GUIDANCE NOTES ON

USING UNMANNED AERIAL VEHICLES

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Foreword

Suitable means of access to structures is required for surveys to be carried out safely, effectively and efficiently. Surveyors use a combination of permanent and alternative means of access (e.g. staging, scaffolding, rafting, and rope access) in order to conduct class surveys. Remote inspection techniques are considered as additional alternative means of access. These means help to reduce safety risks to the Surveyor (e.g., working at heights).

Unmanned Aerial Vehicles (UAVs), as a remote inspection technique, allows the attending Surveyor to evaluate the condition of the structure from a stationary location. This technique also provides a benefit to the asset Owner/Operator by reducing operational intrusiveness.

These Guidance Notes are intended to offer best practices for class surveys and non-class inspections carried out using UAVs. These best practices include recommendations and guidance on applications of UAVs, qualification and proficiency of the UAV Service Provider, UAV operation and data handling, all intended to facilitate a safer, more effective and efficient survey. IACS Recommendations No. 42, Guidelines for Use of Remote Inspection Techniques for Surveys, has been considered in the development of these Guidance Notes.

This revision incorporates additional, relevant industry standards and ABS Guides and Guidance Notes. Section 5 has been removed and the content is reorganized into Section 2 and 4 to streamline the guidance. A recommended checklist is in Appendix 3 to aid asset owners and operators in decision making for UAV inspection process.

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

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SECTION 1 Introduction

1 General

An Unmanned Aerial Vehicle (UAV) is an aircraft with no pilot on board that is controlled remotely or able to fly autonomously based on a pre-defined flight route and/or dynamic automation systems. These Guidance Notes provide best practice recommendations on the use of UAVs to facilitate safer, more effective, and efficient inspections.

3 Scope

The purpose of these Guidance Notes is to provide:

i) Information related to the use of UAVs in conjunction with class surveys

ii) Guidance to the marine and offshore industries on non-class-related UAV inspections

If UAVs are used in conjunction with class-related activities:

i) It is considered an alternative remote inspection technique to assist the attending Surveyor in performing an examination of hard to reach structures.

ii) Data supporting the crediting of class-related activities should be submitted to ABS.

Note: The acceptance of the inspection results is at the discretion of the attending Surveyor. If the attending Surveyor is not satisfied with the results provided by the UAV inspection, additional inspections using alternative or traditional inspection techniques may be required.

For non-class-related inspections, recommendations on selecting a Service Provider, conducting flight operations and data handling should be considered to allow for a safer, more effective, and efficient inspections.

These Guidance Notes are intended for pilot-operated UAVs, which may be referred to as Remote Piloted Aircraft (RPA), applications only. Local requirements and regulations for the use of UAVs should be checked and followed.

These Guidance Notes cover:

- Applications of UAVs (Section 2)
- Guidance for Service Provider Selection (Section 3)
- Survey Process (Section 4)

IACS Recommendations No. 42, Guidelines for Use of Remote Inspection Techniques for Surveys, were considered in the development of these Guidance Notes.

5 Associated Documents

- ABS *Guidance Notes on Job Safety Analysis for the Marine and Offshore Industries*
- ABS *Guidance Notes on Risk Assessment Applications for the Marine and Offshore Oil and Gas Industries*
- ABS *Guidance Notes on the Investigation of Marine Incidents*
- ABS *Guide for Means of Access to Tanks and Holds*
- ABS *Guide for Dropped Object Prevention on Offshore Units and Installations*

- ABS Guides and Guidance Notes on CyberSafety™
- ABS *Rules for Survey After Construction (Part 7)*
- ABS *Rules for Building and Classing Mobile Offshore Drilling Units*, Part 7, "Surveys"

7 Terminology and Abbreviations

ABS Recognized External Specialist Program: A program that ABS administers to certify service providers who perform services on behalf of an equipment manufacturer, shipyard, vessel's owner or other clients in connection with classification and/or statutory services.

Beyond Visual Line of Sight (BVLOS) Operation: Operations where the pilot does not need to keep the UAV within their visual line of sight at all times.

Civil Aviation Authority (CAA): The statutory corporation that oversees and regulates all aspects of civil aviation in the United Kingdom. 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 Steel Vessels (SVR)*. A Close-up Survey may be referred by the offshore industry as "Close Visual Inspection" (CVI), which is defined in the ABS *Rules for Building and Classing Mobile Offshore Drilling Units (MODU Rules)*.

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

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 a 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. Use of UAVs within the United States is subject to FAA regulations.

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

Hazardous Areas: In the context of these Guidance Notes, areas where flammable or explosive gases, vapors, or dust are normally present or likely to be present.

Hazardous Area Plan: An arrangement plan clearly indicating the hazardous areas with classification levels. It may be referred to as "Area Classification Plan" by the industry.

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

Job Safety Analysis (JSA): A technique that focuses on job tasks as a way 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. JSA's can be done formally, with requisite subject matter experts. They may be performed at the job site immediately prior to the beginning of a work activity.

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

Notice to Airman: A notice 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.

Original Equipment Manufacturer (OEM): In the context of these Guidance Notes, an original UAV equipment manufacturer.

Overall Survey: A survey intended to report on the overall condition of the structure and to determine the extent of additional Close-up Surveys, which is defined in the ABS *Rules for Building and Classing Steel*

Vessels (*SVR*). An Overall Survey 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 Drilling Units* (*MODU Rules*).

Payload: The carrying capacity of a UAV in terms of weight. It normally refers to the reserved lifting ability of the UAV to perform additional operations excluding the basic systems required for flying.

Pilot: An operator who directly controls the flight of the UAV.

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

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

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 Piloted Aircraft (RPA): A type of UAV that is controlled remotely by a pilot

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, meant to determine the need for, and adequacy of, new or revised risk controls based on the assessment of acceptable risk.

Safety Assurance (SA): A key component of the SMS, meant to evaluate the continued effectiveness of applied risk control strategies and supports the identification of new hazards.

Service Provider: A company which provides specialized inspection services using UAVs.

SOLAS: International Conventions 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.

Unmanned Aerial Vehicle (UAV): An aircraft with no pilot on board that is controlled remotely or able to fly autonomously based on a pre-defined flight route and/or dynamic automation systems. Unmanned Aerial Vehicles may be referred to by the industry as “drones” or Remotely Operated Aerial Vehicles (ROAVs). UAV is also referred to as Unmanned Aircraft System (UAS), a system which comprises of the unmanned aircraft (i.e., UAV) and its associated ground control station, data links, and other support equipment. In these Guidance Notes, UAV is intended for remote-controlled vehicles only.

Visual Line of Sight (VLOS) Operation: Operations that keeps the UAV in the visual-line-of-sight of the pilot at all times. For example not flying a UAV into clouds or fog, not flying behind (or partially behind) topsides, jackup legs or other obstructions.

SECTION 2 Application of Unmanned Aerial Vehicles

1 General

UAVs are typically equipped with a camera and flight control modules that are capable of collecting visual data in the form of still images, live-stream videos, or recorded videos of difficult to reach structures.

Listed below are a few examples of where UAVs can be used to aid/assist in inspection-related activities:

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

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

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

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

It is noted that UAVs are an evolving technology. Additional applications for the use of UAVs may become available in the future.

3 Application to Class Survey

UAVs are a tool which may be used to assist the attending Surveyor with class-related activities where the visual examination of the structure is required.

If a vessel owner or operator intends to incorporate the use of a UAV into an ABS Survey the local ABS office should be advised in advance, and the intended use of the UAV should be incorporated into the survey planning.

Compliance with all Rule and Regulatory requirements, in particular requirements for Close-Up Inspection, Hull Thickness Measurements and NDE also need to be considered, and incorporated into Survey Planning Documents as applicable. The role of the Owner/Operator, UAV Company, and ABS are outlined in Section 2, Table 1, "Roles and Responsibilities" below. For details on survey planning, scheduling and execution, the local ABS Survey office or ABS Divisional Assistant Chief Surveyors office should be contacted.

TABLE 1
Roles and Responsibilities

Activity	*Role of Owner/Operator*	*Role of Service Provider*	*Role of ABS*
Planning	Determine, in consultation with ABS, if the use of a UAV is appropriate Select a UAV Service Provider Provide supporting information to the Service Provider about the asset condition and drawings related to the work scope Review and accept the UAV inspection plan proposed by the Service Provider 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 UAV to be used • Performing a risk assessment and develop the UAV flight plan based on the work scope	Review the proposed Survey Planning Document to verify the survey plan satisfies the applicable Rules, Guides, and organizational processes while employing the UAV as an inspection technique.
Operation	Initiate the UAV inspection Co-ordinate Survey and UAV activity with the Surveyor and the UAV Company	Execute the UAV inspection in accordance with the agreed to Survey Planning Document, Flight plan and to the satisfaction of the ABS Surveyor	Conduct the class survey in compliance with applicable Rules, Guides, and organizational processes
Reporting	Review the inspection results provided by the Service Provider	Provide inspection results and data to the Owner/Operator and ABS, as applicable	Evaluate the results of the UAV inspection for Surveyor credit.

As with Survey activity, acceptance of the inspection results will be to the satisfaction of the attending Surveyor. If the Surveyor is not satisfied with the inspection results provided by the UAV, alternative or traditional survey techniques may be required.

Additional conditions for using UAVs during class-related activities are discussed in Section 4.

SECTION 3 Guidance for Service Provider Selection

1 General

When a UAV is used for an inspection the asset Owner/Operator is responsible for:

i) Selecting a UAV Service Provider whose qualifications and capabilities are appropriate for the intended application

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

If the UAV is used in conjunction with crediting a survey, the Service Provider is to be an ABS Recognized External Specialist.

The following recommendations can be used as guidance for the Owner/Operator to assess the qualifications of the UAV Service Provider.

3 Regulations

The UAV Service Provider should obtain all applicable certificates of authorization from national/local aviation authorities where the inspection is to be performed. Where no national/local requirement is applicable, it is recommended to follow the requirements implemented by recognized aviation authorities such as the FAA's Title 14 Code of Federal Regulations (14 CFR), Part 107 requirements and the CAA's CAP 722 guidance.

5 Quality Management System

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 on a continual basis. The UAV Service Provider should have an internal QMS to:

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

ii) Enhance customer satisfaction through the effective 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 Service Provider obtains 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 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 UAVs for inspection

7 Safety Management System

A Safety Management System (SMS) provides a systematic approach to manage 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. The FAA suggests that the SMS for product/service providers integrate modern safety risk management and safety assurance concepts into repeatable, proactive systems.

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

7.1 Safety Policy

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

i) Safety commitment

ii) Safety objectives

7.3 Safety Risk Management

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 Provider should incorporate system descriptions, risk assessment, and risk controls as part of their service planning documents.

7.5 Safety Assurance

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 Provider has organizational procedures that address compliance with SMS requirements and aviation orders, standards, policies, and directives. Actions to demonstrate safety assurance include, but are not limited to:

i) Internal audits and evaluations

ii) Reporting culture and incident (including near miss) reporting system

iii) Safety data analysis and assessment

iv) Safety oversight and improvement

7.7 Safety Promotion

The Service Provider should promote a positive safety culture through training, communications, and other actions within all levels of the workforce in the company.

9 Management of Change

Modifications to the equipment, operational policies, and organizational structure or personnel may be required. A Management of Change (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. Developing an effective MoC strategy requires establishing, documenting, and successfully implementing formal policies to evaluate and manage both 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 Provider have a MoC strategy in place as part of their quality and/or safety management system.

11 Recommendations for Service Provider Selection

The asset Owner/Operator is recommended to review the QMS and SMS of the Service Provider for the aspects provided in the following subsections.

11.1 Equipment

The Service Provider can be an Original Equipment Manufacturer (OEM) of the UAV that is capable of providing inspection services to the asset Owner/Operator. The Service Provider can also be an inspection service firm that utilizes UAVs 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

Based on the intended application of the UAV (e.g., external offshore structure inspection, internal marine vessel cargo tank/hold/ballast/void inspections, wind turbine inspection, dropped objects inspection), the specifications and capabilities of the UAV hardware and software equipment may be different. The following considerations are recommended when selecting a Service Provider, UAV device, and associated equipment.

i) *Safety:*

a) The UAV and any onboard inspection modules should be rated for its intended operational environment (e.g., intrinsically safe in hazardous areas, operational wind speed, temperature, humidity, etc.).

b) The materials of the UAV 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 UAV device possess a protection component to minimize damage to the structure and coatings (e.g., propeller guards).

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

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

f) *Fatigue Management Program:* The UAV service provider should have a fatigue management program for its pilots. It is recommended that the daily operating time for each pilot is limited to eight hours, and the continuous operating time for each task is limited to three hours.

ii) *Operability:*

a) The UAV system has a control station that allows the pilot to easily operate the UAV.

b) The UAV device has onboard flight control modules that allows for the maintenance of stable and accurate positions.

c) The UAV has onboard localization and navigation modules (e.g., GPS for external inspection).

d) The UAV device is able to operate for a sufficient amount of time relevant to the inspection being conducted (e.g., sufficient battery life).

e) The maximum operating range of the UAV should be accurately defined (e.g. in terms of flight height, distance from the pilot).

f) The functionality of the selected UAV type should have been tested by original equipment manufacturer.

g) Dimensions of the UAV device allows for access and navigation within the intended space (e.g., manhole, opening to small confined spaces, size of the openings and structural limitations within the space, etc.).

h) The UAV system should provide and maintain an interference-resistant communication channel.

i) The UAV system should include reliable connectivity equipment to maintain constant communication amongst team members during operations.

iii) *Acquisition, Review and Security of UAV 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 any post-processed data

d) The UAV has an onboard camera that provides adequate visual quality of still images, live-stream videos, and recorded videos. It is recommended the UAV camera possess a High-Definition (HD) resolution

e) If applicable, the UAV device has onboard sensors that can provide additional information such as geo-tag information, anomaly measurement (e.g., crack length measurement and corrosion area measurement), thermal imaging, 2D/3D modeling, etc.

f) The UAV system should include an appropriate platform to display and replay visual data including still images, live-stream videos, and recorded videos

g) All frequencies used to support safety-critical UAV functionality should be coordinated and licensed in accordance with the appropriate licensing regime

h) The Service Provider should have data security policies and procedures in place for verification that data collected during the operation and any data analyses are captured, transmitted, and stored in a secure way that has minimum vulnerability to unauthorized manipulation and distribution.

- If the Service Provider provides a remote data access portal for their client, it is recommended that cybersecurity is properly addressed in the implementation. Further guidance for the implementation of cybersecurity programs and associated class notations, refer to the following ABS publications:
  - ABS *Guidance Notes on Data Integrity for Marine and Offshore Operations – ABS CyberSafety™ Volume 1*
  - ABS *Guide for Cybersecurity Implementation for Marine and Offshore Operation – ABS CyberSafety™ Volume 2*
  - ABS *Guidance Notes on Data Integrity for Marine and Offshore Operations – ABS CyberSafety™ Volume 3.*

11.1.2 Battery Handling

The Service Provider should have procedures in place for the proper handling of UAV batteries including the following:

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

11.1.3 Maintenance

It is recommended that the Service Provider 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 deliver safe, effective, and efficient service.

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

i) *Calibration:* Equipment should be calibrated on a regular basis for its fitness-for-service

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 should be maintained for each type of maintenance activity. It is recommended the logbook include all pre-flight and post-flight inspection records, and a record of any malfunctions (e.g., loss of link), anomalies, and damaged parts.

11.3 Personnel

The UAV Service Provider should utilize competent personnel to perform UAV-related services.

Depending on the nature of the job, different training programs should be provided by the Service Provider to their UAV operators. If national/local aviation authorities have qualification and training requirements, these should be considered as minimum standards for the Service Provider to comply with. In addition to the applicable statutory and regulatory requirements, the Service Provider is recommended to have mandatory standard requirements for the qualification and training of its personnel.

11.3.1 Safety Awareness

Safety awareness training should be part of the Service Provider's SMS. The objective of this training should be to confirm that the personnel in the field can execute the inspection safely, not only in regards to 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 Provider should provide safety training to the designated personnel that include:

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 Pilot Proficiency

A pilot is the person in direct flight control of the UAV device. Therefore, his proficiency in UAV operations can affect the safety of onsite personnel and the asset that is being inspected. If applicable, the pilot should meet statutory and regulatory flight training requirements to maintain their pilot license.

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

i) The pilot should have formal training

ii) The pilot should have sufficient ground and flight 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.

11.3.3 Inspection Knowledge

If the Service Provider's personnel are not sufficiently familiar with basic maritime and/or offshore asset designs, training should be provided. This training should include maritime and/or offshore nomenclatures in order to communicate effectively with the asset Owner/Operator and/or the attending Surveyor during the inspection.

Working knowledge of applicable Rules, Guides, and guidelines should be required (e.g., Part 7 of the ABS *Rules for Survey After Construction*, Part 7 of the ABS *Rules for Building and Classing Mobile Offshore Drilling Units*, the ABS *Guide for Means of Access to Tanks and Holds for Inspection*, and IACS Recommendation No. 42, etc.).

11.5 Documentation

The Service Provider is to possess 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 organization and management structure.

ii) *Statutory and Regulatory Certificates:* Required certificate of authorization from national/local aviation authorities, if applicable.

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

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

v) *Operation Logbook:* The Service Provider should maintain a logbook to record all applicable operational flight/training information such as flight date, time, duration, malfunction incident, accident, etc.

vi) *Operations Manual:* The Service Provider should have operations manuals for each UAV detailing the operating environments, inspection plans and procedures, as well as pre-flight checks and flight procedures.

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

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

13 Liability

It is recommended that the Service Provider maintain a third party liability insurance in case of any accidents or incidents.

15 ABS Recognized External Specialist Program

ABS Recognized External Specialists are approved Service Providers that perform services on behalf of an equipment manufacturer, shipyard, asset owner, or other client in connection with classification/statutory services.

In order to become an ABS Recognized Specialist in Remote Inspection Techniques, the following procedures should be followed:

i) Submit a signed application to the nearest ABS port office

ii) Send the list of documents to the Surveyor-in-Charge as outlined in the response letter sent by the ABS port office

iii) Prepare for a facility audit, the purpose of which is to confirm:

- The Service Provider is organized and managed in accordance with the submitted documentation
- The Service Provider is considered capable of providing consistent inspection service in accordance with established requirements
- The technicians have adequate education, experience and training in the process

iv) Carry out an onboard practical demonstration witnessed by an ABS Surveyor

Once approved as ABS Recognized External Specialists, Service Providers can obtain an ABS Recognized Specialist Certificate and be listed in the ABS External Specialist database, searchable by worldwide asset Owners/Operators.

For more information, please refer to http://ww2.eagle.org/en/rules-and-resources/recognized-specialists.html or contact Corporate ABS Programs at externalspecialist@eagle.org.

SECTION 4 Survey/Inspection Process

1 General

This Section provides guidance on the survey process when a UAV is employed during class-related activities. Similar guidance should also be used as a reference during owner self-inspection activities.

3 Operational Limitations

There are several potential limitations to using UAVs as a sole means of inspection. During UAV operations, various conditions may be identified that could require the use of different inspection techniques or methodologies. These conditions include, but are not limited to:

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)

If any of the above conditions are found to exist, additional surveys or inspections using conventional techniques may be required for a proper assessment.

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

5 Survey/Inspection Planning

Proper pre-planning, preparation and close cooperation between the attending Surveyor, asset Owner/Operator representatives, and UAV Service Provider is an essential part of the survey/inspection process. For details about the roles and responsibilities of different groups, please refer to Section 2, Table 1, "Roles and Responsibilities".

Prior to 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 subsections should be addressed in the meeting and included in the Survey Planning Document.

5.1 Scope

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

i) Type and Extent of Survey (i.e., overall survey/GVI, close-up survey/CVI, Annual survey, Intermediate survey, Special Periodic survey, damage survey, etc.)

ii) Asset type, operational details, etc.

iii) Arrangement 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 anticipated time frame for the survey as well as operational status of the asset (i.e., shipyard, repair facility or lay berth, etc.)

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

5.3 Risk Assessment

A case specific risk assessment should be carried out to identify any hazards related to planned UAV operation and the need for risk control measures. It is recommended that this risk assessment is finalized during the survey planning meeting attended by all parties and incorporated in the Survey Planning Document. Each party should acknowledge the risks associated with the UAV operation and agree to the mitigation plan associated with those risks.

Risk assessment should include, but is not limited to the following categories:

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

- Payload: risks associated with the motor, camera, or other onboard modules
- Battery: risk associated with battery storage, usage, change out, and re-charge
- Operation: risk associated with operational incidents/accidents

ii) *Dropped Object Risks:* In the event the UAV fails or malfunctions, risks can be imposed on the asset and onsite personnel. Typical dropped object factors to consider include, but are not limited to:

- Take-off/landing zones
- Fly-by areas where the asset is in operation or occupied by people

For consequence severity to personnel safety caused by potential dropped object (in this case, the UAV or its payload), please 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, UAV malfunction(s), and/or human errors, including:

- Collisions with birds, other UAVs in operation, asset structures or operating machinery
- Collisions due to device communication interference or unexpected malfunction of the UAV system
- Collisions where visual line of sight (VLOS) is not maintained or an unexpected interruption of the pilot operation.

iv) *Loss Link Risks:* The 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 disturbance of GPS signal such as large steel structures in close proximity to 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 UAV operations
- Emergency scenarios that requires evacuation from the asset

For further guidance on risk assessment techniques, please refer to the ABS *Guidance Notes on Risk Assessment Application for the Marine and Offshore Oil and Gas Industries*.

5.5 Flight Plan

A flight plan should be developed and agreed upon by all parties at the planning stage. It is recommended that the flight plan prepared by the UAV Service Provider be developed based on the survey work scope and requirements and the asset's Hazardous Area Plan.

The Service Provider should check with national/local aviation authorities for any required flight plan submittals or approvals needed prior to any UAV operations.

It is essential to the survey process to establish a video replay protocol. Experience has shown that recorded image quality (including stability and clarity) can be significantly better than the live-stream video displayed during the flight operation. A protocol should be established and agreed upon by all parties to determine when and where the video should be reviewed and when the results of the survey will be determined.

In addition to the video replay protocol, a typical flight plan scope should contain at least the following information:

i) *Operations Team*: It is recommended that the UAV operations team consist of at least two persons.

- *Pilot:* Direct flight control of the UAV device to maintain flight stability and accuracy
- *Camera/Payload Operator:* Direct control of the onboard camera and other intended modules to collect the data and coordination with the Surveyor
- A designated safety watch is recommended. This person should monitor 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 Flight Method:*

- Planned UAV type and specifications for the intended survey: verify the capabilities of the selected UAV(s) are appropriate for the survey being conducted
- Planned UAV limits: identify the selected UAV operating limitations and restrictions
- Planned take-off/landing zones: select potential locations for take-off/landing based on the supporting information provided by the asset Owner/Operator
- Flight maps or diagram: flight maps and diagram should be developed to maximize the effectiveness and efficiency of the UAV inspection for the intended structure based on the work scope and requirements
- Planned altitudes and distances from the structure: altitudes and distances should be determined based on local regulatory requirements and safety consideration
- An emergency flight plan should be in place in case of an environmental change, malfunction of the UAV system, loss of link incident or total loss of the UAV.
- An incident response checklist should be in place which could be 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 at night (e.g., proper lighting should be provided to assist external operation at night).
- Before the inspection a Notice to Airman (NOTAM) should be filed by the UAV service provider for any potential affected airspace.
- Distraction Management Strategies should be developed to reduce the communication sources during the operation to keep UAV pilots' attention focused. It is also recommended that all information be filtered or prioritized before passed to UAV pilots.

iii) *Communication Method*:

- Means for reliable and constant communication should be provided and maintained between all the UAV team members throughout the operation
- Communication protocol between the attending Surveyor and UAV operations team (e.g., RF set up)
- Unified nomenclatures between the attending Surveyor and UAV operations team
- Intermediary between the attending Surveyor and the pilot

iv) *Data Viewing Capability*:

- Means for real-time data display
- Means for video data replay

v) *Flight Alteration:* Any changes to the flight method should be agreed upon by all parties

- Appropriate time for proposing the change to the flight method (e.g., during the flight operation, between flights or after data review)
- Intermediary on the UAV team to whom changes will be proposed

7 Flight Operation

7.1 Pre-flight

On the date of the field operation, before the commencement of the UAV operation, it is recommended that a short briefing session and job safety analysis (JSA) be held for all participating personnel addressing the following items:

i) Confirm the work scope of the intended operation and flight plan

ii) Assess the field condition and determine if any amendments to the flight plan are necessary

iii) Verify the responsibilities of all personnel, including the representatives from Owner/Operator, ABS Surveyor and UAV Operations Team.

iv) Review identified risks and associated mitigation plans

v) Review of the emergency escape/evacuation plan

vi) Review permit to work requirements

vii) Review of UAV maintenance records to verify that pre-flight and periodic inspections are up to date and the UAV is airworthy in all respects

viii) Review of weather forecast to determine the meteorological conditions for external inspection

ix) Verification of proper personal protective equipment (PPE)

Any party should have the authority to immediately 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-Flight

The UAV Service Provider should have its organizational Standard Operation Procedures (SOP) for each flight operation. Following action items are recommended to be included in the SOP:

i) *Checklist Clearance:* The checklists should contain relevant system checks, inspection condition checks, personnel readiness checks, communication equipment checks, and testing flight checks

ii) *Take-off and Landing Zones:* Take-off and landing zones should be visibly marked and access should be restricted. It is recommended that the designated landing zones are clear of any personnel and hazards during the inspection process in case of any unexpected lost link incidents.

iii) *Visual Line of Sight (VLOS):* Some aviation authorities require human direct and unaided VLOS 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 all parties' agreement when no regulatory requirement applies

iv) *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 operations team and reported through the incident reporting process.

v) *De-confliction:* Procedures should be in place so that adequate de-confliction with helicopters or surface vessels servicing the asset is achieved (e.g., There should not be any UAV operations for external inspection within 30 minutes prior to a scheduled helicopter activities)

vi) *Documentation:* Whenever an anomaly is found during the operation, reference data (i.e., still image capture, location, etc.) should be properly documented for final reporting as well as included within the operational and maintenance logbooks.

The attending Surveyor should be present or in the vicinity of the space that is subject to the survey and direct the UAV operations team, as needed, with regard to the survey requirements and executions.

7.5 Post-flight

i) *Logging:*

- After the UAV is securely shut down and packaged, all flight details should be logged including time of take-off, duration of the flight, time of landing, and the type of work completed.
- If any maintenance or technical adjustment was conducted during the operation, it should also be documented.
- If any accident or near-miss was observed during the operation, it should be documented and reported to all parties so that the decision to abort the work or other adjustments can be made in a timely manner. The incident or near-miss may also need to be reported to local regulatory authorities based on local laws and requirements (e.g., USA FAA, UK CAA, etc.)

ii) *Maintenance:*

- Post-flight maintenance may be required by the OEM instructions and should be completed immediately after the flight, as applicable.
- Maintenance should be performed safely and efficiently to minimize the impact to the onsite personnel and the asset.

iii) *On-site Battery Handling:*

- Battery checks should be conducted and documented to confirm the reliability of its safety and endurance for the next operation.
- Batteries should be clearly marked for maintenance and re-charged.
- Batteries should be stored and recharged in fire proof containers.
- Transportation of the batteries should be in compliance with applicable regulations and work site requirements.
- Damaged or underperforming batteries should be removed from the battery line

9 Data Review

Digital data is to be submitted to the attending Surveyor. The following criteria should be considered to evaluate the visual data collected by a UAV:

i) Image quality should be adequate enough to make a meaningful assessment of the structure condition and to identify possible anomalies.

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

iii) Video footage, live-streaming and recorded, should be uninterrupted so that no portion of the structure is overlooked by the Surveyor/Inspector.

iv) Structural member identification data should be collected, especially associated with anomalies, in a way that such data can be tracked afterwards.

As agreed upon by all parties during the planning stage, the attending Surveyor is to either:

i) Review all the visual data on-site after the flight so that additional flights can be made if considered necessary, or

ii) Review all forms of visual data off-site within a specified period of time so that additional flight requests or other alternative inspection methods can be arranged

Proper equipment should be arranged by the asset Owner/Operator and the UAV Service Provider for the attending Surveyor to review the data. If the Surveyor is not satisfied with the result, an additional flight request may be made or additional alternative survey techniques may be required.

11 Data Post-Processing

Though most of the data analysis will be performed in real-time during the operation or within a short period of time after the flight operation, some Service Providers offer post processing of data for further evaluation after the UAV operation. Advanced post processing techniques may include:

i) Advance image processing to perform anomaly measurement (e.g., crack dimension measurement, corrosion area measurement, space volumetric measurement, etc.)

ii) Artificial intelligence for pattern recognition of crack, fracture, corrosion, etc.

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 use on 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.

13 Reporting

The UAV Service Provider should prepare a report which identifies the asset and structure inspected. Any descriptive information associated with the class survey should be factual and objective only. If the asset Owner/Operator has contracted the UAV Service Provider to provide additional data, technical support or recommendations outside the scope of the class 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, year of build, etc.

ii) Survey information including survey type, name, and/or location of the structure or space that was surveyed *iii)* UAV Service Provider's information including company name, operations team members' names, and the UAV model name used during the survey

iv) Any digital data supporting the crediting of class-related activities.

Reporting to support crediting class survey activities should be done in accordance with ABS practices. If the UAV was used in conjunction with the Close-up Survey/CVI, additional reporting requirements may apply.

If review of the data reveals any condition that is not identified at the time of the Survey and affects or may affect classification, the Owner/Operator should advise ABS as required by the ABS Rules.

APPENDIX 1 References

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

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   http://publicapps.caa.co.uk/docs/33/CAP%20722%20Sixth%20Edition%20March%202015.pdf

3. ISO 9001:2015 Quality Management Systems-Requirements, 2015

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

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13. ABS *Guide for Cybersecurity Implementation for* Marine and Offshore Operations – *ABS CyberSafety™ Volume 2*, Houston, TX, United States, 2016

14. ABS *Guidance Notes on Data Integrity for Marine and Offshore Operations – ABS CyberSafety™ Volume 3*, Houston, TX, United States, 2016

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18. ABS *Guide for Means of Access to Tanks and Holds*, Houston, TX, United States, 2016

19. ABS *Guide for Dropped Object Prevention on Offshore Units and Installations*, Houston, TX, United States, 2017

20. ABS *Guide for Building and Classing Floating Offshore Wind Turbine Installations*, Houston, TX, United States, 2015

21. ABS *Guide for Building and Classing Bottom-founded Offshore Wind Turbine Installations*, Houston, TX, United States, 2015

22. Unmanned Aircraft Systems (UAS) Operations Management Standards and Guidelines, Oil & Gas UK, London, United Kingdom, 2017

23. Unmanned Aerial Systems Guidelines, Helicopter Safety Advisory Conference (HSAC), HSAC RP UASRP 15-1, United States, 2015

APPENDIX 2 UAV Design 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)

APPENDIX 3 Checklist for Asset Owners/Operators

Appendix 3 contains a checklist which provides suggestions and recommendations for the Asset Owners/ Operators in decision making during different stages of the UAV inspection process. The four stages include: 1. Inspection Objective, 2. UAV selection, 3. Inspection Plan & Operation, and 4. Post Processing.

Please 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 External Specialist	Yes	☐	No	☐
Local Requirements and Regulations:				
Purpose of the Inspection:				
Stated Goal 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	☐			

<table>
<tr><td colspan="6">Stage 2: UAV Selection</td></tr>
<tr><td colspan="6">Type of Sensor/Payload</td></tr>
<tr><td colspan="3">In Situ Sensing</td><td>Y/N</td><td colspan="2">Comments</td></tr>
<tr><td colspan="3">a. Thickness Gauging</td><td>☐</td><td colspan="2"></td></tr>
<tr><td colspan="3">b. NDE Detector</td><td>☐</td><td colspan="2"></td></tr>
<tr><td colspan="3">c. Meteorological Sensors</td><td>☐</td><td colspan="2"></td></tr>
<tr><td colspan="3">d. Chemical Sensors</td><td>☐</td><td colspan="2"></td></tr>
<tr><td colspan="3">e. Biological Sensors</td><td>☐</td><td colspan="2"></td></tr>
<tr><td colspan="3">f. Microphones</td><td>☐</td><td colspan="2"></td></tr>
<tr><td colspan="6">Remote Sensing</td></tr>
<tr><td colspan="3">a. High Definition (HD) Cameras</td><td>☐</td><td colspan="2"></td></tr>
<tr><td colspan="3">b. Visible Spectrum Cameras</td><td>☐</td><td colspan="2"></td></tr>
<tr><td colspan="3">c. Near-Infrared Cameras</td><td>☐</td><td colspan="2"></td></tr>
<tr><td colspan="3">d. Long-Wave Infrared Cameras</td><td>☐</td><td colspan="2"></td></tr>
<tr><td colspan="3">e. Multispectral/Hyperspectral Cameras</td><td>☐</td><td colspan="2"></td></tr>
<tr><td colspan="3">f. Light Detection and Ranging (LiDAR)</td><td>☐</td><td colspan="2"></td></tr>
<tr><td colspan="3">g. Synthetic Aperture Radar (SAR)</td><td>☐</td><td colspan="2"></td></tr>
<tr><td colspan="6">Type of UAV</td></tr>
<tr><td colspan="6">1. Propulsion Types</td></tr>
<tr><td>a. Fixed-Wing</td><td>☐</td><td>b. Rotary-Wing</td><td>☐</td><td>c. Hybrid</td><td>☐</td></tr>
<tr><td colspan="6">2. UAV Size</td></tr>
<tr><td>a. Mini UAV (≤ 5kg)</td><td>☐</td><td>b. Small UAV (5-25kg)</td><td>☐</td><td>c. Large UAV (>25 kg)</td><td>☐</td></tr>
<tr><td colspan="6">3. Energy Source</td></tr>
<tr><td>a. Internal Combustion</td><td>☐</td><td>b. Battery Cells</td><td>☐</td><td>c. Fuel Cells</td><td>☐</td></tr>
<tr><td>d. Solar Cells</td><td>☐</td><td colspan="4">e. Others</td></tr>
<tr><td colspan="6">4. Control Methods</td></tr>
<tr><td>a. Manual Control</td><td>☐</td><td>b. Stabilized Control</td><td>☐</td><td>c. Automated Control</td><td>☐</td></tr>
<tr><td colspan="6">5. UAV Parameters</td></tr>
<tr><td colspan="3">Hardware</td><td>Input</td><td colspan="2">Comments</td></tr>
<tr><td colspan="3">a. Model</td><td></td><td colspan="2"></td></tr>
<tr><td colspan="3">b. Manufacture</td><td></td><td colspan="2"></td></tr>
<tr><td colspan="3">c. Registration Number</td><td></td><td colspan="2"></td></tr>
<tr><td colspan="3">d. Dimension (mm x mm x mm)</td><td></td><td colspan="2"></td></tr>
<tr><td colspan="3">e. Weight (kg)</td><td></td><td colspan="2"></td></tr>
<tr><td colspan="3">f. Flight Endurance (min)</td><td></td><td colspan="2"></td></tr>
<tr><td colspan="3">g. Wind Tolerances (m/s)</td><td></td><td colspan="2"></td></tr>
<tr><td colspan="3">h. Top Speed (mi/hr)</td><td></td><td colspan="2"></td></tr>
<tr><td colspan="3">i. Visibility Limit (ft)</td><td></td><td colspan="2"></td></tr>
<tr><td colspan="3">j. Telemetry Range (ft)</td><td></td><td colspan="2"></td></tr>
<tr><td colspan="3">k. Maximum Flight Altitude (ft)</td><td></td><td colspan="2"></td></tr>
<tr><td colspan="3">l. Control Frequency (HZ)</td><td></td><td colspan="2"></td></tr>
<tr><td colspan="3">m. Vertical Take-off Landing (VTOL)</td><td>☐</td><td colspan="2"></td></tr>
<tr><td colspan="3">n. Contact Protection Cage</td><td>☐</td><td colspan="2"></td></tr>
<tr><td colspan="3">o. Maintenances Record Checked</td><td>☐</td><td colspan="2"></td></tr>
<tr><td colspan="3">p. Energy Source Maintenance Control Plan Available</td><td>☐</td><td colspan="2"></td></tr>
<tr><td colspan="3">q. Airframe Maintenance Control Plan Available</td><td>☐</td><td colspan="2"></td></tr>
</table>

r. Avionics Maintenance Control Plan Available	☐	
s. UAV Properly Protected in Storage	☐	
Software		
a. Measuring Tool	☐	
b. Autopilot System	☐	
c. Attitude Stabilization System	☐	
d. GPS System	☐	
e. Waypoint Flight Planning	☐	
f. Collision Avoidance Sensor	☐	
g. Backup Manual Controls	☐	
h. Real-time Data Telemetry	☐	
i. Operate Without Payload	☐	
j. Cyber Security System	☐	
k. Software System Testing Procedures	☐	
Stage 3: Inspection Plan & Operation		

Inspection Environment			
Inspection Location:			
Maximum Ground Elevation (ft):		Maximum Inspection Distance (ft):	
Number of Operation Team Members		Expected Number of Flights	
Marine Asset	☐	Offshore Asset	☐
Wind Turbine	☐	Dropped Object Inspection	☐
Internal Inspection	☐	External Inspection	☐

Hazard Identification & Risk Control		
Common	Y/N	Comments
a. Clear Airspace	☐	
b. Open Take-off & Landing Space	☐	
c. Sufficient Light	☐	
d. Reachable Distance	☐	
e. Hot Work Permit	☐	
Potential Risk Environment		
a. Electro-Magnetic Interference	☐	
b. Loss of Link	☐	
c. Flight Location Access Controlled	☐	
d. Flying Over People	☐	
e. Confined Space	☐	
f. Soft Coating	☐	
g. Dusty Environment	☐	
h. Windy Environment	☐	
i. Foggy Environment	☐	
j. Sunny Environment	☐	
k. Raining Environment	☐	

Operator & Ground Crew		
a. Pilot Certificate	□	
b. Training Records Available	□	
c. Familiarization with selected UAV 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. Flight Readiness Review Process	□	
d. Data Reviewing Protocol Established	□	
e. Communication Equipment Checked	□	
f. Loss of Link Procedures Available	□	
g. Landing Procedures Available	□	
h. Emergency Flight Plan Available	□	
i. Distraction Management Program Available	□	
j. Fatigue Management Program Available	□	
Stage 4: Post Processing		
Post-Flight Operations		
a. Post-Flight Inspection Completed	□	
b. Flight 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 UAV Inspection Needed	□	
k. Additional Inspection Using Alternative/Traditional Inspection Needed	□	