours, dates, scores, and other company-specified categories.

v) *Operations Logbook:* The Service Supplier should maintain a logbook to record all applicable operational information such as operation date, time, duration, malfunction incident, accident, etc.

vi) *Operations Manual:* The Service Supplier should have operations manuals for each RIV or robotic arm detailing the operating environments, inspection planning, and procedures, as well as pre-operation checks and operational procedures.

vii) *Maintenance Logbook:* The Service Supplier should maintain a logbook to record maintenance activities, calibration certificates, and software revision for each device and payload module.

viii) *Safety Assessment Plan:* The remote inspection Service Supplier should have a documented plan in place that details how to assess potential risks and hazards, corresponding mitigation plans, and emergency procedures for a response, escape, and evacuation.

13 Liability *(1 May 2022)*

It is recommended that the remote inspection Service Supplier maintain third-party liability insurance in case of any accidents or incidents.

15 ABS Recognized Service Supplier Program *(1 May 2022)*

ABS Recognized Service Suppliers are recognized service suppliers that perform services on behalf of an equipment manufacturer, shipyard, asset owner, or other clients in connection with classification/statutory surveys. The inspection results provide supporting information regarding classification and/or statutory survey decisions.

The Service Suppliers should have internal management systems (e.g., QMS, SMS, MoC) and are recommended to obtain ISO 9001 certification or equivalent third-party vetting credentials.

For more information, refer to the ABS website www.eagle.org.

SECTION 4

Survey/Inspection Process

1 General *(1 May 2022)*

This Section provides guidance on the survey process when a RIT is employed during class surveys and, when approved by the flag State, statutory activities for the close-up survey (see Subsection 2/3). Similar guidance should also be used as a reference during owner self-inspection activities.

3 Operational Limitations *(1 May 2022)*

There are several potential limitations to using RIT as a sole means of inspection. During remote inspection operations, various conditions may be identified that could require additional inspection using other inspection techniques or methodologies. These conditions include, but are not limited to when:

i) The inspection reveals damage that requires immediate attention.

ii) The inspection reveals deterioration that requires immediate attention.

iii) The review of the data captured does not allow for a meaningful examination (e.g., condition or color of tank coatings).

iv) The inspection area/tank surface is not clean and covered by mud, grime, or marine growth.

Additionally, there are instances where remote inspections are not appropriate, such as when historical records indicate abnormal levels of deterioration or damage to the areas of interest.

For operational limitations specific to each RIV, remote camera and robotic arm, see 4/3 TABLE 1 below:

TABLE 1
Operational Limitations of RIVs and Remote Cameras and Robotic Arms
(1 May 2022)

	UAVs	*ROVs*	*Robotic Crawlers*	*Remote Cameras and Robotic Arms*
Operational environment	In air	Underwater	In air and underwater	In air and underwater
Operational limitations	• The thickness measurement on an inclined structure (e.g., hopper plate) requires additional development of UAV technology. • For external inspections, high wind speed, insufficient ambient light, rain, and snow conditions, and inspections in shadow areas should be considered. • For internal inspections, the temperature inside the tank should be monitored to avoid overheating of the UAV equipment • The certified safe type for use in hazardous areas as defined in IEC 60079 should be applied.	• The in-water visibility and the hull's cleanliness below the waterline should be sufficient to permit a meaningful examination. For example, enclosed spaces may have sediments, which are easily stirred up by the ROV, reducing visibility. • For external inspection, the sea environment (e.g., strong ocean current, severe wave) should be monitored to avoid the loss of the ROV • The return route of the ROV should follow the entering route to avoid entanglement of the ROV's tether.	• The in-water visibility and the hull's cleanliness below the waterline should be sufficient to permit a meaningful examination. • The height limits of crawlers should consider the weight of the tether. • Most crawlers have difficulty overcoming obstacles, marine growth, or complicated structures over 5 cm (2 in.). • The certified safe type for use in hazardous areas as defined in IEC 60079 should be applied.	• The pendulum movement of a long robotic arm due to ship/unit motion may affect arm stability and thus image quality. • The areas of shadowing, dirty (e.g., oil sludge), obstruction by structure, and lower portion of the tank may not be inspected. • Sufficient lighting should be provided for any specific long-range areas. • The certified safe type for use in hazardous areas as defined in IEC 60079 should be applied.

5 Survey/Inspection Planning *(1 May 2022)*

Proper pre-planning, preparation, and close cooperation between the attending Surveyor, asset owner/shipyard representatives, and the remote inspection Service Supplier is essential for an effective survey/inspection process. For details about the roles and responsibilities of different groups, refer to 2/3 TABLE 1, "Roles and Responsibilities".

Prior to engaging in the RIT activity on board the vessel or offshore unit, the attending Surveyor is to review the RIT approval and confirm that the process is approved for the planned inspection. Before the commencement of the survey, a survey planning meeting should be held between all parties to verify that the arrangements envisioned in the survey process are in place. A Survey Planning Document prepared by the asset Owner/Operator, with the inspection plan incorporated, should be provided to the attending Surveyor for review and agreement.

The following topics should be addressed and included in the Survey Planning Document.

5.1 Scope *(1 May 2022)*

The following information should be considered in the Survey/Inspection Planning scope:

i) Type and extent of survey (i.e., close-up survey/CVI, Annual Survey, Intermediate Survey, Special Periodical Survey, damage survey, etc.).

ii) Asset type, operational details, and other asset general information

iii) Arrangements for the attending Surveyor and third-party specialist to perform confirmatory inspections by conventional means and thickness measurements (i.e., safe access, cleaning/de-scaling, illumination, ventilation, etc.).

iv) Location and the anticipated timeframe for the survey and the operational status of the asset (e.g., shipyard, repair facility or lay-by berth, etc.).

v) Logistics, including permissions from local authorities, site permissions, work permits, transportation, accommodations, etc.

vi) Risk assessment (4/5.3), RIV or robotic arm operations plan (4/5.5), and Classification Service Supplier certificate number of Service Supplier.

5.3 Risk Assessment *(1 May 2022)*

A case-specific risk assessment should be carried out to identify any hazards related to any planned remote operations and the need for risk control measures. This risk assessment is recommended to be finalized during the survey planning meeting and incorporated in the Survey Planning Document. Each party should acknowledge the risks associated with the remote inspection activities and agree to the mitigation plan associated with those risks.

Risk assessment should include, but is not limited to:

i) *Explosion Risks in Hazardous Areas:* If the remote operation is proposed within a hazardous area, the RIV or robotic arm should be rated for the intended classification level, or the area should be made safe for the equipment. The remote inspection Service Supplier should refer to the asset's Hazardous Area Plan for area identification and follow the Owner/Operator company-specified safe operation requirements if applicable. Typical factors to consider include, but are not limited to:

- *Payload:* Risks associated with the motor, camera, or other onboard modules
- *Battery:* Risks associated with battery storage, usage, change out, and recharge
- *Operations:* Risks associated with operational incidents/accidents

ii) *Dropped Object Risks:* If the RIV or robotic arm fails or malfunctions, it can become a dropped object hazard and become a danger to onsite personnel or the asset. Example dropped object factors to consider include, but are not limited to those in 4/5.3.ii TABLE 2:

TABLE 2
Example Dropped Object Risks for Each RIT Type *(1 May 2022)*

UAVs	*ROVs*	*Robotic Crawlers*	*Remote Camera and Robotic Arm*
• Launch/recovery zones • Fly-by or inspection areas occupied by people • Fly-by or inspection areas occupied by safety-critical equipment or systems	• Launch/recovery zones • Launch and recovery system (LARS) components (e.g., crane, winch, wires) • ROV shackle or hooks • Disconnection of tether(s)	• Launch/recovery zones • Areas where the asset is climbing structures • Inability to overcome obstacles • Disconnection of tether(s)	• Disconnection of the camera or robotic arm

For consequence severity to personnel safety caused by a potential dropped object (in this case, the RIV, robotic arm, or its payload), refer to the DROPS calculator in the ABS *Guide for Dropped Object Prevention on Offshore Units and Installations.*

iii) *Collision Risks:* Collisions may occur due to unexpected change in the inspection environment, RIV or robotic arm malfunction(s), and/or human errors, including:

- Collisions with other RIV or robotic arm in operation, asset structures, operating machinery, or animals (e.g., birds, fish).
- Collisions due to device communication interference or unexpected RIV or robotic arm malfunction.
- Collisions of UAV where visual line of sight (VLOS) is not maintained or upon unexpected interruption of pilot operation.

iv) *Lost Link Risks:* Communication control links could be lost when a UAV is operated in an unreliable radio frequency (RF) environment or if nearby systems interfere with the UAV's RF. It is recommended to consider a spectrum or Receiver Autonomous Integrity Monitoring (RAIM) analysis to determine frequency strength, integrity, and areas of possible interference. Typical factors to consider include, but are not limited to:

- Sources of possible radio frequency (RF) interference such as microwave antennas and high voltage lines
- Sources of possible electromagnetic disturbances of a GPS signal such as large steel structures near each other

v) *Other Risks:* Other risks should be identified in terms of personnel health and safety, including:

- High-risk working areas that may contain high voltage, toxic gases, or hazardous contents
- Risk associated with other ongoing operations in the area during RIV or robotic arm operations
- Emergency scenarios requiring evacuation from the asset

Refer to the ABS *Guidance Notes on Risk Assessment Applications for the Marine and Offshore Industries* for further guidance on risk assessment techniques.

5.5 RIV or Robotic Arm Operations Plan *(1 May 2022)*

A RIV or robotic arm operations plan should be developed and agreed upon by all parties at the planning stage. It is recommended that the RIV or robotic arm operations plan be prepared by the remote inspection Service Supplier and the owner/operator/shipyard. The plan should be developed based on the survey work scope and requirements and the asset's Hazardous Area Plan.

The Service Supplier should check with national/local authorities for any required RIV operations plan submittals or approvals needed before any RIV operations.

It is essential to the survey process to establish a video replay/image reviewing protocol. Experience has shown that recorded image quality (including stability and clarity) can be significantly better than the live-stream video displayed during inspection activities. In addition to the Surveyor's real-time monitoring of RIT activities, all parties should establish and agree upon a protocol to determine when and where the video/photos should be reviewed and when the survey results will be determined.

A typical RIV or robotic arm operations plan scope should contain at least the following information:

i) *RIV or Robotic Arm Operations Team:* It is recommended that the RIV or robotic arm operations team consist of at least three persons:

- *Pilot:* Responsible for direct control of the RIV or robotic arm to maintain operational stability and accuracy.
- *Camera/Payload Operator:* Responsible for direct control of the onboard camera and other intended modules to collect the data and coordinate with the Surveyor.
- *Designated Safety Watch:* Responsible for monitoring any potential safety hazards that may arise and is empowered to abort the operation in the event of perceived or actual safety hazards.

ii) *Equipment Selection and RIT Method:*

- *Planned RIV or Robotic Arm Type and Specifications for the Intended Survey:* Verify the capabilities of the selected RIV(s) or robotic arm are appropriate for the survey being conducted.
- *Planned RIV or Robotic Arm Limits:* Identify the selected RIV or robotic arm operating limitations and restrictions.
- *Planned Procedure for Bringing RIV(s) or Robotic Arm and Equipment into the Survey Site/ Country:* Identify the national/local authorities' requirements to bring RIV(s) or robotic arm and equipment into/out of the survey site/country.
- *Planned Launch/Recovery Zones:* Select potential locations for launch/recovery based on the supporting information provided by the asset Owner/Operator.
- *RIV or Robotic Arm Operation Routes, Maps, or Diagram:* RIV or robotic arm operation routes, maps, or diagrams should be developed to maximize the effectiveness and efficiency of the remote inspection for the intended structure based on the work scope and requirements.
- *Planned Distances from the Structure:* Altitudes, depths, and distances should be determined based on local regulatory requirements and safety considerations. Before an autonomous UAV is operated, the Ground Sample Distance (GSD) and the distance between the UAV and the structural surface should be defined by the Service Supplier.
- An emergency RIV or robotic arm operation plan should be in place in case of an environmental change, malfunction of the RIV or robotic arm, loss of link incident, or total loss of the RIV or remote camera and robotic arm.
- An incident response checklist should be in place and followed after an incident or accident.

- Night operations may be considered if the operator provides a safety case and sufficient risk mitigation to avoid collision hazards (e.g., provide proper lighting to assist external operations at night).
- Distraction Management Strategies should be developed to reduce the communication sources during the operation to keep pilots' attention focused. It is also recommended that all information be filtered or prioritized, and only essential/accurate messages pass to pilots.
- Before external inspection using a UAV, the Service Supplier should file a Notice to Airman (NOTAM) for any potentially affected airspace, as necessary.

iii) *Communication Method:*

- Means for reliable and constant communication should be provided and maintained between all the RIV or robotic arm operations team members throughout the operation.
- A communications protocol should be established between the attending Surveyor and RIV or robotic arm operations team (e.g., RF setup).
- An understanding of the survey procedural process and terminology between the attending Surveyor and RIV or robotic arm operations team should be maintained.
- An intermediary (e.g., camera/payload operator) between the attending Surveyor and the pilot should be present.

iv) *Data Viewing Capability:*

- Means for real-time data display.
- Means for video data replay/photo reviewing.

v) *RIV or Robotic Arm Operations – Modifications:* Any changes to the RIV or robotic arm operations methodology should be agreed upon by all parties, such as:

- The appropriate time for proposing a change to any RIV or robotic arm operations methods (e.g., during the operation, between operations, or after data review).
- The intermediary (e.g., camera/payload operator) on the RIV or robotic arm operation team to whom changes will be proposed.

7 RIV or Robotic Arm Operational Considerations *(1 May 2022)*

7.1 Pre-operations *(1 May 2022)*

On the date of field operations, but before the commencement of the RIV or robotic arm operations, it is recommended that a short briefing session and job safety analysis (JSA) be held for all participating personnel addressing, at a minimum, the following items:

i) Confirm the work scope of the intended RIV or robotic arm operations and survey/inspection plans.

ii) Assess the field condition and determine if any amendments to the RIV or robotic arm operations plan are necessary.

iii) Verify the responsibilities of all personnel, including the representatives from Owner/Operator, ABS Surveyor, and RIV or robotic arm operations team.

iv) Review identified risks and associated mitigation plans.

v) Review the emergency escape/evacuation plan.

vi) Review permit to work requirements.

vii) Review RIV or robotic arm maintenance records to verify that pre-operations and periodic inspections are up-to-date and the RIV or robotic arm is fit for purpose in all respects.

viii) Review weather forecast to determine the meteorological conditions (e.g., wind speed, waves, ocean current, rain, etc.) for external inspections.

ix) Verify proper personal protective equipment (PPE).

x) Confirm the inspection area/tank surface is clean and devoid of mud, grime, and marine growth. The cleaning tools (e.g., grinding, brushing) on the RIV (e.g., UAV, ROV, or robotic crawler) can be used for local cleaning and/or descaling of the structure's surface.

xi) For ROV, confirm the enclosed space is free of sediments that the ROV may easily stir, reducing the visibility.

Any party should have the authority to abort the operation at any time if deemed necessary.

Further guidance on JSA can be found in the ABS *Guidance Notes on Job Safety Analysis for the Marine and Offshore Industries.*

7.3 In-operation *(1 May 2022)*

The remote inspection Service Supplier should possess a Standard Operation Procedure (SOP) for each RIV or robotic arm operation. The following action items are recommended to be included in the SOP, at a minimum:

i) *Checklist Clearance:* The checklist should contain relevant system checks, inspection condition checks, personnel readiness checks, communication equipment checks, and testing RIV or robotic arm operation checks (e.g., flight for UAV, magnetic capability for the crawler, underwater operation for ROV).

ii) *RIV Launch and Recovery Zones:* For typical restrictions of launch and recovery zones to be considered, see 4/7.3.ii TABLE 3, below:

TABLE 3
RIV Launch and Recovery Zones

UAVs	*ROVs*	*Robotic Crawlers*
• Launch and recovery zones should be identified, and access should be restricted. • It is recommended that the designated landing zone(s) remain clear of any personnel and obstacles during the inspection process in case of any unexpected lost-link incidents.	• Launch and recovery zones should be identified, and access should be restricted. • It is recommended that the designated launch and recovery zones remain clear of any personnel during the inspection process to avoid tripping hazards of tethers.	• Launch and recovery zones should be identified, and access should be restricted. • It is recommended that the designated launch and recovery zones remain clear of any personnel during the inspection process in case of any unexpected dropped crawlers and modules.

iii) *Communication:* If the communication signal is lost or experiences significant interference, the operation should be aborted immediately. The time and duration of each lost-link event should be recorded by the RIV or robotic arm operations team and reported through the incident reporting system in Safety Assurance.

iv) *Digital Data:* The acquired digital data (e.g., photos, videos, and Light Detection and Ranging - LiDAR point clouds) are to be reviewed by the attending Surveyor in live streaming or on-site (see Subsection 4/9). Also, the digital data can be utilized in post-processing data (see Subsections 4/11 and 4/13).

v) *Documentation:* Whenever conditions that do or may affect Class are found during operations, reference data (e.g., still image capture, location, and orientation about the vessel, etc.) should be appropriately documented for final reporting and be recorded in the operations and maintenance logbooks.

vi) *Visual Line of Sight (VLOS) for UAVs:* Some civilian aviation authorities require human direct and unaided VLOS to be maintained throughout the operation. It is recommended that VLOS be maintained even if no regulatory requirement applies. Extended VLOS (EVLOS) or beyond VLOS (BVLOS) can be accepted upon agreement by all parties when no regulatory requirements apply.

vii) *De-confliction for UAV:* Procedures should be in place to achieve adequate de-confliction with helicopters or surface vessels servicing the asset (e.g., There should be no UAV operations for external inspection within 30 minutes before scheduled helicopter activities).

viii) *Autonomous Flight for UAV:* The autopilot and anti-collision capabilities should be included for an autonomous UAV.

The attending Surveyor should be present and direct the RIV or robotic arm operations team, as needed, in relation to the class survey requirements.

7.5 Post-operation *(1 May 2022)*

i) *Logging:*

- RIV or robotic arm operational details should be logged, including launch time, operation duration, recovery time, and the type of work completed.
- Maintenance or technical adjustments conducted during the operation should be documented.
- Any accidents or near misses observed during the operation should be documented and reported to all parties so that the decision to abort the work or other adjustments can be made promptly. If required by local laws and requirements (e.g., USA FAA, UK CAA, or relevant Civilian Aviation Authority), the incident or near miss may need to be reported to local regulatory authorities.

ii) *Maintenance:*

- Post-operation maintenance may be required according to the OEM instructions and should be completed immediately after RIV or robotic arm operations, as applicable.
- Maintenance should be performed safely and efficiently to minimize the impact on onsite personnel and the asset.

iii) *On-site Battery Handling:*

- Battery checks should be conducted and documented to confirm the reliability of the battery's safety and endurance for the next operation.
- Batteries should be clearly marked for maintenance and recharged.
- Batteries should be stored and recharged in fireproof containers.
- Transportation of the batteries should comply with applicable regulations and worksite requirements.
- Damaged or underperforming batteries should be removed from service.

9 Data Review *(1 May 2022)*

Digital data is to be reviewed in real-time and/or submitted to the attending Surveyor as agreed in the survey planning stage. The following criteria should be considered to evaluate the visual data collected by RIT:

i) Image (photos, videos, and LiDAR data) quality should be adequate to make a meaningful assessment of the structure's condition and identify possible anomalies that may affect Class or Statutory requirements and the crediting associated Surveys. Potential factors affecting image quality include:

- Poor image resolution (see 3/11.1.1)
- Image out of focus
- Occluded camera lens (e.g., rain, snow, dust, on the lens)
- Inadequate lighting (see 3/11.1.1 and 4/5.5)
- Unstable RIV or robotic arm (see 3/11.1.1 and 4/5.5)
- Dark or shadowy areas (see 4/3 TABLE 1)
- Glare from strong lights or the sun
- Grime, mud, or marine growth on tank surface (see 4/7.1)
- Reduced visibility from sediments inside enclosed space stirred up by RIV (see 4/7.1)
- Lost connectivity between RIV and on-site video monitors (e.g., stuttering frame rate or inconsistent stream speed)
- Environmental conditions such as fog or rain

ii) If an anomaly is suspected or determined to affect the survey, the image quality should enable the Surveyor/Inspector to identify further the nature, severity level, and approximate dimension (if applicable).

iii) Video footage, live-streaming, and recorded data, should be uninterrupted. If there are any breaks, gaps, or interruptions in the data, the Surveyor and owner/operator should be notified. The date and time are recommended to be stamped on images (photos and videos)

iv) Structural member identification data should be collected, especially those structural members associated with anomalies affecting class and statutory requirements so that such data can be tracked afterwards.

As agreed upon by all parties during the planning stage, recorded data is to be available for Surveyor review:

i) On-site so that additional RIV or robotic arm operations can be made if necessary, or

ii) Off-site within a specified time period so that additional RIV or robotic arm operations or other alternative inspection methods can be arranged if necessary.

The Machine Learning (ML)-based image recognition tool for coating breakdown can be used to assist the Surveyor as a screening tool to evaluate coating conditions from acquired digital data. In this ML-based image recognition tool, two steps (i.e., detection and assessment) should be performed on-site to identify potential areas where the Surveyor may request additional data:

- Detection of the appearance of coating breakdown
- Coating conditions of hard coatings in three levels: GOOD, FAIR, and POOR are based on coating breakdown areas according to the assessment criteria in 7-1-1/3.21 of the ABS *Rules for Survey After Construction (Part 7)*.
- For ballast tanks and combined cargo/ballast tanks on oil tankers, more clarification of coating condition assessment criteria is offered in IACS Recommendation No. 87 *"Guidelines for Coating Maintenance & Repairs for Ballast Tanks and Combined Cargo/Ballast Tanks on Oil Tankers*.

Proper equipment should be arranged by the asset Owner/Operator and the Service Supplier to enable the attending Surveyor to review the data. The Surveyor may require additional inspections using other alternative or traditional inspection techniques depending on the conditions found and results of the inspection.

11 Data Post-Processing *(1 May 2022)*

Some remote inspection Service Suppliers offer post-processing of data for further evaluation after the remote inspection. Advanced post-processing techniques may include:

i) Advanced image processing to perform anomaly measurement (e.g., crack dimension measurement, coating breakdown area measurement, or space volumetric measurement)

ii) Machine Learning (ML) for pattern recognition of cracks, fractures, or coating breakdown

iii) Data analytics for anomaly trending and prediction

iv) 3D model generation for data integration and reporting

These enhanced post-processing techniques can be particularly beneficial for an asset where life expectancy is important, such as those engaged in site-specific operations. The use of the post-processing of data is at the discretion of the Owner/Operator. However, if such post-processing data reveal conditions that can or do have an immediate impact on Class and were not identified during the survey, ABS is to be notified.

11.1 Machine Learning for Pattern Recognition of Coating Breakdown *(1 May 2022)*

For the ML-based pattern recognition of coating breakdown, the post-processing of acquired data can be performed to develop an ML-based image recognition tool for coating breakdown images. Three models can accomplish this development: Segmentation Model, Classification Model, and Joint Segmentation/Classification Model.

The Segmentation Model separates the images into segments based on different features and patterns of the images, such as structural components and coating failures, and then assesses the coating criteria for grading. This model can reach at least a 90% accuracy on coating grading.

The Classification Model is more straightforward as it takes the image, processes it, and immediately classifies it. This model is quick to develop and deploy but has less interpretability and accuracy.

The Joint Segmentation/Classification Model is the most complex model as it classifies and segments the image in the same model. It uses previous model methods to "filter" the data into areas worth analyzing for coating failure. This model requires more time and resources during the algorithm training stage but provides the most helpful information for the end-user.

The best model is the Segmentation Model based on case studies, as it has the best accuracy, interpretability, and segmentation performance. The table below shows the "Best" and "Worst" performer in each category:

TABLE 4
Three Models to Develop ML-based Image Recognition Tool

	Segmentation Model	*Classification Model*	*Joint Segmentation and Classification Model*
Coating Grade Accuracy	Best	Worst	
Ease of Development and Deployment		Best	Worst

	Segmentation Model	*Classification Model*	*Joint Segmentation and Classification Model*
Post-Processing for End-User		Worst	Best
Interpretability	Best	Worst	
Flexibility		Worst	Best
Segmentation Performance	Best	Worst	

11.3 Generation of 3D Models *(1 May 2022)*

The generation of 3D models can be performed by Light Detection and Ranging (LiDAR) and 360° photogrammetry.

LiDAR scanning can generate a point cloud that can be post-processed into a 3D model. This model can be utilized to compare equipment dimensions and implement spatial tagging with relevant documents, hyperlinks, or various metaverse information using a Cartesian coordinate system. Data captured from LiDAR needs to be logistically planned as such data size (e.g., gigabytes) can be controlled by the equipment and software depending on the desired levels of accuracy and detail. Most hardware manufacturers of LiDAR use proprietary registration software to compile and interpret LiDAR scans. Data sets from LiDAR require post-production for stitching, decimation, voxelization, and exportation of the data into an industry-compatible format.

Photogrammetry with 360° imagery yields greater raster visual quality than digital point cloud data. Between 3K-5K resolution, photogrammetry images are better suited for a point cloud texture mapping but demonstrate a lower accuracy level than LiDAR. Interferometry techniques used to interpret and create a 3D surface reconstruction from imaging have the potential to have the same difficulty as LiDAR to capture surfaces with reflective coatings, transparent or beyond the line of sight.

Colorization for LiDAR and Photogrammetry data is dependent on optimal lighting for 3D spatial point cloud reconstruction. Using 360° photogrammetry requires sufficient lighting for colorization and high-quality images. LiDAR is not dependent on lighting for spatial reconstructions, but poor lighting may result in an inaccurate colorized representation of real-world conditions.

When using LiDAR and 360° photogrammetry, the accuracy of dimensions and the quality of images should be satisfactory to the ABS Surveyor.

13 Reporting *(1 May 2022)*

The remote inspection Service Supplier should prepare a report identifying the asset and structure inspected. Any descriptive information associated with the survey performed should be factual and objective. If the asset Owner/Operator has contracted the remote inspection Service Supplier to provide additional data, technical support, or recommendations outside the scope of the survey, such information should be provided in a separate report.

The report submitted to ABS is to include:

i) General particulars of the asset, including asset name, Classification identification number, port of registry, and year of build.

ii) Survey information, including survey type and cycle number, locations of the structure or space surveyed, and inspection results (satisfactory, further inspection required including areas that will require examination by traditional Survey practices, or require repair). The recorded inspection result is at the discretion of the Surveyor. The specific inspection areas identified in the Survey Planning Document should be detailed in the report.

iii) Attestation from the Service Supplier that the RIT process was carried out within the approved RIT operation plan and Survey Planning Document.

iv) Remote inspection Service Supplier's information, including company name, Classification Service Supplier certificate number, RIV or robotic arm operation team members' names, the RIV or robotic arm model name used during the survey, and dates of inspection.

v) Details of the RIV or robotic arm operation records, including launch time, operation period, and recovery time.

a) Any digital data (e.g., photos and videos) supporting the crediting of survey related activities.

b) Each inspection report is to be endorsed by the Service Supplier technician, Owner, and Surveyor.

c) Video should be uninterrupted. Any breaks, gaps, or interruptions in the video, should be documented in the report.

A sample of an inspection report using RIT is shown in Appendix 4.

If the review of the data reveals any condition that is not identified at the time of the survey and affects or may affect class or statutory requirements; the Owner/Operator should advise ABS as required by the ABS Rules.

APPENDIX 1

References (1 May 2022)

1) Title 14 Code of Federal Regulations (14 CFR), Part 107, Federal Aviation Administration (FAA), Washington, DC, United States, 2016. Available at:

http://www.faa.gov/uas/media/RIN_2120-AJ60_Clean_Signed.pdf

2) Title 46 Code of Federal Regulations (46 CFR), Part 115, Department of Homeland Security, Coast Guard, United States, 2018. Available at:

https://www.law.cornell.edu/cfr/text/46/115.630

3) Title 46 Code of Federal Regulations (46 CFR), Part 176, Department of Homeland Security, Coast Guard, United States, 2018. Available at:

https://www.law.cornell.edu/cfr/text/46/176.630

4) CAP 722 Unmanned Aircraft System Operations in UK Airspace-Guidance, Civil Aviation Authority (CAA), West Sussex, United Kingdom, 2020 Available at:

http://publicapps.caa.co.uk/docs/33/CAP722%20Edition8(p).pdf

5) ISO 9001:2015 Quality Management Systems-Requirements, 2015

6) The National Unmanned Aircraft Systems Credentialing Program, Lone Star Unmanned Aerial System Center of Excellence & Innovation, Corpus Christi, TX, United States, 2016. Available at:

https://www.tamucc.edu/lone-star-uas/nuascp/index.php

7) Safety Management System, Federal Aviation Administration (FAA), Washington D.C., United States, 2015. Available at:

https://www.faa.gov/about/initiatives/sms/explained/

8) Manual on Remotely Piloted Aircraft System (RPAS), International Civil Aviation Organization (ICAO), First Edition, Montreal, Quebec, Canada, 2015

9) Safety Management Manual (SMM), International Civil Aviation Organization, Third Edition, Montreal, Quebec, Canada, 2013

10) Safety and Environment Management Systems, Bureau of Safety and Environmental Enforcement (BSEE), Washington, DC, United States, 2010

11) IACS Rec-42: Recommendation No. 42 Guidelines for Use of Remote Inspection Techniques for surveys, International Association of Classification Societies (IACS), Revision 2, June 2016

12) IACS Rec-87: Recommendation No., 87 Guidelines for Coating Maintenance & Repairs for Ballast Tanks and Combined Cargo/Ballast Tanks on Oil Tankers, International Association of Classification Societies (IACS), Revision 2, May 2015

13) IACS UR Z7: Hull Classification Surveys, International Association of Classification Societies (IACS), Revision 26, January 2018

14) IACS UR Z17: Procedural Requirements for Service Suppliers, International Association of Classification Societies (IACS), Revision 13, January 2018

15) ABS *Guidance Notes on the Development of Procedures and Technical Manuals*, Houston, TX, United States

16) ABS *Guidance Notes on Risk Assessment Applications for the Marine and Offshore Industries*, Houston, TX, United States

17) ABS *Guidance Notes on Job Safety Analysis for the Marine and Offshore Industries*, Houston, TX, United States

18) ABS *Guidance Notes on Management of Change for the Marine and Offshore Industries*, Houston, TX, United States

19) ABS *Guidance Notes on Safety Culture and Leading Indicators of Safety*, Houston, TX, United States

20) ABS *Guidance Notes on the Investigation of Marine Incidents*, Houston, TX, United States

21) ABS *Guide for Means of Access to Tanks and Holds*, Houston, TX, United States

22) ABS *Guide for Nondestructive Inspection*, Houston, TX, United States

23) ABS *Guide for Dropped Object Prevention on Offshore Units and Installations*, Houston, TX, United States

24) ABS *Guide for Building and Classing Floating Offshore Wind Turbines*, Houston, TX, United States

25) ABS *Guide for Building and Classing Bottom-founded Offshore Wind Turbines*, Houston, TX, United States

26) Unmanned Aircraft Systems (UAS) Operations Management Standards and Guidelines, Oil & Gas UK, London, United Kingdom

27) Unmanned Aerial Systems Guidelines, Helicopter Safety Advisory Conference (HSAC), HSAC RP UASRP 15-1, United States

APPENDIX 2

Remote Inspection Vehicle (RIV) Standards

1) ASTM Standard F2910-14: Standard Specification for Design and Construction of a Small Unmanned Aircraft System (sUAS)
2) ASTM Standard F2911-14: Standard Practice for Production Acceptance of Small Unmanned Aircraft System (sUAS)
3) ASTM Standard F3002-14a: Standard Specification for Design of the Command and Control System for Small Unmanned Aircraft Systems (sUAS)
4) ASTM Standard F3178-16: Standard Practice for Operational Assessment of Small Unmanned Aircraft System (sUAS)
5) API Recommended Practice 17H: Remotely Operated Tools and Interfaces on Subsea Production Systems

APPENDIX **3**

Checklist for Asset Owners/Operators (*1 May 2022*)

This Appendix contains a checklist providing suggestions and recommendations for the Asset Owners/ Operators in decision-making during different stages of the RIT inspection process. The four stages include: 1. Inspection Objective, 2. RIV Selection, 3. Inspection Plan & Operation, and 4. Post-Processing.

Note that some of the capabilities contained in the checklist have not been covered in the Guidance Notes, as they are either:

1) Out of scope of the current Guidance Notes (e.g., not class-related), or

2) The Technology is still in the testing and evaluation stage and not available for use in the marine/ offshore industry at this time.

Stage 1: Inspection Objective				
General Description				
Inspection Type	Owner Self-Inspection		☐	
	Class-related Inspection		☐	
ABS Recognized Service Supplier	Yes	☐	No	☐
Local Requirements and Regulations:				
Purpose of the Inspection:				
	Gross General Inspection	☐	Detailed Inspection	☐
Type of Data Needed				
Data Type	Y/N	Required Resolution		
a. Still Image	☐			
b. Full Motion Video	☐			
c. Recorded Video	☐			
d. Real-Time Video	☐			
e. Ortho-photomap	☐			
f. 3D Model Scanning	☐			
g. Material Property	☐			
h. Meteorology Data	☐			

Stage 2: Sensor/Payload and RIV/Robotic Arm Selections		
Type of Sensor/Payload		
In Situ Sensing	Y/N	Comments
a. Thickness Gauging	☐	
b. NDE Detector	☐	
c. Meteorological Sensors	☐	
d. Chemical Sensors	☐	
e. Biological Sensors	☐	
f. Microphones	☐	
Remote Sensing		
a. High Definition (HD) Cameras	☐	
b. Visible Spectrum Cameras	☐	
c. Near-Infrared Cameras	☐	
d. Long-Wave Infrared Cameras	☐	
e. Multispectral/Hyperspectral Cameras	☐	
f. Light Detection and Ranging (LiDAR)	☐	
g. Synthetic Aperture Radar (SAR)	☐	
Tools on Vehicles		
a. Cleaning	☐	
b. Object Retrieval	☐	
c. Measurement on mooring chain dimensions (ROV)	☐	
d. Paint & Coating	☐	

Type of ROV					
1. ROV Categorization (ABS *Rules for Building and Classing Underwater Vehicles, Systems and Hyperbaric Facilities*)					
a. Class I (Pure Observation)	☐	b. Class II (Observation with Payload Option)	☐	c. Class III (Work Class Vehicles)	☐
d. Class IV (Seabed-working Vehicles)	☐	e. Class V (Prototype or Development Vehicles)	☐		

2. ROV Parameters		
Hardware	Input	Comments
a. Model		
b. Manufacture		
c. Serial Number		
d. Year Built		
e. Dimension (cm × cm × cm)		
f. Weight (kg)		
g. Design Operation Depth (m)		
h. Maximum Operation Depth (m)		
i. Maximum Allowable Working Pressures (MPa)		
j. Maximum Allowable Working Temperatures (°C)		
k. Hydrostatic Test Pressure (MPa)		
l. Maximum Tether Length (m)		
m. Tether Management System	☐	
n. Emergency Recovery Features	☐	
o. Emergency Locating Devices	☐	

p. Corrosion Protection	☐	
q. Mechanical Protection	☐	
r. Frames	☐	
s. Lifting Lugs/Attachments	☐	
t. Towing Attachments	☐	
u. Variable Ballast Systems	☐	
v. ROV Properly Protected in Storage	☐	
w. Maintenances Record Checked	☐	
Software	Input	Comments
a. ROV Control Stations	☐	
b. ROV Control Box	☐	
c. Handling System	☐	
d. System Testing Procedures	☐	

Type of UAV

1. Propulsion Types					
a. Fixed-Wing	☐	b. Rotary-Wing	☐	c. Hybrid	☐
2. UAV Size					
a. Mini UAV ($\leq$ 5 kg)	☐	b. Small UAV (5-25 kg)	☐	c. Large UAV (>25 kg)	☐
3. Energy Source					
a. Internal Combustion	☐	b. Battery Cells	☐	c. Fuel Cells	☐
d. Solar Cells	☐	e. Others	☐		
4. Control Methods					
a. Manual Control	☐	b. Stabilized Control	☐	c. Automated Control	☐
5. UAV Parameters					

Hardware	Input	Comments
a. Model		
b. Manufacture		
c. Registration Number		
d. Dimension (mm × mm × mm)		
e. Weight (kg)		
f. Flight Endurance (min)		
g. Wind Tolerances (m/s)		
h. Top Speed (miles/hr)		
i. Visibility Limit (m)		
j. Telemetry Range (m)		
k. Maximum Flight Altitude (m)		
l. Control Frequency (Hz)		
m. Vertical Take-off Landing (VTOL)	☐	
n. Contact Protection Cage	☐	
o. Maintenances Record Checked	☐	
p. Energy Source Maintenance Control Plan Available	☐	
q. Airframe Maintenance Control Plan Available	☐	
r. Avionics Maintenance Control Plan Available	☐	
s. UAV Properly Protected in Storage	☐	

Software	Input	Comments
e. Measuring Tool	☐	
f. Autopilot System	☐	
g. Attitude Stabilization System	☐	
h. GPS System	☐	
i. Waypoint Flight Planning	☐	
j. Collision Avoidance Sensor	☐	
k. Backup Manual Controls	☐	
l. Real-time Data Telemetry	☐	
m. Operate Without Payload	☐	
n. Cyber Security System	☐	
o. Software System Testing Procedures	☐	

Type of Crawler					
1. Propulsion Type					
a. Tracks	☐	b. Wheels	☐	c. Others	☐
2. Power Source / Communication Method					
a. Tether/Wired	☐	b. Battery/Wireless	☐	c. Others	☐
3. Crawler Parameters					

Hardware	Input	Comments
a. Model		
b. Manufacture		
c. Serial Number		
d. Year Built		
e. Dimension (cm × cm × cm)		
f. Weight (kg)		
g. Design Underwater Operation Depth (m)		
h. Maximum Underwater Operation Depth (m)		
i. Design Operation Height (m)		
j. Maximum Operation Height (m)		
k. Maximum Allowable Underwater Working Pressures (MPa)		
l. Maximum Allowable Underwater Working Temperatures (°C)		
m. Hydrostatic Test Pressure (MPa)		
n. Maximum Tether Length (m)		
o. Tether Management System	☐	
p. Emergency Recovery Features	☐	
q. Telemetry Range (m) for Wireless Communication		
r. Control Frequency (Hz) for Wireless Communication		
s. Maintenances Record Checked	☐	
Software	**Input**	**Comments**
a. Crawler Control Stations	☐	
b. Handling System	☐	
c. Real-time Data Telemetry for Wireless Communication	☐	
d. System Testing Procedures	☐	

Type of Robotic Arm					
1. Robotic Arm Types					
a. Robotic Arm /Manipulator	☐	b. Telescopic Poles	☐	c. Others	☐
2. Power Source / Communication Method					
a. Tether/Wired	☐	b. Battery/Wireless	☐	c. Others	☐
3. Robotic Arm Parameters					

Hardware	Input	Comments
a. Model		
b. Manufacture		
c. Serial Number		
d. Dimension (mm × mm × mm)		
e. Weight (kg)		
f. Design Operation Depth (m)		
g. Maximum Operation Depth (m)		
h. Design Operation Height (m)		
i. Maximum Operation Height (m)		
j. Telemetry Range (m) for Wireless Communication		
k. Control Frequency (Hz) for Wireless Communication		
l. Maximum Allowable Working Temperatures (°C)		
m. Maximum Allowable Working Swing angles (degrees)		
n. Lifting Lugs/Attachments	☐	
o. Emergency Recovery Features	☐	
p. Maintenances Record Checked	☐	
Software	**Input**	**Comments**
a. Control Stations	☐	
b. Handling System	☐	
c. Real-time Data Telemetry for Wireless Communication	☐	
d. Cyber Security System	☐	
e. System Testing Procedures	☐	

Stage 3: Inspection Plan & Operation			
Inspection Environment			
Inspection Location:			
Maximum Elevation from Waterline/Ground (m):		Maximum Inspection Distance (m):	
Number of RIV Operation Team Members		Expected Number of RIV Operations	
Marine Asset	☐	Offshore Asset	☐
Wind Turbine	☐	Dropped Object Inspection	☐
Internal Inspection	☐	External Inspection	☐

Hazard Identification & Risk Control		
Common	Y/N	Comments
a. Clear Operation Space	☐	
b. Open Launch & Recovery Space	☐	
c. Sufficient Light	☐	
d. Reachable Distance	☐	
e. Hot Work Permit	☐	
Potential Risk Environment		
a. Electro-Magnetic Interference	☐	
b. Loss of Link	☐	
c. Operation Location Access Controlled	☐	
d. Operation Over People	☐	
e. Confined Space	☐	
f. Soft Coating	☐	
g. Dusty Environment	☐	
h. Windy Environment	☐	
i. Foggy Environment	☐	
j. Sunny Environment	☐	
k. Raining Environment	☐	
l. Wave Environment	☐	
m. Current Environment	☐	
Operator & Ground Crew		
a. Pilot Certificate	☐	
b. Training/Re-training Records Available	☐	
c. Familiarization with selected RIV Operation System	☐	
d. Familiarization with Inspection Environment	☐	
e. Previous Operation Experience	☐	
Operation Procedures		
a. Survey Documentation Prepared	☐	
b. Short Briefing Session and JSA Held	☐	
c. RIV Operation Readiness Review Process	☐	
d. Data Reviewing Protocol Established	☐	
e. Communication Equipment Checked	☐	
f. Loss of Link Procedures Available	☐	
g. Landing/Recovery Procedures Available	☐	
h. Emergency RIV Operation Plan Available	☐	

i. Distraction Management Program Available	☐	
j. RIV Operation Management Program Available	☐	
Stage 4: Post-Processing		
Post-Operations		
a. Post-Operation Inspection Completed	☐	
b. RIV Operation Information Logged	☐	
c. Hardware Adjustment Conducted during Operation Documented	☐	
d. Software Adjustment Conducted during Operation Documented	☐	
e. Incident/Near-miss during Operation Documented	☐	
f. Accident/Near-miss during Operation Reported	☐	
g. Data Analysis Procedures Available	☐	
h. Data Validation Procedures Available	☐	
i. The Purpose of Inspection Achieved	☐	
j. Additional RIT Inspection Needed	☐	
k. Additional Inspection Using Alternative/Traditional Inspection Needed	☐	

APPENDIX 4

Sample of Inspection Report using RITs (1 May 2022)

This Appendix is a sample of inspection report using RITs. It illustrates the report-writing principles and practices discussed in Subsection 4/13.

INTERMEDIATE HULL SURVEY 3
REMOTE INSPECTION

Remote Inspection Technology – Reporting details for use in close-up survey

General Particulars

1. Ship name: TANKER
2. IMO number: xxxxxxx
3. ABS identification number: xxxxxxxx
4. Date of build: DD-MM-YYYY
5. Survey task and cycle number: Intermediate Hull Survey No.3
6. ABS report number: xxxxxxxxx
7. Name of company providing remote inspection service: xxxxxxxxxx
8. ABS External Specialist Certificate No: xx-xxxxxxxxxx-x
9. Certificate valid from DD-MM-YYYY to DD-MM-YYYY
10. Place of inspection: xxxxxxxxxx
11. First date of inspection: DD-MM-YYYY
12. Last date of inspection: DD-MM-YYYY
13. Details of RIV and associated equipment:
    - RIV type and brand name / Serial No.: xxxxxxxxxxxxxxxxx
    - RIV type and brand name / Serial No.: xxxxxx
14. Details of operator:
    - First Name Last Name / Pilot
    - First Name Last Name / Co-Pilot
    - First Name Last Name / Safety Watch
15. Name of operator, signature – First Name Last Name, DD-MM-YYYY
16. Name of surveyor, signature – First Name Last Name, DD-MM-YYYY
17. Name of owner's representative, signature – First Name Last Name, DD-MM-YYYY

Remote Inspection Areas

1. Details of areas inspected for survey credit and considered satisfactory
2. Details of areas identified requiring further inspection (traditional means of inspection)
3. Details of areas identified requiring repair

Space/Tank /Hold	Survey Plan Reference	Area (STBD, Center, Port)	Location (Frame, Strake, etc.)	Result – Satisfactory (SAT), Further inspection required (FIR), Requires repair (REP)
No. 1 COT	xxxxxxxx	STBD	Fr. 107, 108, 109, 112,114	SAT
No. 2 COT	xxxxxxxx	STBD	Fr. 99, 100, 101, 105,107	SAT
No. 3 COT	xxxxxxxx	STBD	Fr. 91, 92, 93, 97,99	SAT

Note:
The selection of any suspect areas or areas for inspection in addition to the Survey Plan is at the option of the Surveyor. Videos and still images may be provided in a separate report for Owner. Videos or still images of any specific location are to be provided to the Surveyor on request for internal reporting.