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 that reduce the safety risks to the Surveyor. 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 provide 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 Service Provider, operation and data handling, 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.

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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CONTENTS

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 a safer, more effective, and efficient inspection.

3 Scope

The purpose of these Guidance Notes is to provide information related to the use of UAVs in conjunction with class surveys and to provide guidance to the marine and offshore industries on non-class related UAV inspections.

If the application of UAVs is used in conjunction with class related activities, inspection by way of UAVs is considered as an alternative remote inspection technique to assist the attending Surveyor in performing an examination of hard to reach structures. 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 inspection using alternative or traditional inspection techniques may be required.

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

These Guidance Notes are intended for pilot-operated UAV applications only.

These Guidance Notes cover:

- Applications of UAVs (Section 2)
- Qualification of Service Providers (Section 3)
- Survey Process (Section 4)
- Data (Section 5)

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

5 Terminology and Abbreviations

ABS Recognized External Specialist Program: A program that ABS administers 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.

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)*.

ESP: Enhanced Survey Program.

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.

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.

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 work environment. It also includes steps to eliminate or reduce the hazards to an acceptable regime.

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 operational missions excluding the basic systems required for flying.

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

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

Personal Protection Equipment (PPE): Protective clothing, helmets, goggles, or other garments or equipment designed to protect the 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.

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 ABS 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.

SECTION 2 Application of Unmanned Aerial Vehicles

1 General

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

Application of UAVs may be considered in the following cases to reduce operational intrusiveness:

i) *Avoid Working at Heights:* UAVs can reduce or remove the need for personnel working at heights through 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.

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 to assist the attending Surveyor with class related activities where visual examination of the structure is required. The acceptance of the inspection results is at the discretion of the attending Surveyor. If the attending Surveyor is not satisfied with the inspection results provided by the UAV, alternative or traditional survey techniques may be required.

Compliance with Regulatory requirements, in particular SOLAS and the ESP Code also need to be considered.

Conditions for using UAVs to assist class related activities are discussed in Section 4.

5 Roles of Asset Owner/Operator, Service Provider, and ABS

The use of UAVs requires cooperation from all parties. The roles and responsibilities of the main parties are summarized in Table 1.

TABLE 1
Roles and Responsibilities

Activity	*Role of Owner/Operator*	*Role of Service Provider*	*Role of ABS*
Planning	Determine if the use of a UAV is appropriate Select the UAV Service Provider Provide supporting information to the Service Provider about the asset condition and drawings related to the work scope Review and accept UAV inspection plan proposed by the Service Provider Provide Survey Planning Documentation, with inspection plan incorporated, to the attending Surveyor if the UAV application is in conjunction with class related activities Coordinate logistical aspects of the inspection, such as obtaining work/site permit, onboarding crews, inspection preparation, etc.	Develop inspection plan which includes, but is not limited to: • Determining the appropriate type of UAV to be used • Performing risk assessment and develop the UAV flight plan based on the work scope	Review the proposed Survey Planning Document
Operation	Agree to inspection results	Execute the UAV inspection	Conduct class survey in compliance with applicable Rules, Guides, and organizational processes while employing the UAV as an inspection technique
Reporting	Review the inspection results provided by the Service Provider	Provide inspection results and data to the Owner/Operator and ABS, if applicable	Review and evaluate the results furnished by the UAV Service Provider

SECTION 3 Qualification of Service Providers

1 General

When UAV inspection is used, the asset Owner/Operator is responsible for selecting a UAV Service Provider whose qualifications and capabilities are appropriate for the intended application, to verify the inspection can be conducted safely, effectively, and efficiently.

If the use of a UAV is 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 the recognized aviation authorities (e.g., Title 14 Code of Federal Regulations (14 CFR), Part 107 requirements by FAA, CAP 722 guidance by CAA).

5 Quality Management System

The UAV Service Provider should have an internal quality management system (QMS), which is to:

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

ii) Strive to enhance customer satisfaction through the effective applications of the 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 third-party vetting credentials. The asset Owner/Operator is recommended to review the QMS of the Service Provider for the aspects provided in the following subsections.

5.1 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. It also can 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.

5.1.1 Equipment Selection

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

i) Safety:

- The UAV and onboard modules should be rated for its intended operational environment
- Materials of the UAV and onboard modules should be non-hazardous to the structure and the inspection environment in normal operation and in case of operation malfunction or failure.
- For internal inspection, it is recommended that the UAV device possess a protecting component to minimize damage to the structure and coatings (e.g., propeller guards)
- Critical UAV component redundancy should be designed in case of malfunction or failure (e.g., motor, battery, controller, etc.)
- Multiple operation modes (i.e., GPS mode, height mode and manual mode) should exist in case of malfunction or failure

ii) Accessibility:

- Specifications verifying the UAV device is designed for intended environment (e.g., maximum operational wind speed, temperature, humidity, etc.)
- 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.)

iii) Operability:

- The UAV system has a control station that allows the pilot to easily operate the UAV
- The UAV device has onboard flight control modules that allow stable and accurate maintenance of position
- The UAV has onboard localization and navigation modules (e.g., GPS for external inspection)
- The UAV device is able to operate for an acceptable duration of time for the inspection being conducted (e.g. battery life, areas covered within one battery life, etc.)

iv) Data Acquisition:

- The UAV has an onboard camera that provides adequate visual quality of still image, live-stream video, and recorded video. It is recommended the UAV camera possesses a resolution of at least 720p
- 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 image, 2D/3D modeling, etc.

v) Communication/Transmission:

- The UAV system should provide and maintain an interference-resistant communication channel
- The UAV system should include reliable communication equipment between each team member

vi) Data Review:

- The UAV system should include an appropriate platform to display and replay visual data including still image, live-stream video, and recorded video to the attending Surveyor

5.1.2 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 a safe, effective, and efficient service.

It is recommended that the Service Provider follows maintenance instructions provided by the OEMs. Where no maintenance instruction is available from the OEMs, the following criteria can be considered:

i) *Calibration:* Equipment should be calibrated on a regular basis by internal technicians or external parities for its fitness-for-service

ii) *Defect Clearance:* If any defect is reported or observed during the internal testing or normal operation, it should be fixed and re-tested

iii) *Fixed Mechanical Component Check and Maintenance:* Blades, motors, wires, and other fixed components should be checked, cleaned, and renewed/replaced if needed

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

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

A logbook should be maintained for each maintenance type for future reference.

5.3 Personnel

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

Depending on the job nature, different training regimes should be provided by the Service Provider to the designated employees. 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 organizational and mandatory requirements for the qualification and training of its employees.

5.3.1 Safety Awareness

Safety awareness should be part of the organizational Safety Management System (SMS), which will be described in the following section, 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 environment. Safety awareness can be addressed through organizational safety training. Safety training contents should adhere to 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 the job related safety training to the designated personnel that may 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)

5.3.2 Pilot Competence

A pilot is the person in direct flight control of the UAV device. Therefore, their competency in operation affects the safety of onsite personnel and the asset being inspected. If applicable, the pilot should meet statutory and regulatory flight training hours and satisfaction level to maintain his/her pilot license.

In addition to the statutory and regulatory requirements, the Service Provider should place a high level of emphasis on their pilot competence 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.

5.3.3 Inspection Knowledge

The Service Provider should provide inspection knowledge training to the appropriate personnel. The members of the operation team should be familiar with marine and/or offshore nomenclatures in order to communicate effectively with the asset Owner/Operator and/or the attending Surveyor during the inspection. If a UAV is used in conjunction with class related activities, working knowledge of the applicable Rules, Guides, and guidelines is 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.).

5.5 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 an effective 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) *Maintenance Logbook:* The Service Provider should maintain a logbook to record maintenance procedure and practice of each device and payload modules.

7 Safety Management System

The Safety Management System (SMS) provides a systematic approach to manage safety. It is becoming a standard throughout the aviation industry and is recognized by international and national organizations such as International Civil Aviation Organization (ICAO) and Joint Planning and Development Office (JPDO). The FAA suggests that the SMS for product/service providers should integrate modern safety risk management and safety assurance concepts into repeatable, proactive systems. SMS should emphasize safety management as a fundamental business process to be considered in the same manner as other aspects of business management.

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 organization structure required to meet safety goals. The Service Provider should have written policies, processes, and/or procedures to address:

i) Safety commitment

ii) Safety objectives

iii) Methods, processes, and organization structure needed to meet safety goals

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 description, risk assessment, and risk control in the process of providing the services.

It is recommended that the Service Provider conceptually assess safety risks during normal operation and the probability and severity of the consequences. A mitigation plan corresponding to those risks should be developed and documented.

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 the compliance with SMS requirements and aviation orders, standards, policies, and directives. Actions include, but are not limited to:

i) Internal audits and evaluations

ii) Reporting culture

iii) Safety data analysis and assessment

iv) Safety oversight and improvement

For further guidance on procedure development, please refer to the ABS *Guidance Notes on the Development of Procedures and Technical Manual.*

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 Liability

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

11 ABS Recognized External Specialist Program

ABS Recognized External Specialists are approved Service Providers that perform services on behalf of an equipment manufacturer, shipyard, vessel's 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 are to 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

v) 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 Process

1 General

This Section provides guidance on the survey process when the UAV is employed during class related activities.

3 Condition

Remote inspection techniques by way of UAVs may not be appropriate if any of the following conditions exist or are found during the course of the survey process:

i) There is a record indicating abnormal deterioration or damage to the structure to be inspected

ii) The condition of the structure or item affects the class of the asset

iii) UAV inspection reveals damage or deterioration that requires immediate attention

iv) The condition or color of the coating on the structure does not allow for a meaningful examination

Where any of the above conditions exist or are found during the course of the survey process using a UAV, additional surveys using conventional inspection techniques may be required. Experience has shown that while the UAV is an effective method of detecting defects and unsatisfactory conditions such as corrosion, other means of access may be required for a proper assessment and the determination of appropriate repair specifications.

5 Survey Planning

Proper preparations and close co-operation between the attending Surveyor, asset Owner/Operator representatives, and UAV Service Provider prior to the survey are an essential part of the process to facilitate a safe, effective, and efficient conduct of survey.

Prior to the commencement of the survey, a survey planning meeting is to be held between all parties to verify that the arrangements envisaged in the survey process are in place. A Survey Planning Document prepared by the asset Owner/Operator should be provided for the attending Surveyor's review and agreement.

The following subsections should be addressed in the meeting and included in the Survey Planning Document, as applicable.

5.1 Scope and Requirement

Survey scope should contain at least the following information, as applicable:

i) Survey type (i.e., Annual survey, Intermediate survey, Special Periodic survey, damage survey)

ii) Asset type, main particulars, and operational details

iii) Extent of the survey (i.e., Overall Survey/GVI, Close-up Survey/CVI, etc.)

iv) Rule requirements based on the survey type, asset type, and extent of the survey

v) Critical structural areas subject to Close-up Survey/CVI

vi) Arrangement for the attending Surveyor and third-party specialist to perform confirmatory inspection by conventional means and thickness measurements, as considered necessary (i.e., safe access, cleaning/de-scaling, illumination, ventilation, etc.)

vii) Location and anticipated time frame for the survey and operational status of the asset (i.e., shipyard, repair facility or lay berth, etc.)

viii) Logistics including site permission, work permit, transportation, accommodation, inspection preparation, etc.

5.3 Risk Assessment

In addition to the generic risk assessment that the Service Provider follows as part of their SMS, 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 the risk assessment is conducted during the survey planning meeting attended by all parties and incorporated in the Survey Planning Document if applicable. 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 hazardous area, the system should be rated for intended classification level or the area should be made safe for the equipment as it is. 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 be considered 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 and replacement, and re-charge
- Explosion due to operational incidents/accidents

ii) *Dropped Object Risks:* In case of UAV malfunction or failure, it can pose risks to the asset and onsite personnel as a dropped object. Typical factors to be considered include, but are not limited to:

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

iii) *Collision Risks:* Collison may occur due to unexpected change of inspection environment, UAV malfunctions, and/or human errors, including:

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

iv) *Other Risks:* Other risks should be identified in terms of personnel's health and safety including:

- High risk working areas that may contain high voltage, toxic gases, or hazardous contents
- Risk associated with any 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 should 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, if applicable, for flight plan submittal and approval requirement before the operation.

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 is to be reviewed and when the results of the survey will be determined.

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

i) *Operation Team*: At current state, the UAV inspection team is to 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
- In some scenarios, a third member as a spotter to conduct a safe operation may be utilized
- A designated personnel as safety watch is strongly recommended, who is to watch out for any safety hazards in the worksite while other people are performing the job and empowered to abort the operation in the event of a perceived or actual safety hazards.

ii) *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 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
- Emergency flight plan in case of environment change, malfunction of the UAV system or total loss of the UAV

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 operation team
- Unified nomenclatures between the attending Surveyor and UAV operation 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 JSA is 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 decide if any amendment of the flight plan is required

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

iv) Review the risks and associated mitigation plans

v) Review of the emergency plan to escape or evacuate

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 are recommended to be visibly marked and the access to the take-off and landing zones should be restricted if needed

iii) *Visual Line of Sight (VLOS):* Some aviation authorities require human direct and unaided VLOS is maintained throughout the operation. At current UAV technology level, it is recommended that VLOS is 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 between the team members is lost or significantly interfered with, the operation should be aborted immediately

v) *Documentation:* Whenever an anomaly is found during the operation, reference data (i.e., still image capture, location, etc.) should be properly documented for the final reporting

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

7.5 Post-flight

i) *Logging:*

- After the UAV device 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 is conducted during the operation, it should also be documented.
- If any accident or near-miss is 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.

ii) *Maintenance:*

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

iii) *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-charge.
- A separate battery logbook for the above information is recommended.

9 Data Review

Three forms of visual data, still image, live-stream video, and recorded video should be available for the attending Surveyor to examine and assess the condition of the structure.

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

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 setup should be arranged by the asset Owner/Operator and 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 by the Surveyor or additional alternative survey techniques may be required.

11 Reporting

The UAV Service Provider should prepare and provide a report which identifies the asset and structure inspected. Any descriptive information associated with the class survey is to be factual and objective only. If the asset Owner/Operator is contracting with 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 should 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, operation team members' name, and the UAV model name used during the survey

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.

SECTION 5 Data

1 General

Based on the current state of UAV technology, data collected by the UAV is mostly visual information. This section summarizes the guidance on visual data acquisition, post-analysis, and data security. This section applies to both class and non-class related activities.

3 Data Acquisition

Visual data (e.g., still image, live-stream video, and recorded video) collected during the flight operation should be reviewed and evaluated at a specified time and location as agreed upon by all parties during the planning stage. The following criteria should be considered to evaluate the visual data collected by a UAV:

i) Image quality should be adequate 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) of this anomaly.

iii) Video footage, including both live-streaming and recorded, should be uninterrupted so that any portion of the structure is not 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.

5 Post-Analysis Data

Though most of the data evaluation 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-analysis data for further evaluation after the UAV operation. Advanced post-analysis techniques may include:

i) Advance imaging 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

Those enhanced post-analysis techniques can be particularly beneficial for use on the asset where life expectancy is important, such as assets engaged in site specific operations. The use of the post-analysis data is at the discretion of the Owner/Operator.

7 Data Security

The objective of data security is to verify that data collected during the operation and any post-analyses are captured, transmitted, and stored in a secure way that has minimum vulnerability to unauthorized manipulation and distribution.

The UAV Service Provider should comply with any statutory or regulatory requirements, company-specified and/or contractual agreements if applicable.

If the Service Provider provides remote data access portal for its client, it is recommended that cybersecurity is properly addressed in the implementation. Further guidance can be found in the ABS *Guidance Notes on Data Integrity for Marine and Offshore Operations – ABS CyberSafety™ Volume 3.* The asset Owner/Operator can refer to the *ABS Guide for Cybersecurity Implementation for Marine and Offshore Operation – ABS CyberSafety™ Volume 2* and the ABS *Guidance Notes on Data Integrity for Marine and Offshore Operations – ABS CyberSafety™ Volume 3* for more information on implementing cybersecurity programs and associated class notations.

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