

SUB-COMMITTEE ON SHIP DESIGN AND  
CONSTRUCTION  
12th session  
Agenda item 4

SDC 12/4  
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## AMENDMENTS TO THE 2011 ESP CODE

### Report of the Correspondence Group

#### Submitted by IACS

#### SUMMARY

*Executive summary:* This document provides the report of the Correspondence Group on the Development of Guidelines on the Use of RIT for 2011 ESP Code Surveys.

*Strategic direction, if applicable:* 7

*Output:* 7.21

*Action to be taken:* Paragraph 27

*Related documents:* SDC 11/6, SDC 11/WP.5 and SDC 11/17

#### Background

1 SDC 11 re-established the Correspondence Group on the Development of Guidelines on the Use of RIT for 2011 ESP Code Surveys, under the coordination of IACS (SDC 11/17, paragraph 6.39).

2 Representatives of the following Member States participated in the Group:

CHINA	NORWAY
DENMARK	REPUBLIC OF KOREA
GERMANY	RUSSIAN FEDERATION
ITALY	SINGAPORE
LIBERIA	UNITED ARAB EMIRATES
MALTA	UNITED KINGDOM
MARSHALL ISLANDS	UNITED STATES

an observer from the following intergovernmental organization:

EUROPEAN COMMISSION (EC)

and observers from the following non-governmental organizations in consultative status:

INTERNATIONAL CHAMBER OF SHIPPING (ICS)  
BIMCO  
INTERNATIONAL ASSOCIATION OF CLASSIFICATION SOCIETIES (IACS)  
INTERNATIONAL ASSOCIATION OF INDEPENDENT TANKER OWNERS  
(INTERTANKO)  
INTERNATIONAL TRANSPORT WORKERS' FEDERATION (ITF)

3 The Coordinator of the Correspondence Group wishes to express its appreciation for the various constructive contributions made by the members of the Group.

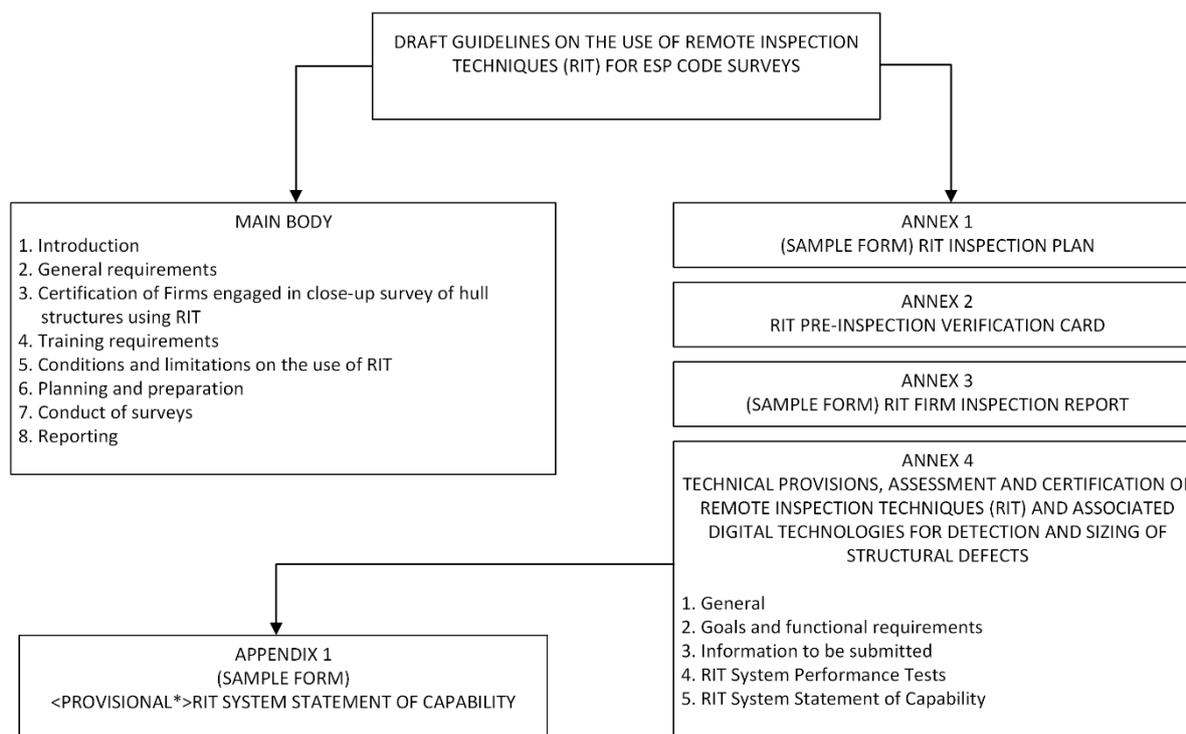
### **Terms of reference**

4 The Correspondence Group was instructed to:

- .1 further develop guidelines on the use of RIT for 2011 ESP Code surveys, based on annex 2 of document SDC 11/6, and taking into account the discussion reflected in paragraphs 20 to 23 of that document (i.e. SDC 11/WP.5);
- .2 consider, as part of the development of the guidelines on the use of RIT:
  - .1 adopting a goal-based approach, including identifying functional requirements and expected performance;
  - .2 also including guidance for RIT thickness measurements capabilities;
  - .3 taking into account the draft amendments to the 2011 ESP Code and also identifying the references to the guidelines on the use of RIT, as set out in annex 1 of document SDC 11/6;
  - .4 including guidance on the use of RIT for surveyors, ships' personnel, firms using RIT and for manufacturers of RIT;
  - .5 including guidance for validation and verification of RIT equipment capability (ashore and on board ships);
  - .6 including guidance for certification of RIT equipment;
  - .7 including guidance for training of personnel of firms and surveyors engaged in the use of RIT; and
  - .8 considering developments within the RIT manufacturing industry and firms using RIT;
- .3 convene virtual meetings using a suitable platform in order to consider any of the terms of reference, as necessary; and
- .4 submit a written report to SDC 12.

## Further development of the guidelines on the use of RIT for 2011 ESP Code surveys (ToR 1);

5 The Group discussed further development of the draft guidelines on the use of remote inspection techniques (RIT) for surveys under the 2011 ESP Code, with annex 2 to document SDC 11/6 as a basis. The proposed structure of the draft guidelines (annexed to the present report), is presented in the diagram below, outlining the main sections and supporting annexes developed by the Group to facilitate consistent implementation and oversight by Administrations and recognized organizations.



**Figure - Draft structure of the draft guidelines on the use of RIT for 2011 ESP Code surveys**

6 As the initial step, the Group revised the content of annex 2 to document SDC 11/6 with a view to reflecting the draft amendments to the 2011 ESP Code (SDC 11/WP.5), including references to the guidelines on the use of RIT, in accordance with the terms of reference (ToR 2.3). The main body of document SDC 11/6, annex 2 was taken as the main body of the draft guidelines worked by the Group, with adjustments made for alignment with the revised 2011 ESP Code provisions, with the resulting structure remaining however closely aligned with the original source. As a result, the main body of the draft guidelines now provides for a comprehensive guidance on the application of RIT in the ESP Code surveys, addressing the scope of the ToRs 2.4 and 2.7.

7 The Group discussed the need to develop sample template forms for the RIT Inspection Plan and the RIT Firm Inspection Report, with a view to promoting a uniform approach regarding the minimum information required to support the ESP Code surveys using RIT and comply with the ESP Code reporting principles. In this regard, the Group reviewed the content already indicated (both directly and indirectly) in the draft amendments to the 2011 ESP Code (SDC 11/WP.5), and considered additional proposals to enhance clarity and completeness. The agreed sample forms, set out in annexes 1 and 3 to the draft guidelines,

aim to assist Administrations, recognized organizations, and service providers in preparing and documenting RIT-based surveys in a consistent and transparent manner.

8 Annex 2 provides a standardized Pre-Inspection Verification Card to verify the performance of RIT systems before surveys begin. It ensures that the equipment can deliver reliable visual data under actual onboard conditions, such as lighting, humidity and cleanliness. The card includes checks for resolution, detail, contrast and colour fidelity, and is used across multiple viewing directions to confirm that the RIT system meets the required inspection standards. This verification process supports surveyor confidence and consistency in RIT-based inspections and aims to address ToR 2.5.

9 Annex 4, entitled "Technical provisions, assessment and certification of remote inspection techniques (RIT) systems and associated digital technologies for detection and sizing of structural defects", was developed based on annex 1 to the draft guidelines as presented in annex 2 to document SDC 11/6, which originally addressed the technical requirements and assessment of unmanned robotic vehicles (URVs). The annex maintains its original purpose of providing guidance for the validation and verification of RIT system capabilities, both ashore and on board ships. It incorporates a goal-based approach and functional requirements, whilst introducing key revisions to align with the draft amendments to the 2011 ESP Code (SDC 11/WP.5) and to address the terms of reference (ToR 2.6 and 2.1). These changes are further explained in paragraphs 10 to 14 below.

**Consider, as part of the development of the guidelines on the use of RIT (ToR 2): including guidance for certification of RIT equipment (ToR 2.6), adopting a goal-based approach, including identifying functional requirements and expected performance (ToR 2.1), and also including guidance for RIT thickness measurements capabilities (ToR 2.2)**

10 Annex 4 to the draft guidelines sets out the technical framework for assessing and certifying RIT systems used in ESP Code surveys. Whilst the original source document (SDC 11/6) only considers the validation of unmanned robotic vehicles (URV), several delegations mentioned that manned techniques (e.g. rope access) may present similar challenges and, therefore, the document should address RIT systems and not just URV, which also reflects the principles laid down in the draft amendments to the 2011 ESP Code (SDC 11/WP.5).

11 Annex 4 also introduces a goal-based approach with six key areas:

- .1 Fitness for purpose: RIT systems should reliably access and provide information to allow the survey of ship structures under expected conditions;
- .2 Safety: Systems should protect personnel, ship structures and themselves during operation;
- .3 Efficiency: Systems should operate efficiently with adequate power, control and redundancy;
- .4 Data Accuracy and Integrity: Visual data should be of high-quality and stable to allow the surveyor to identify structural defects;
- .5 Data retention: Inspection data should be securely recorded, traceable and tamper-proof; and

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- .6 Thickness measurement: If applicable, RIT systems should match manual thickness measurement standards in accuracy and capability.

12 To support each goal, functional requirements were developed, corresponding to specific criteria describing what should be achieved to meet the goal. Functional requirements are not tied to any particular technical solution, allowing flexibility for innovation. They should cover all relevant hazards and provide a clear basis for verifying compliance.

13 Expected performances are provided as provisions for measurable or verifiable outcomes allowing for demonstration that the functional requirements have been met. They are expressed in quantitative terms (e.g. resolution, accuracy, duration) or, where not feasible, in qualitative terms that are still objectively assessable. Expected performances define, in this way, the conditions and thresholds under which the function should operate effectively.

14 Performance is validated through testing protocols both ashore and on board, to confirm that the RIT system can reliably meet the functional requirements under real survey conditions. This process would culminate in the issuance of an RIT System Statement of Capability, documenting formally the system's validated capabilities and limitations. The testing protocols are to be developed by Administrations, recognized organizations or testing laboratories, as appropriate, to ensure conformity with the established goals, functional requirements and expected performance criteria as set out in annex 4.

**Considering developments within the RIT manufacturing industry and firms using RIT (ToR 2.8) and convene virtual meetings using a suitable platform in order to consider any of the terms of reference, as necessary (ToR 3)**

15 The composition of the Group reflected a broad spectrum of expertise in ESP surveys and remote inspection techniques, comprising:

- .1 classification society surveyors with extensive experience in conducting ESP surveys;
- .2 classification society specialists directly responsible for the development and implementation of RIT;
- .3 academic researchers that actively engaged in the study and validation of remote inspection technologies; and
- .4 experts on civil drones.

16 In accordance with the latest provisions introduced to the *Organization and method of work of the Maritime Safety Committee and the Marine Environment Protection Committee and their subsidiary bodies* (MSC-MEPC.1/Circ.5/Rev.6), paragraph 5.26, which clarifies the purpose and limitations of virtual meetings held during the work of correspondence groups, two virtual meetings were convened on 6 June 2025. These meetings aimed to provide insight into the application of RIT and included brief question-and-answer sessions following each presentation.

17 The following delegations contributed to the technical discussions by developing and delivering presentations on relevant subjects:

- .1 China: "Testing, Validation, and Application of UAVs in Hull Structural Surveys";

- .2 China: "UAV Technology for Ship Enclosed Spaces (Including UAV for Close Survey of Ships and for Measuring Thickness of Ship Structures)";
- .3 Italy: "Validation of Digital, Robotic and Remote Inspections Onboard Ships";  
and
- .4 IACS: "Remote Inspection Techniques".

18 The coordinator of the Correspondence Group wishes to express appreciation to the presenters for their valuable contributions and the additional effort made in preparing and delivering the presentations, which were well received by the members of the Group.

19 For the benefit of the wider IMO community, the four presentations can be downloaded [here](#).

#### **Items to be noted for further consideration**

20 Whilst the draft guidelines were revised to align with the recent amendments to the 2011 ESP Code, one delegation expressed concern regarding the use of non-mandatory language (e.g. the term "should") within the draft. It was noted that such language may lead to less stringent interpretations of mandatory provisions in the 2011 ESP Code that reference the guidelines (e.g. "Refer to the guidelines to be developed by the Organization") with a possible impact in the Code safety principles and safeguards.

21 The Pre-Inspection Verification Card, included in annex 2 of the draft guidelines, sets out minimum criteria, namely resolution, detail, contrast, and colour, should be used for verification prior to the commencement of surveys, with a view to ensuring that the equipment is both functional and appropriately adapted to local conditions. It is recommended that further testing be conducted using actual RIT systems to validate the suitability of the established criteria and to revise them as necessary. To this end, with a view to incorporating relevant experience from the use of RIT in respect of relevant image parameters and resolution, the text of the associated MSC circular of draft the guidelines may include a specific invitation to Administrations to submit relevant experience to the Organization, for future consideration.

22 The Pre-Inspection Verification section in the main body of the guidelines stipulates that the RIT system should be verified and tested on-site to ensure that, under prevailing conditions (e.g. lighting, humidity and structural cleanliness), the system can perform to the required standard and deliver information with a level of assurance equivalent to that of a close-up visual inspection. The process recommends the use of the "Pre-Inspection Verification Card", as provided in annex 2 of the draft guidelines, to assess resolution, detail, contrast and colour. Whilst the draft guidelines, as currently drafted, would allow for other appropriate means to be used, one delegation proposed the withdrawal of this flexibility in order to maintain a consistent standard and ensure that, regardless of the RIT firm or system employed, the results achieved remain harmonized.

23 In relation to the development of goals, functional requirements and expected performances, one delegation noted that certain elements of the proposed text may blur the distinction between goals and functional requirements. It was suggested that further refinement might be required to ensure that these concepts were clearly delineated and consistently applied throughout the document.

24 Whilst there was general support for prescribing a minimum resolution for cameras and visualization screens, differing views were expressed regarding the specific resolution

should be adopted, namely HD (1280 × 720 pixels), FHD (1920 × 1080 pixels) or 4K (3840 × 2160 pixels). Taking into account performance, practicality and market availability, there appeared to be a slight preference for HD (1280 × 720 pixels) as the minimum resolution. However, it was acknowledged that this matter should require further discussion and consideration by the ESP Working Group, if reestablished, at this session.

25 It should be recognized that the 2011 ESP Code continues to follow a traditional approach, primarily relying on visual examination and conventional non-destructive testing techniques (e.g. ultrasonic thickness measurements or magnetic particle inspection for crack detection in suspect areas). The draft guidelines were developed on the premise that video livestreaming should be sufficient for the surveyor to conduct close-up surveys, identify defects and make informed decisions. Nevertheless, the rapid advancement of sensor technologies and machine learning now enables supplementary information to be provided to the surveyor, some in real time, others through post-processing. The Group expressed differing views on the integration of such technologies, and further discussion is recommended to determine how they may be appropriately incorporated within the context of ESP Code surveys. Examples of emerging technologies include:

- .1 laser scanning techniques, which enable the generation of three-dimensional models to facilitate the identification of deformation, buckling, or contact-related defects; and
- .2 AI-based image recognition, which can assist in the real-time identification and quantification of defects.

#### **Re-establishment of the Working Group on the Development of Guidelines on the Use of RIT for 2011 ESP Code Surveys**

26 As the Group was unable to finalize some of the work, and to conclude on some of the discussion points, as listed above, the Group was of the view that the Working Group on the Development of Guidelines on the Use of RIT for 2011 ESP Code Surveys should be re-established at this session under the following terms of reference, taking into account the draft guidelines included in annex 1 to the present document, its annexes 2 to 4, and any relevant submitted document to this session:

- .1 further develop, with a view to finalization, the draft guidelines on the use of RIT for 2011 ESP Code surveys;
- .2 further refine the goals and functional requirements for RIT systems;
- .3 further consider the need to restrict the on-site verification and testing method to a single standardized technique (e.g. use of Pre-Inspection Verification Card);
- .4 further consider the minimum RIT image resolution provision;
- .5 further consider the need to revise novel technologies based on the strategic principles set out by the Sub-Committee; and
- .6 submit a written report.

**Action requested of the Sub-Committee**

- 27 The Sub-Committee is invited to approve the report in general, and in particular to:
- .1 note the discussions of the Group and the progress made on the draft guidelines (paragraphs 5 to 25, and annex);
  - .2 note the discussion concerning the relationship between the mandatory requirements of the 2011 ESP Code and the draft guidelines, which are generally considered non-mandatory, and clarify the principles to be followed to avoid inconsistencies and unintended interpretations of mandatory provisions (paragraph 20);
  - .3 note the discussion on RIT image quality and resolution; and consider whether an invitation to the Administrations should be inserted in the associated MSC circular on sharing experience of the use of RIT related to image quality and resolution, for setting of a standard threshold in future (paragraph 21);
  - .4 decide on the need to address novel technologies and establish strategic principles for their integration (paragraph 25); and
  - .5 re-establish the Working Group on the Development of Guidelines on the Use of RIT for 2011 ESP Code Surveys to further develop the draft guidelines, with a view to finalization (paragraph 26).

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## ANNEX

### DRAFT GUIDELINES ON THE USE OF REMOTE INSPECTION TECHNIQUES (RIT) FOR ESP CODE SURVEYS

#### 1 INTRODUCTION

1.1 These guidelines intend to provide guidance on technical and operational aspects to be considered when using remote inspection techniques (RIT) as an alternative means of access to support the surveyors during the close-up survey and thickness measurement, in providing access to parts of the structure which may not be fully accessed by the permanent means of access, in accordance with the 2011 ESP Code, as amended. The guidelines include a sample form<sup>1</sup> for the RIT inspection plan (annex 1), a pre-inspection verification procedure and acceptance criteria (annex 2) and a sample form<sup>1</sup> for the RIT firm inspection report (annex 3). Additionally, annex 4 provides technical provisions, assessment and certification of RIT systems and associated digital technologies for detection and sizing of structural defects.<sup>2</sup>

1.2 The 2011 ESP Code (International Code on the Enhanced Programme of Inspections During Surveys of Bulk Carriers and Oil Tankers, 2011) defines close-up surveys (i.e. normally within hands reach) requirements for bulk carriers and oil tankers that require significant planning, preparation and execution. Means of access to enable close-up surveys are required by SOLAS regulation II-1/3-6. *Technical provisions for means of access for inspections* (permanent means of access) (resolution MSC.133(76), as amended) are the primary enabler for close-up surveys, but it is recognized that these will not give access to all the areas required to be inspected and gauged. Therefore, it is essential that all areas outside of reach of the "permanent means of access" (i.e. normally beyond hand's reach) are accessed by "alternative means" in combination with the "permanent means of access". The use of RIT systems may supplement or replace some of the traditional "alternative means of access", such as scaffolding or rafting, as long as the RIT system can provide information with the same level of assurance as conventional close-up visual inspection. Such equivalency is verified to the satisfaction of the Administration (as defined in the 2011 ESP Code), subjected to the applicable conditions and limitations as set out in the Code and these guidelines.

1.3 RIT may be categorized as "manned" or "unmanned": Manned techniques include rope access inspection techniques performed by rope climbers, or hand operated telescopic poles whilst unmanned techniques use unmanned robotic vehicles.<sup>3</sup>

1.4 Both, manned and unmanned techniques are largely supported by digital technologies in various aspects ranging from the control of motions and positioning up to the acquisition, collection and elaboration of survey information as well as the data presentation to the surveyor in various formats. Visual livestreaming of an image from a camera is the main element, but other technologies may be used to provide supplementary information.

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<sup>1</sup> These are suggested sample forms indicating the minimum content and the Administration may develop equivalent forms as deem necessary.

<sup>2</sup> A Remote Inspection Technique System is an integrated set of tools, technologies, and procedures intended to enable the survey of any parts of the ship's structure without the need for direct physical access by the attending surveyor. These systems typically employ the use of technologies such as cameras, drones, robotic vehicles, or sensor-equipped devices to collect visual and other types of data.

<sup>3</sup> Unmanned Robotic Vehicle (URV) refers to a subset of RIT system technologies that uses robotic systems without a human on board the remote vehicle. Common types of URV typically include Unmanned Aerial Vehicles (UAV), robotic crawlers and robotic arms.

1.5 The development of different digital technologies and combinations of multiple sensors may lead to different capabilities. It is therefore essential that the RIT capabilities and limitations are properly known and identified in the RIT firm approval, to:

- .1 validate the RIT efficiency;
- .2 confirm that RIT system provides information to the surveyor with the same level of assurance as the surveyor performing close-up survey; and
- .3 identify the situations that require a conventional close-up survey and/or thickness measurement techniques to be applied.

## **2 GENERAL REQUIREMENTS**

2.1 The remote inspection techniques (RIT) systems should provide information to the surveyor with the same level of assurance as the surveyor performing close-up survey, *i.e. normally within reach of hand*, in accordance with the 2011 ESP Code survey procedures and requirements.

2.2 Visual livestreaming technology should be used as the primary means of inspection. The visual livestreaming should have sufficient quality to provide the same level of assurance as conventional close-up visual inspection. *i.e. normally within reach of hand*. Whilst other technologies may be used to provide supplementary information, their use should not be considered as a replacement of visual livestreaming or a justification for a reduction in its quality.

2.3 The RIT system should be provided with a "RIT System Statement of Capability" issued by the Administration, detailing the equipment, capabilities, and limitations in accordance with annex 4 – Technical Provisions, Assessment and Certification of Remote Inspection Techniques (RIT) Systems and Associated Digital Technologies for Detection and Sizing of Structural Defects.

2.4 An inspection plan for the use of remote inspection techniques (RIT) should be submitted together with the 'Survey planning questionnaire' required by annex A and annex B of the 2011 ESP Code, as appropriate, for review and acceptance in advance of the survey to the Administration. The inspection plan should also form part of the ESP "Survey Programme" documentation. The inspection plan applies to both manned and unmanned techniques. The inspection plan should be prepared in accordance with "6. Planning and preparation", following the sample form provided in annex 1.

2.5 Items to be examined using a RIT should be sufficiently clean to permit meaningful examination. Visibility is to be sufficient to allow for a meaningful examination, complemented by illumination as required. These factors may vary in accordance with the RIT system, as such, the information available in the "RIT System Statement of Capability" should be considered.

2.6 Sufficient livestreaming recording is to be made to represent the structural condition of the ship, together with the recording of all identified defects. On completion of the inspection, the RIT firm should provide a report (RIT firm Inspection Report) including the firm details, approved service supplier certificate, equipment used, and operators supplemented by records of all livestreaming videos and images with a chapter detailing the areas covered and damages found, if any. The report should be prepared in accordance with "8 Reporting", following the sample form provided in annex 3.

### **3 CERTIFICATION OF FIRMS ENGAGED IN CLOSE-UP SURVEY OF HULL STRUCTURES USING RIT**

#### **3.1 Remote Inspection Techniques**

The use of RIT in close-up surveys should be carried out by a firm certified by the Administration, in accordance with the 'Procedures for Certification of Remote Inspection Techniques (RIT) firms' set out in the applicable annexes of the 2011 ESP Code.

#### **3.2 Thickness measurement using RIT**

To take thickness measurements using RIT, the firm should also be certified by the Administration, in accordance with the "Procedures for Approval and Certification of a firm Engaged in Thickness Measurement of Hull Structures" set out in the applicable annexes of the 2011 ESP Code.

### **4 TRAINING REQUIREMENTS**

#### **4.1 General knowledge requirements**

4.1.1 The training requirements should be reviewed by the Administration as part of the firm Certification, refer to 3. Certification of firms engaged in survey using RIT as an alternative means of access for close-up survey. RIT firm personnel should be certified in accordance with the procedures for certification of a firm engaged in close-up survey of hull structures using a remote inspection technique (RIT) as detailed in the 2011 ESP Code.

4.1.2 Personnel involved in remote inspection techniques (i.e. rope climbers, URV Operators, UT Technicians, etc.) should have appropriate knowledge of the following:

- .1 marine and/or offshore topologies and nomenclatures;
- .2 the structural configuration of relevant ships types, including internal structure;
- .3 the remote inspection equipment and its operation;
- .4 survey plans for examination of hull spaces of various configurations; including appropriate flight plans if using an Unmanned Aerial Vehicle (UAV) or path plans if using crawlers, legged robots or other RIT technologies;
- .5 health and safety requirements, including industry guidance to work on ship and potentially hazardous environment on tankers/bulk carriers and in enclosed spaces;
- .6 concurrent operations on board the ship; and
- .7 role and responsibilities of the master and officer in charge (OIC) during RIT operation [for smooth communication].

### **4.3 Additional training requirements for rope climbers**

Rope climbers should be trained in accordance with a national or international standard and certified by a recognized body (e.g. IRAT - Industrial Rope Access Trade Association, SPRAT - Society of Professional Rope Access Technicians).

### **4.4 Additional training requirements for URV Operators**

URV operators should be qualified and licensed in accordance with applicable national requirements or an equivalent industrial standard acceptable to the Administration (e.g. ISO 23665:2023). The firm is responsible to ensure their URV operators are duly licensed in accordance with the requirements of the local authorities (i.e. where the RIT survey will take place).

### **4.5 Additional training requirements for UT Operators**

In addition to the operator training requirements, personnel performing thickness measurement should be certified in accordance with a national or international NDT standard (e.g. EN 473 level II). This applies to both manned and unmanned techniques.

## **5 CONDITIONS AND LIMITATIONS ON THE USE OF RIT**

### **5.1 General**

5.1.1 In accordance with the 2011 ESP Code requirements, for ships up to and including the third renewal survey, consideration may (subjected to the requirements in 5.3 below) be given by the Administration to allow the use of remote inspection techniques (RIT) in achieving the objectives of a close-up survey. Additionally, for periodic surveys after the third renewal survey, the agreement and requirements of the Administration<sup>4</sup> to use a RIT to undertake close-up surveys is to be obtained prior to undertaking the survey.

5.1.2 Close-up surveys conducted by using RIT should be completed in any case to the satisfaction of the attending surveyor, in accordance with the 2011 ESP Code requirements and these guidelines. The 2011 ESP Code also requires that when RIT is used for a close-up survey, means of taking the corresponding thickness measurements as specified in this part should be provided unless such RIT is also able to carry out the required thickness measurements.

5.1.3 In addition to the conditions and limitation defined in the 2011 ESP Code, the below listed considerations should be taken into account when deciding on permitting the use of a RIT on a ship:

- .1 Structural condition of the ship;
- .2 Survey history of the ship;
- .3 PSC/FSC history of the ship; and
- .4 Record of owner/company.

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<sup>4</sup> In the context of this paragraph, Administration means the Government of the State whose flag the ship is entitled to fly and not the recognized organization.

## **5.2 Limitations related to previous findings and condition**

5.2.1 Use of remote inspection techniques (RIT) should be restricted or limited where there is a record of abnormal deterioration or damage to structure to be inspected. Remote inspection techniques should not be used in the following cases:

- .1 for close-up survey and thickness measurement of areas where substantial corrosion was previously identified (e.g. during previous renewal or intermediate surveys);
- .2 for close-up survey of ballast tanks or any spaces where a hard protective coating is required and where the coating was previously graded as less than good (i.e fair or poor), or ballast tanks where a soft or semi-hard coating has been applied, or where a hard protective coating has not been applied from the time of construction;
- .3 for areas already identified for repairing (e.g. are subjected to a condition of class); and
- .4 in areas which have a recorded significant history of structural failures defects, damage or deterioration (corrosion, cracks and buckling), as defined in the 2011 ESP Code.

## **6 PLANNING AND PREPARATION**

### **6.1 Risk assessment**

A risk assessment should be carried out by the approved RIT firm at planning phase to identify hazards and ensure appropriate risk controls are in place and included in the ESP programme and verified during the survey planning meeting. The risk assessment should include as a minimum:

- .1 RIT system minor failure (e.g. URV emergency landing/deployment);
- .2 RIT catastrophic failure (e.g. URV crashing and falling);
- .3 battery depletion;
- .4 loss of communication and signal interference issues;
- .5 RIT and ship damages due to collisions;
- .6 risks related to tethered and untethered systems;
- .7 interference with other works occurring simultaneously in the space or vicinity;
- .8 operator(s) and surveyors (s) location during inspection;
- .9 operation next to hazardous areas;
- .10 involvement of relevant stakeholders (owners/crew/surveyor) in risk assessment process to identify hazards; and

- .11 take into consideration the ship's specific structural arrangements and locations to use the RIT.

## **6.2 RIT inspection plan**

The RIT inspection plan (refer to the sample form in annex 1), should be submitted together with the "Survey planning questionnaire" and the RIT System Statement of Capability, for review and acceptance in advance of the survey, and is to include:

- .1 type of survey;
- .2 asset type, operational details, and other asset general information;
- .3 location and the anticipated time frame for the survey and the operational status of the asset (e.g., shipyard, repair facility or lay-by berth, etc.);
- .4 ship and associated spaces preparation including gas freeing prior to inspection, if applicable;
- .5 logistics details, including permissions from local authorities, site permissions and work permits, as applicable;
- .6 proposed RIT firm, including approval details;
- .7 details of RIT equipment, recording facilities and associated "RIT System Statement of Capability";
- .8 details of RIT supporting equipment, including battery characteristics (operational time) and spare battery details;
- .9 proposed structural locations where the RIT will be used, with details of possible hot spots;
- .10 arrangements for the attending surveyor to perform confirmatory inspections by conventional means (e.g. safe access cleaning/descaling, illumination, ventilation, etc.);
- .11 risk assessment (see above) analysis, including safeguards to mitigate risk;
- .12 procedure and criteria to validate the use of RIT for specific structure and conditions (light, humidity, cleanliness) at the start of inspection;
- .13 details on how to report identified deficiencies; and
- .14 methods for thickness measuring (simultaneously with RIT). Additionally, when a RIT is able to take thickness measurements, supplementary details are also to be submitted, including TM firm approval, TM equipment, measuring capabilities (e.g. direction limitations) and operator(s) details/qualifications as per ESP Code requirements.

## **6.3 Survey planning meeting**

6.3.1 Prior to commencement of any part of the renewal or intermediate survey, a survey planning meeting should be held between the attending surveyor(s), the owner's

representative in attendance, the master of the ship, the thickness measurement firm representative, the RIT firm representative, where involved, and the master of the ship or an appropriately qualified representative appointed by the master or company; for the purpose to ascertain that all the arrangements envisaged in the survey programme are in place, so as to ensure the safe and efficient conduct of the survey work to be carried out, taking fully into account each ship's unique safety management system.

6.3.2 The inspection plan (included as part of the approved survey programme) together with the "RIT Statement of Capability" should be reviewed during the survey planning meeting, to:

- .1 confirm the RIT system is suitable for the intended works, including certification to operate in hazardous areas (e.g. ATEX, IECEx), if the spaces are not in gas-free condition;
- .2 confirm the equipment on hand matches the "RIT Statement of Capability";
- .3 review RIT system access limitations and determined alternatives (e.g. provision of access means to perform conventional close-up survey); and
- .4 review RIT system capabilities related to defect quantification/measuring and determine whether further arrangements may be required (e.g. provision of access means to detect/identify/quantify/measure/NDT defects).

## **6.4 Pre-inspection verification**

6.4.1 Prior to every survey on board the RIT system should be verified and tested on-site to validate that under the existing conditions (i.e. light, humidity, structure cleanliness, etc.) the system can perform to the required standard and provide information to same level of assurance as the close-up visual inspection. These verifications and tests should be witnessed by the attending surveyors.

6.4.2 This verification may be carried out using a physical (printed) version of the "RIT Pre-Inspection Verification Card" available in annex 2 or by other appropriate means, as per the RIT firm procedures (assessed for suitability during RIT firm).

6.4.3 If the RIT system is capable of undertaking cleaning/surface preparation, these should also be verified and test on-site before being applied.

6.4.4 If the RIT is able to take thickness measurements, this capability should also be demonstrated on-site to the surveyor, including the calibration of the gauging device(s).

## **7 CONDUCT OF SURVEYS**

### **7.1 General**

7.1.1 When RIT systems are used to support the surveyor during close-up surveys, the attending surveyors should be present, witness the inspection and assess the RIT inspection and results. If the surveyor determines that goals and functional requirements for use of a RIT system (as defined in annex 4) are not being achieved in a manner that substantially conforms with these guidelines the survey should be suspended immediately until or unless the goals can be achieved. The surveyor should be guided by the overarching goal as defined in annex 4.

7.1.2 Random confirmatory surveys/close-up surveys should be carried out at locations selected by the surveyor for the purpose at selected locations to verify the results of the RIT.

7.1.3 The 2011 ESP Code requires that if the RIT reveals damage or deterioration that the surveyor judges require attention or further investigation, the surveyor should require traditional survey to be undertaken without the use of a RIT. These should be the methods proposed by the owner in the survey programme and agreed before the surveys.

7.1.4 If the RIT reveals that the coating condition is less than GOOD condition as defined in 2011 ESP Code, the surveyor should require traditional survey to be undertaken without the use of a RIT. These should be the methods proposed by the owner in the survey programme and agreed before the surveys.

7.1.5 The damage or deterioration identified and surveyors' judgement must be detailed in the RIT report together with records of all livestreaming videos and images.

## **7.2 Data capture and recording**

7.2.1 Video capturing requirements should be agreed with the surveyor prior to commencing of the survey. As a minimum, representative video recordings should be made to:

- .1 demonstrate the video quality of the RIT;
- .2 demonstrate the general condition of the structure; and
- .3 record all defects found using the RIT.

7.2.2 When recording, the ship, location onboard and items being looked at should be identified. These can be done by audio, visual or 3 D point cloud means, as well as by markers/labelling suitably placed onto the surfaces of the structures.

7.2.3 The Pre-Inspection Verification process and random confirmatory close-up surveys should be included in the records of the livestreaming video with a clear identification as detailed above.

7.2.4 The above guidelines may also be applied to data obtained with other technologies that were used to provide supplementary information, as detailed in 1.4 above.

## **7.3 Dealing with findings and deficiencies**

7.3.1 Any damage or deterioration identified should be assessed by the surveyor and if judged to require attention or further investigation, the surveyor should require traditional survey to be undertaken without the use of a RIT.

7.3.2 Any damages or deterioration should be assessed by the surveyor taking in consideration the requirements set in the ESP Code and by the Administration.

## **8 REPORTING**

### **8.1 General**

8.1.1 The 2011 ESP Code requirements and survey reporting principals should be complied with. When thickness measurements are taken by remote inspection techniques, the

results should be reported in accordance with the Code's requirements and appropriate ESP thickness measurements (TM) Forms.

8.1.2 After completion of the survey, the RIT firm should provide a comprehensive RIT firm inspection report complemented by any relevant video recordings, as agreed with the surveyor, in accordance with the sample form in annex 3.

8.1.3 The report should include also all supplementary data obtained with other technologies that were used to provide supplementary information, as detailed in 1.4 above.

## **8.2 RIT firm Inspection Report**

8.2.1 The firm report should include at least the following:

- .1 copy of the firm certificate of approval;
- .2 copy of the "RIT System Statement of Capability";
- .3 general survey details, (e.g. survey scope I, survey dates, etc);
- .4 details of the equipment used, (e.g. cameras, drone maker, type, S/N, etc);
- .5 details of the spaces and areas examined;
- .6 general condition results;
- .7 method used for thickness measurements (if applicable);
- .8 details of findings and defects, including categorization and size;
- .9 any limitations on scope of survey or deviation required from inspection plan;
- .10 any spaces or areas unable to be accessed/examine and reasoning;
- .11 index of the video recordings or any other digital data recorded;
- .12 records of all livestreaming videos and images used by the surveyor to assess the areas and structure subject to close-up survey with the RIT system; and
- .13 records of all supplementary data obtained with other technologies.

Annex 1

**SAMPLE FORM**

**RIT INSPECTION PLAN**

This RIT Inspection Plan is prepared in accordance with section 6.2 of the Guidelines for the RIT for ESP Surveys. It outlines the necessary details for planning and executing a Remote Inspection Technique (RIT) survey.

**1. Basic information and particulars**

Ship's name:
IMO number:
Flag State:
Port of registry:
Gross tonnage:
Deadweight (metric tonnes):
Length between perpendiculars (m):
Recognized organization (RO):
RO ship identity:
Date of build of the ship:
Owner:
Thickness measurement firm:

**2. RIT firm and personnel details**

Name of the RIT firm:
RIT firm base location (country):
RIT firm approval certificate No.:
RIT firm approval certificate expiry date:
TM approval certificate (when applicable <sup>1</sup> ):
TM approval expiry date (when applicable <sup>1</sup> ):
Supervisor details (name and relevant qualifications):
Operator(s) details (name and relevant qualifications):

Note 1. Applicable when the TM firm is also approved as a thickness measurement firm.

**3. Survey details**

Type of survey: <i>e.g. renewal survey no.1, intermediate survey no.3</i>
Survey location:
Operational status: <i>e.g. in drydock ABC, alongside in ABC port, anchorage in ABC</i>
Survey time frame:
Additional information and logistics (when applicable): <i>e.g. Include permissions from local authorities, site permissions, and work permits</i>
Ship and Space Preparation <i>e.g. Describe ship and associated space preparation including gas freeing, if applicable.</i>

**4. RIT equipment details**

RIT equipment details: <i>e.g. maker and type</i>
RIT System Statement of Capability details: <i>e.g. Issued by, document no, issuing date</i>
Powering supply arrangements: <i>e.g. tethered system, batteries</i>

Battery details (when applicable): e.g. *battery characteristics, operational time, no of back-up batteries*

Tethered system details (when applicable): e.g. *external power supply requirements.*

Livestreaming viewing screen details: e.g. *maker, type, diagonal size and resolution*

Recording facilities details: e.g. *recording means, video resolution, storage capacity*

#### **5. Areas subjected to close-up survey where it is proposed to use RIT, with details of possible hot spots**

e.g. *deck transverse web frame in cargo tanks.*

e.g. *Corrugated transverse bulkheads in cargo tanks, except lower stool external structure.*

#### **6. Thickness measurement**

Is the RIT system validated to take thickness measurements? e.g. YES/NO  
(refer to the RIT System Statement of Capability)

(If YES, the following sections are also to be completed)

TM description and capabilities:

e.g. *URV fitted with UT probe able to measure through coated structures.*  
e.g. *Able to take thickness measurements in horizontal and upward orientations.*

TM limitations:

e.g. *not able to take thickness measurements in where there's coating breakdown.*  
e.g. *not able to take thickness measurements in downward and inclined directions.*

#### **7. Pre-survey verification procedures**

e.g. *Outline procedure and criteria to validate RIT use for specific structures and conditions.*  
e.g. *Use of the RIT Pre-Inspection Verification card, or alternative method (if alternative method, attachment to be added to plan).*

#### **8. Additional arrangements for confirmatory surveys**

e.g. *Safe access cleaning/descaling, illumination, ventilation, etc.*

#### **9. Reporting**

e.g. *A written report in accordance with the Guidelines for the RIT for ESP Surveys, annex 3 sample form will be delivered by the RIT firm within 14 days of completion.*

*All videos and photographs will be labelled in accordance with the written report.*

*All videos and photographs will be shared for downloading with the Administration (or recognized organization) via cloud system.*

*The report will be supplemented by a copy of the firm approval certificate, RIT inspection plan and a RIT System Statement of Capability.*

### 10. Risk assessment summary

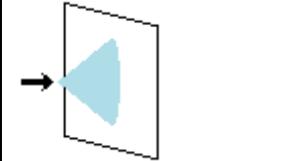
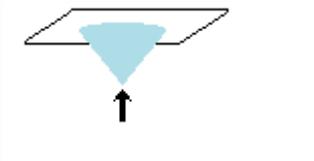
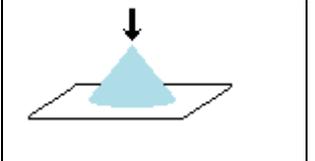
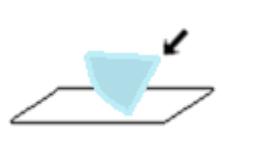
*The below tables provide an example of a risk assessment methodology (other methodologies may apply). The Risk Assessment should be in accordance with the RIT firm procedures.*

No.	Scenarios	Causes	Consequences	Risk			Mitigation measurements
				L	S	R	
1							

Annex 2

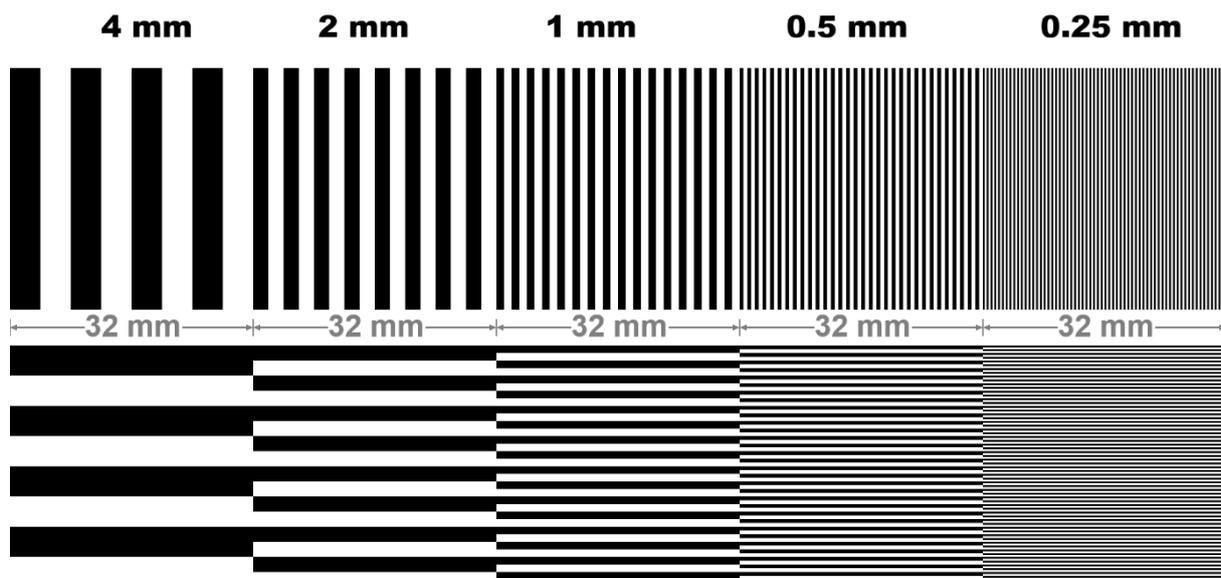
**RIT PRE-INSPECTION VERIFICATION CARD**

The following two pages should be colour printed in an A4 size paper using a recommended minimum resolution of 600 dpi and placed in a flat structural element in position 1. Confirm equipment is pre-calibrated, and communication tests are carried out prior to the verification, as applicable. The verification should be repeated in positions 2, 3 and 4 when the areas to be inspected require so. The capturing equipment should be deployed (e.g. UAV should be flying) and below validation tests (resolution, detail, contrast and colour) should be carried out.

Position 1 Front view	Position 2 Bottom view	Position 3 Overhead view	Position 4 Angle view
			

**Resolution verification**

All vertical and horizontal stripes should be visible within the five thickness grades:



**Detail verification**

The following pangrams should be legible down to a size of 1.8 mm:

4.9 mm	"Jinxed wizards pluck ivy from the big quilt."
4.2 mm	"The five boxing wizards jump quickly."
3.9 mm	"Bright vixens jump; dozy fowl quack."
3.5 mm	"The quick onyx goblin jumps over the lazy dwarf."
3.2 mm	"Amazingly few discotheques provide jukeboxes."
2.8 mm	"Crazy Fredrick bought many very exquisite opal jewels."
2.5 mm	"Jovial zookeeper quickly brightens the fun with mixed quizzical antics."
1.8 mm	"Jack quickly vexed the dwarf with his amazing gymnastic skills."

**Contrast verification:**

All 25 numbers in the rectangles should be readable:

67	940	55	844	124
418	130	311	724	175
659	36	634	71	829
266	423	647	80	446
584	690	281	30	366

**Colour verification:**

Each colour spectrum should be discernible:

Red	Yellow	Green	Cyan	Blue	Magenta

Red	Red brown	Dark brown	Light brown	Brown orange	Orange yellow

Annex 3

**SAMPLE FORM**

**RIT FIRM INSPECTION REPORT**

**Ship details:**

Name: .....  
IMO number: .....  
Recognized organization (RO)/Administration identity number: .....  
Port of registry: .....  
Ship type: .....  
Gross tonnage: .....  
Deadweight: .....  
Date of build: .....  
Recognized organization (RO): .....

**RIT firm details<sup>1</sup>:**

Name: .....  
Approval certificate no.: .....  
Approval Certificate valid from: ..... to .....

***Note 1** A copy of the RIT firm certificate of approval to be submitted together with the report.*

**Survey details:**

Survey: .....  
Place of Survey: .....  
Survey dates from: ..... to .....

**RIT system details<sup>2</sup>:**

RIT method: *e.g. URV (drone), rope access, etc*.....  
URV maker, type and serial number (if applicable): .....  
Camera maker, type and serial number: .....  
Screen maker, type and serial number: .....

***Note 2** A copy of the RIT system statement of capability to be submitted together with the report.*

**Thickness measurement<sup>3</sup>:**

Method used for thickness measurement: .....

***Note 3** Thickness measurement report to be submitted in accordance with the ESP Code report.*

Report number: ..... consisting of ..... pages  
Name of operator: ..... Name of surveyor: .....  
Signature of operator: ..... Signature of surveyor: .....  
Firm official stamp: ..... Administration: .....

### **Spaces and areas subjected to close-up survey using RIT**

e.g.  
COT No3P:  
- deck transverse web frame, frame no. 71.  
- corrugated transverse bulkheads no 68 and 75.  
...

### **Spaces and areas subjected to thickness measurement using RIT (when applicable)**

e.g.  
COT No3P:  
- deck transverse web frame, frame no. 71.  
- corrugated transverse bulkheads no 68 and 75.  
...

### **RIT survey limitations on scope of survey or deviations from inspection plan**

e.g. *Limitations on Scope of Survey*  
e.g. *Deviations from Inspection Plan*  
e.g. *Spaces or Areas Unable to be Accessed/Examined and Reasoning*

### **Report general condition**

e.g.  
COT No3P:

### **Findings and Defects**

e.g.  
COT No3S:

### **Pre-inspection verification details**

e.g. Prior to commencing of the survey, the pre-inspection verification was carried out in accordance with <RIT firm procedure reference> using the IMO RIT Pre-Inspection Verification Card.

### **Index of video recording and images**

All video and images listed below are included in <storage media name> which is part of this report.

e.g.  
COT No1P:

### **Index of supplementary data obtained with other technologies**

...

### **Index of other documents**

e.g. *RIT firm certificate of approval, 'RIT System Statement of Capability', etc.*

Annex 4

**TECHNICAL PROVISIONS, ASSESSMENT AND CERTIFICATION OF REMOTE INSPECTION TECHNIQUES (RIT) SYSTEMS AND ASSOCIATED DIGITAL TECHNOLOGIES FOR DETECTION AND SIZING OF STRUCTURAL DEFECTS**

**1 General**

1.1 Remote Inspection Techniques (RIT) systems may be based on different technologies, typically either manually operated (e.g. rope access climbers, telescopic cameras and generally referred as manned techniques) or using Unmanned Robotic Vehicles (URV).

1.2 Different technologies will result in different capabilities (e.g. accessibility, navigation, stabilization, image, thickness measurements, etc). Additionally, the continuous innovation and development of new technologies requires assessment flexibility, therefore this document uses a goal-based standard approach. As such, new RIT systems are to be assessed by the Administration (as defined in the 2011 ESP Code) to validate its design and performance against the goals and functional requirements set out in section 2.

1.3 The assessment should include a review of documentation including the intended use, equipment data, types of sensors, automation and conditions, followed by performance testing to the satisfaction of the Administration. A final onboard test should also be carried out before the issuing of the permanent documentation. The assessment should confirm that the RIT system can provide information with at least the same level of assurance as the close-up visual inspection. i.e. normally within the reach of hand (as defined in the 2011 ESP Code).

1.4 On satisfactory completion of the assessment, the Administration should issue a "RIT System Statement of Capability" (in accordance with the appendix 1 sample form), which should include, as a minimum:

- .1 RIT system basic details (type of equipment, equipment's maker, type, version no., etc);
- .2 types of structure subject to close-up for which the RIT system has been designed to perform (e.g. cargo holds, cargo tanks or ballast tanks);
- .3 data capture/collection associated with the sensors, including thickness measurement capability, if provided;
- .4 data review/analytics methods associated with the RIT system;
- .5 illumination conditions (e.g. external light requirements);
- .6 condition of structure/space;
- .7 defect type detection/identification capability, if provided;
- .8 defect type quantification/sizing capability, if provided;
- .9 automation capabilities relating to navigation, data collection and analysis as further specified in the following;
- .10 equipment to visualize and record the livestreaming video and still image;

- .11 certification for electrical equipment capable of operating in hazardous areas (explosive gas atmospheres or in the presence of combustible dusts), if provided; and
- .12 power supply concept (e.g. battery capacity and expected lifetime, details of tethered systems).

1.5 The *"RIT System Statement of Capability"* is only valid for the assessed design type.

1.6 Any change in the design and capability of the RIT system, which impacts on the performance criteria against which has been tested, invalidates the *"RIT System Statement of Capability"* and retesting may be required. The URV manufacturer or a RIT firm are to notify the Administration whenever changes are made and the RIT system subjected to reassessment whenever the goals and functional requirements are affected.

## **2 Goals and functional requirements**

The overarching goal of any RIT system is to provide information with the same level of assurance as conventional close-up visual inspection ensure that the inspection results are at least equivalent to those obtained by a surveyor conducting a close-up survey, i.e. normally within reach of hand, in accordance with the 2011 ESP Code.

The RIT system should be designed and tested to meet goals related to its:

- .1 fitness for purpose (2.1);
- .2 safety (2.2);
- .3 efficiency (2.3);
- .4 data accuracy and integrity (2.4);
- .5 data retention (2.5); and
- .6 thickness measurements (when applicable) (2.6).

Each goal is supplemented by functional requirements to detail the capabilities and requirements that the RIT system needs to comply with to achieve the applicable goals and which should be taken into account when issuing a RIT System Statement of Capability to a system manufacturer or RIT firm.

Evaluation criterion of each goal and functional requirement is based on the capability of the RIT system to provide information with the same level of assurance as conventional close-up visual inspection to ensure that the inspection results are equivalent to those obtained by a surveyor conducting a conventional survey as above-mentioned. Assessment and validation of the capabilities may be obtained by testing protocols comparing the inspection outcomes quantitatively, i.e. on the basis of appropriate parameters and measurements.

### **2.1 Fitness for Purpose**

#### **Goal**

RIT systems should provide accurate, reliable and consistent performance under the various environmental conditions and in the relevant space/structures for which they are designed for.

## Functional requirements

2.1.1 The equipment forming part of the RIT system should be able to provide the inspection data in the environment and conditions intended for its use, which should be specified in full detail (i.e. ship type, structure and its location, etc.). Transfer of data between the several components of the RIT system (e.g. between vehicle camera and viewing screen) should not be affected by the ship's surrounding structure, equipment of systems.

2.1.2 Any equipment forming part of the RIT system should not interfere with the operation of equipment on board.

2.1.3 For RIT systems using unmanned robotic vehicles, the URV should possess sufficient manoeuvrability to navigate complex environments and perform inspection tasks.

EP.1 The design should ensure smooth and controlled movements, allowing the URV to access hard-to-reach areas and operate effectively in confined, narrow and/or geometrically complex spaces.

EP.2 Manoeuvrability should be maintained under various operational conditions to ensure consistent performance within different structural arrangements.

EP.3 The URV should have sufficient manoeuvring characteristics to permit inspections on structures with stiffening elements, including collision braking and fall avoidance functions.

EP.4 The URV should have stabilization and hovering capabilities to provide a stable and clear livestreaming video and still image.

EP.5 URV should locate itself onboard accurately determining its position, thus enabling proper data acquisition.

2.1.4 The RIT system should be capable of accessing and examining all the structural areas within a space for which the RIT system is designed for that would otherwise require the provision of temporary or alternative access means for close-up survey. This includes the ability to inspect plating and stiffening elements from all required sides and orientations (e.g. frontal, overhead, lateral) via livestreaming of video and images.

EP.1 Any inaccessible areas should be explicitly listed in the RIT System Statement of Capability issued by the Administration (e.g. unable to pass through manholes below 800 x 600 mm in size, unable to operate in spaces with less than 2 m width, unable to overcome stiffeners greater than [x] mm in height, unable to acquire data under faceplates of stiffening members if spaced less than [x] mm apart, etc).

2.1.5 The RIT system shall be able to provide stable and clear video livestreaming and still image of the hull structure area being inspected.

EP.1 Equipment stabilization should be sufficient to address the environmental and working conditions, as well as any disturbances, such as air drafts, humidity, vibrations, etc.

EP.2 The RIT system should be equipped with tools for sensor cleaning sufficient to address the environmental and working conditions, such as wiping fogged lenses, etc.

## **2.2 Safety**

### **Goal**

The design and operation of the RIT system should ensure the safety of all personnel involved in or affected by its use, including operators, surveyors, seafarers and any personnel on board and prevent any damage to ships and equipment.

### **Functional requirements**

2.2.1 RIT systems should be provided with protection to safeguard persons, ship's structure, equipment, piping, coatings and the RIT system itself. For URV systems, the vehicle movement (e.g. flying, rolling or crawling) and any securing features (e.g. magnetic gripping, harness) should not damage ship structure, piping, equipment and coating.

- EP.1 High speed rotating parts (e.g. UAV propellers) should be provided with cages or protections to avoid direct contact with structure or people.
- EP.2 UAV design should consider collision avoidance, which may include automatic collision prevention or any other measures to mitigate collision risks.
- EP.3 For RIT systems using unmanned robotic vehicles, the URV is to be equipped with visual indicators to displaying equipment status (e.g. battery status, signal).
- EP.4 Any part of the RIT system which generates heat and may become hot (e.g. engines, batteries, spotlights) should be marked, insulated or protected.

2.2.2 For RIT systems using unmanned robotic vehicles, the URV should have sufficient redundancy to avoid any incident.

2.2.3 For RIT systems using unmanned robotic vehicles, power and communications failure (including low battery) should be mitigated by appropriate technical measures. This may include emergency landing capabilities, fall arrestors or safe return systems and/or any other technical solution.

2.2.4 Tethered RIT systems cables (i.e. for power supply and communications purposes) should comply with applicable national or international standards. Cable construction should be such as to avoid snag itself in structural elements or fittings.

## **2.3 Efficiency**

### **Goal**

The design and operation of the RIT system should ensure operational efficiency under all specified conditions.

### **Functional requirements**

2.3.1 The RIT system should be provided with sufficient power during inspection activities:

- EP.1 For battery powered RIT systems, including battery powered elements (e.g. URV, screens, remote controllers), measures should be taken to ensure a smooth survey process. This includes but are not limited to:
- .1 An individual power management plan should be provided for each inspection activity, including planned time duration, number of required batteries, individual battery capacity, recharging means and segregation of charged batteries from depleted batteries, position of charging facility during inspection, etc.
  - .2 A sufficient number of batteries and charging facilities should be provided in order to ensure the total charging ratio higher than the consumption ratio. Whilst interruptions for battery replacement are expected, the objective should be to ensure continuous operation as far as possible, and that any inspection is not prematurely interrupted due to lack of power.
- EP.2 For wireless equipment, the battery status should be available to the operator at any time.
- EP.3 For non-electrical RIT systems, power source should be managed to last the planned time duration and replacements available following the same principles of electrical RIT systems as far as practicable.
- EP.4 Tethered RIT systems should ensure power transmission in any planned situation, including in geometrically complex areas as well as in case of long or sharp bended cables.

2.3.2 For RIT systems using URV, these should be able to adjust speed in accordance with the space under survey and the task being performed (e.g. commuting, moving and inspecting, steady on a specific area, also in case of disturbances).

## **2.4 Data accuracy and integrity**

### **Goal**

The design and operation of the RIT system should ensure at least the same level of accuracy and integrity as those a survey is able to achieve when using direct access close-up surveys (without use of RIT).

### **Functional requirements**

2.4.1 Adequate procedures should be in place to ensure the reliability and usability of the information gathered during inspections, including calibration, pre-inspection verification and adaptability of its sensors.

- EP.1 RIT system sensors should be capable of being calibrated or verified prior to any survey, to confirm their satisfactory performance and data accuracy under real conditions.
- EP.2 RIT system sensors should be capable of adjusting to conditions during survey, by either self-adjusting or remote adjusting by operator (URV based systems).

2.4.2 The RIT system should collect and process data with accuracy and integrity. As a minimum, the equipment should be able to provide livestreaming video that is consider equivalent to manned close-up sighting by a surveyor during ESP surveys.

- EP.1 Video cameras should make the livestreaming video and image with a minimum HD resolution (1280 x 720 pixels).
- EP.2 The visualization monitors/screens should have a minimum HD resolution (1280 x 720 pixels) and 12 inches of minimum diagonal size.
- EP.3 The RIT system should be able to video livestreaming of localized details of the structure inspected (e.g. by zooming function, by being able to stand close to the structure or both).

2.4.3 RIT system video cameras should be able to adjust to low lighting environments and sufficiently protected from expected vibrations.

- EP.1 Cameras should be provided with image stabilization (either optical, digital, sensor-shift, mechanical or other means).

2.4.4 The RIT system livestreamed video and still image should be clear and free of distortion. The colours should report a meaningful representation of the structural details.

2.4.5 The RIT system should be able take high-resolution still images simultaneously with the video livestreaming.

2.4.6 The use of other sensors should not replace the mandatory visual livestreaming capability and should not affect its performance.

2.4.7 The RIT system should be capable of being used to detect/identify the specified defects in the steel structure of ships, including:

- .1 cracking (fractures);
- .2 deformation (contact damages, dents or buckling);
- .3 corrosion (including general wastage, edge wastage, grooving and pitting);  
and
- .4 coating breakdown.

2.4.8 For the specified structural and lighting conditions the RIT system should be capable of being used to assess coating condition in accordance with the 2011 ESP Code.

2.4.9 The surveyor should be able to roughly assess the size of a defect by visual means (e.g. visual comparison with the stiffener spacing or dimensions). When specified that the RIT system is capable of being used to quantify/measure identified defects (e.g. crack length, dent depth, corrosion area width and height), the measurements capabilities and accuracy should be assessed and recorded in the 'RIT System Statement of Capability'.

## **2.5 Data Retention**

### **Goal**

The design and operation of the RIT system should ensure sufficient and comprehensive evidence retention of data.

### **Functional requirements**

2.5.1 The RIT system should be provided with video recording capability and sufficient storage capacity to retain video livestreaming, still images and any other data of the inspected areas, as detailed in the guidelines.

EP.1 Recording and capturing functions should be controlled in real time by the operator (i.e. the operator should be able to start/stop recording or take a still image from the local controls).

EP.2 The enabling or disabling of recording should not affect the video livestreaming performance.

2.5.2 All recorded evidence should be tamper-proof and easily retrievable for sharing, review and analysis. Mechanisms should be in place to ensure the integrity and authenticity of the recorded data.

EP.1 The recordings should be exportable using conventional video formats (e.g. mp4) that may be reviewed later.

EP.2 The recording metadata type (e.g. date, time, geolocation, etc.) as well as the video quality features should be listed in the 'RIT System Statement of Capability'.

2.5.3 Any other data collected in addition to videos and still images should be listed in the "RIT System Statement of Capability" along with their accuracy and acquisition specifications.

EP.1 The data should include sampling frequency, geolocation, synchronization with video, etc.

2.5.4 Data transmission, elaboration and presentation should be efficient and sufficiently accurate for ESP structural assessment, satisfactory fulfilling survey scope and information needs, duly considering the survey time frame and their usage in practice either on board or remotely.

## **2.6 Thickness measurements**

### **Goal**

When a RIT system is intended to be used to take thickness measurements, its design and operation should ensure the same accuracy, integrity, and efficiency as conventional manual thickness measurement techniques.

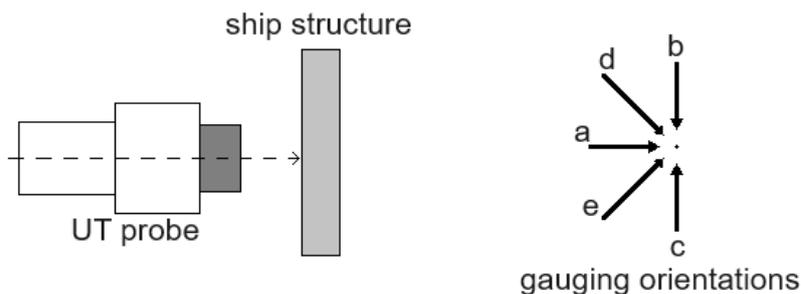
### **Functional requirements**

2.6.1 The URV should be able to maintain a steady position against the structural element whilst the equipment is taking a thickness reading.

2.6.2. The equipment should be able to take measurements in different orientations.

EP.1 The measuring orientations and the means to adjust them (e.g. remotely controlled by the operator, manual adjustment before URV deployment) should be defined and listed in the 'RIT System Statement of Capability'. The applicable measuring orientations may be defined and specified at least as it follows:

- .a horizontal (e.g. TM gauging of e.g. bulkheads, deck transverse web, web frames and similar plating);
- .b downward (e.g. TM gauging of e.g. stringers, horizontal stiffeners and similar plating);
- .c upward (e.g. TM gauging of e.g. deck plating, deck transverse face plate and similar plating);
- .d inclined Downward (e.g. TM gauging of e.g. hopper plating); and
- .e inclined Upward (e.g. TM gauging of e.g. topside tank plating).



2.6.3 The equipment should be able to take readings through coating on coated surfaces.

EP.1 The technique applied to enable thickness measuring on coated surfaces should be listed in the "RIT System Statement of Capability" (e.g. UT probes using pulsed echo technique).

EP.2 Additionally, when the equipment is able to take measurements on corroded surfaces, this is to be verified by testing on samples different levels of corrosion (e.g. light surface rust, moderate corrosion, heavy corrosion, severe corrosion). The technique applied to enable thickness measuring on corroded surfaces should be listed in the "RIT System Statement of Capability" (e.g. surface cleaning tool).

2.6.4 The equipment should be able to operate continuously, allowing a reasonable number of measurements to be taken before retrieval of the URV.

EP.1 The applicable details of how the system operates continuously (e.g. power source, built-in supply of coupling gel) should be listed in the "RIT system Statement of Capability".

2.6.5 The gauging results should be streamed in real time to the operator.

2.6.6 The operator should be able to clearly distinguish consecutive measurement results.

2.6.7 The equipment should provide accurate measurements. Means to assess gauging accuracy and calibration should be available during surveys. Thickness measurement calibration should be carried out before work commencing, and accuracy of measurements should be demonstrated to surveyor's satisfaction.

EP.1 The thickness measurement readings should have a minimum accuracy of 0.1 mm.

2.6.8 When the RIT system is provided with georeferenced data capture capability (i.e. ability to associate each thickness measurement reading to particular location of the space), the recording and labelling method should be assessed. The data should be presented in a way that supports the preparation of the thickness measurement report.

### **3 Information to be submitted**

#### **3.1 All RIT systems**

When applying for the assessment of RIT systems (manned or URV based), at least the following information should be submitted:

3.1.1 Information on the cameras and display screens provided to enable video livestreaming and still images:

- .1 manufacturer details and type designation;
- .2 resolution (video and still images, if different);
- .3 for display screens, size (e.g. 12 in);
- .4 for video cameras, frame rate (e.g. 30 fps, 60fps);
- .5 camera sensor type (e.g. CMOS, CCD);
- .6 camera lens type (e.g. fixed, interchangeable);
- .7 camera lens focal length and aperture (e.g. fixed, interchangeable);
- .8 zoom capabilities (e.g. 10x optical, 10x digital);
- .9 image stabilization characteristics (e.g. optical, digital, sensor-shift, mechanical); and
- .10 other image quality enhancements (e.g. HDR, low-light performance).

3.1.2 Information on the additional data collection sensors and their technical features, examples being:

- .1 infrared/Thermal camera;
- .2 stereoscopic (3D) camera;
- .3 RGB-D camera;

- .4 laser scanning; and
- .5 TM probe.

3.1.3 Information on the lighting conditions, illumination minimum requirements and other environmental limitations for the intended inspection use(s), which may be:

- .1 daylight, e.g. external or in a cargo hold with hatch covers open;
- .2 lit by artificial light separate to the RIT system;
- .3 using only RIT system mounted lighting;
- .4 moisture, humidity level, sprinkling; and
- .5 dust and other contaminants level.

3.1.4 Information on the data retention details, including:

- .1 recording support system (e.g. SD Card, in-built drive, external recorder);
- .2 video recording format (e.g. mp4, avi, mkv, mov, wmv);
- .3 steady image format (e.g. png, jpeg, tiff); and
- .4 file metadata details (e.g. date, time, geolocation).

## **3.2 URV based systems**

Additionally, when applying for the assessment of RIT systems based on URV technology, the following information should be submitted:

3.2.1 Information on:

- .1 URV manufacturer details and URV type designation;
- .2 URV description and basic drawings;
- .3 communication details (wired, wireless and applicable frequency bands);
- .4 data elaboration and presentation details (e.g. algorithms, data management, visualization, etc.); and
- .5 copies of any other certificates the URV may have.

3.2.2 Information on intended use:

- .1 types of structure subject to close-up for which the URV has been designed to perform (e.g. cargo holds, cargo tanks or ballast tanks);
- .2 any areas of the specified inspections that the URV has not been designed to examine;

- .3 the defect types for which the URV has been designed to detect/identify (considering the functional requirements as defined in 2.4.7;
- .4 the defect types for which the URV has been designed to quantify/size; and
- .5 the lighting and cleanliness requirements for proper work the URV.

3.2.3 Information on the levels of navigation automation, which may be:

- .1 manual control; and
- .2 semi-autonomous control (e.g. position hold and collision avoidance).

3.2.4 Information on the levels of sensor automation, which may be:

- .1 sensor operation manual; and
- .2 sensor operation semi-autonomous.

3.2.5 Information on data elaboration and presentation details, including:

- .1 any algorithm applied to elaborate video streaming and measurement signals, if any;
- .2 description of data management system (e.g. storage on board, transmission to base station or to remote servers, etc.); and
- .3 description of presentation of data to the URV users (e.g. tablet display for videos, spreadsheets for data, etc.).

3.2.6 Information specifying what type training should be undertaken by URV operators.

## **4 RIT System Performance Tests**

### **4.1 General requirements**

4.1.1 Tests should be performed as specified below to demonstrate that the RIT system meets the goals and functional requirements. Testing protocols should be defined providing practical approaches to obtain objective evidence that evaluation criteria corresponding to goals and functional requirements are satisfactorily fulfilled.

4.1.2 The testing should be carried out in an environment that replicates the space of the specified survey type(s) for which the RIT system is to intend to be used. This includes the environmental and lighting conditions, as well as, the structural condition of the space/structure to be surveyed. Alternatively, the testing may be carried out on board a ship. In such case, adequate environmental and lighting conditions as well as satisfactorily representative structural conditions including comprehensive and reliable information on space/structure to be surveyed should be available for the trials and subsequent assessment of the RIT system.

4.1.3 The test environment, whether real (i.e. ship) or replicated (i.e. testing laboratory), is to contain the specified defects and those defects should be duly detected, identified and characterized in advance and scattered throughout the space. Testing may be undertaken over a series of tests.

4.1.4 The defects to be considered in tests should be according to 2.4.7.

4.1.5 Prior to testing, a test plan including detailed description of testing protocols and assessment criteria for each test carried out should be submitted to the Administration for review and acceptance. The test plan is to include the location at which the tests are to be held (i.e. a test facility or ship's name and IMO number), a test programme adequate to the intended capabilities of the URV, ensuring it addresses all the applicable goals and functional requirements.

4.1.6 The tests should be witnessed and conducted to the satisfaction of the attending surveyor of the Administration.

4.1.7 Reports, records and video livestreaming recordings and still image should be retained by the Administration.

## **4.2 Onboard testing**

4.2.1 The surveyor of the Administration should witness the tests conducted to confirm the compliance with the ESP Code and guidelines.

4.2.2 Once the RIT system is provided with a 'provisional RIT System Statement of Capability', the RIT system should be tested under real conditions, either during an ESP survey or during an onboard demonstration.

4.2.3 Planning of onboard testing should be in consultation with the master of the ship to ensure the testing procedure considers each ship's specific safety management system, in particular for any interactions amongst the master, officer in charge, operator(s) and the surveyor(s).

4.2.4 As part of the onboard demonstration, a survey trial in the presence of the surveyor of the Administration should be carried out to demonstrate that the RIT system may be effectively used during an ESP survey. The trial should include a pre-inspection verification in accordance with paragraph 6. Planning and preparation, by using the RIT Pre-Inspection Verification Card, (in annex 2) or any other agreed means, followed by a confirmatory survey, in accordance with paragraph 7. Conduct of surveys, by comparison of results with a conventional close-up survey technique.

4.2.5 Reports, records and video livestreaming recordings and still image should be retained by the Administration.

## **5 RIT system statement of capability**

### **5.1 Provisional RIT system statement of capability**

5.1.1 Following document review and after satisfactory completion of tests addressed under 4.1 General requirements, the Administration may issue a 'provisional RIT System Statement of Capability'.

### **5.2 Full term RIT system statement of capability**

5.2.1 After satisfactory completion of the onboard testing addressed under 4.2 Onboard testing, the Administration may issue a full term 'RIT System Statement of Capability'.

**APPENDIX 1**

**SAMPLE FORM  
<PROVISIONAL\*>RIT SYSTEM STATEMENT OF CAPABILITY**

This statement is issued to: ..... e.g. *URV manufacturer or RIT firm*  
 Address: ..... e.g. *URV manufacturer or RIT firm address*  
 Date of issue: ..... DD MMM YYYY

To confirm the <Administration> has assessed the below RIT System in accordance with the MSC.1/Circ.[...], annex 4 "Technical Provisions, Assessment and Certification of Remote Inspection techniques (RIT) and Associated Digital Technologies for Detection and Sizing of Structural Defects" to confirm that the system can be used to support the 2011 ESP Code close-up survey by providing information to the surveyor with the same level of assurance as conventional close-up visual inspection with the characteristics, capabilities and limitations as indicated below.

<\*This statement is considered provisional, pending the satisfactory completion of an onboard testing on a ship in accordance with MSC.1 Circ.[...], annex 4, section 4.2.>

**1. System identification**

RIT method: e.g. <i>URV based, manned based</i>
Method description: e.g. <i>unmanned aerial vehicle, battery powered and remotely controlled by a pilot:</i> e.g. <i>portable camera transported and manoeuvred by a rope access operator.</i>
Manufacturer:
Model and Version:

**2. Capabilities**

<p><b>2.1 Fitness for purpose:</b> e.g. <i>The vehicle may be deployed in enclosed spaces, including cargo holds, cargo tanks, ballast tanks, other tanks and void spaces and open deck with light wind conditions. The screen and controllers may be used in the same spaces. The vehicle may access hard-to reach areas and can pass through manholes and other openings with a minimum radius of 400 mm. (see details below)</i></p>
<p><b>2.2 Safety:</b> e.g. <i>the URV propellers have physical protection, and the vehicle can withstand light contacts with the surrounding structure without damaging itself or the ship structure, fittings or coating. The system is able to fly with one motor down and is provided with automatic emergency landing which will be initiated whenever there a low battery warning or failure of one of the motors.</i></p>
<p><b>2.3 Efficiency:</b> e.g. <i>Manoeuvrability functionalities include the ability to hover steady and move at very low speed. Camera system has independent rotational features that allows it to rotated around the horizontal axis (180° up-down). The system is provided with spare batteries and recharging facilities, as detailed below. Battery state-of-charge is continuously monitored, and information is available to the operator in the remote controller.</i></p>

<p><b>2.4 Data accuracy and integrity</b> e.g. <i>Livestreaming with high definition that allows the surveyor to detect all applicable defects, including cracking, deformation, corrosion, and coating breaking. Camera provided with optical stabilization and zoom x10. The system is also provided with Lidar system that allows 3d mapping of structure and detection of deformations. (see details below)</i></p>
<p><b>2.5 Data retention</b> e.g. <i>Livestreaming video may be recorded to a SD card, on request of the operator. High definition photographs may also be taken on request of the operator. (see details below)</i></p>
<p><b>2.6 Thickness measurements</b> e.g. <i>Thickness measurement capability not provided.</i> e.g. <i>Able to take thickness measurements on smooth surfaces (see details below)</i></p>

**3. Defect detection and quantification (see note A)**

Item	Detection	Quantification
Cracks	Yes (AI image recognition)	Yes (Length)
Deformation	Yes, Lidar	Yes (height, width and depth)
Corrosion	Yes (AI image recognition)	No
Coating breakdown	Yes (AI image recognition)	Yes (height and width)

Note A: As a core requirement, the livestreaming video should have sufficient quality to allow the surveyor to visually identify all defects, including assessing relative position and size. This table refers to RIT system additional capabilities for the machine to independently detect and measure defects which may be used as supplementary information to the surveyor, but not a replacement of the video livestreaming core capabilities.

**3. Intended use**

Spaces: <i>e.g., cargo holds, cargo tanks, ballast tanks</i>
Structure: <i>e.g. plating, ordinary stiffeners, primary members, brackets, welds, etc.</i>
External Illumination requirements (if any): <i>e.g. minimum lux</i>
Other pre-inspection requirements: <i>e.g. cleaning of spaces, labelling of frame numbers, safety ropes, etc</i>
Level of navigation automation: <i>e.g. remotely operated, tethered-operated, radio-operated</i>

**4. Limitations**

Inaccessible areas, including passage through structure openings and manholes and structural condition constrains:
Environmental constraints:
Operational constraints:

**5. Livestreaming equipment details**

Camera maker and type:
Camera specifications: <i>e.g. image resolution, frame rate, sensor type</i>
Display screen maker and type:
Display screen specifications: <i>e.g. resolution, size</i>
Zoom capabilities:
Image Stabilization Features:

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**6. Photography equipment details (if not the same device or details as in 5)**

Camera maker and type
Camera specifications: <i>e.g. image resolution, sensor type</i>
Lense specifications: <i>e.g. focal distance, aperture</i>
Zoom capabilities:
Image Stabilization Features:

**7. Other sensors details**

Additional sensor 1 specifications: <i>e.g. laser scanning, UTM</i>
Additional sensor 2 specifications:
Additional sensor 3 specifications:

**8. Thickness measurement system details (if applicable)**

Method: <i>e.g. ultrasonic, eddy current</i>
Probe specifications: <i>e.g. for UT indicate probe frequency</i>
Measuring orientations: <i>e.g. horizontal, upward, inclined upward</i>
Means to change measuring orientation: <i>e.g. remotely controlled, manual replacement</i>
Other information: <i>e.g. provided with coupling gel dispenser, multiple-echo enabled.</i>
Surface condition: <i>e.g. Intact condition only, corrosion to be removed prior to measurements.</i>

**9. Data handling details**

Recording formats (video, image, database):
Metadata details (date, time, geolocation, annotations):
Storage and export capabilities:
Data integrity and tamper-proof measures:

**10. Other details**

Power supply: <i>e.g. battery capacity, expected lifetime, and details of tethered systems</i>
IP rating:
Hazardous areas certification and rating:

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