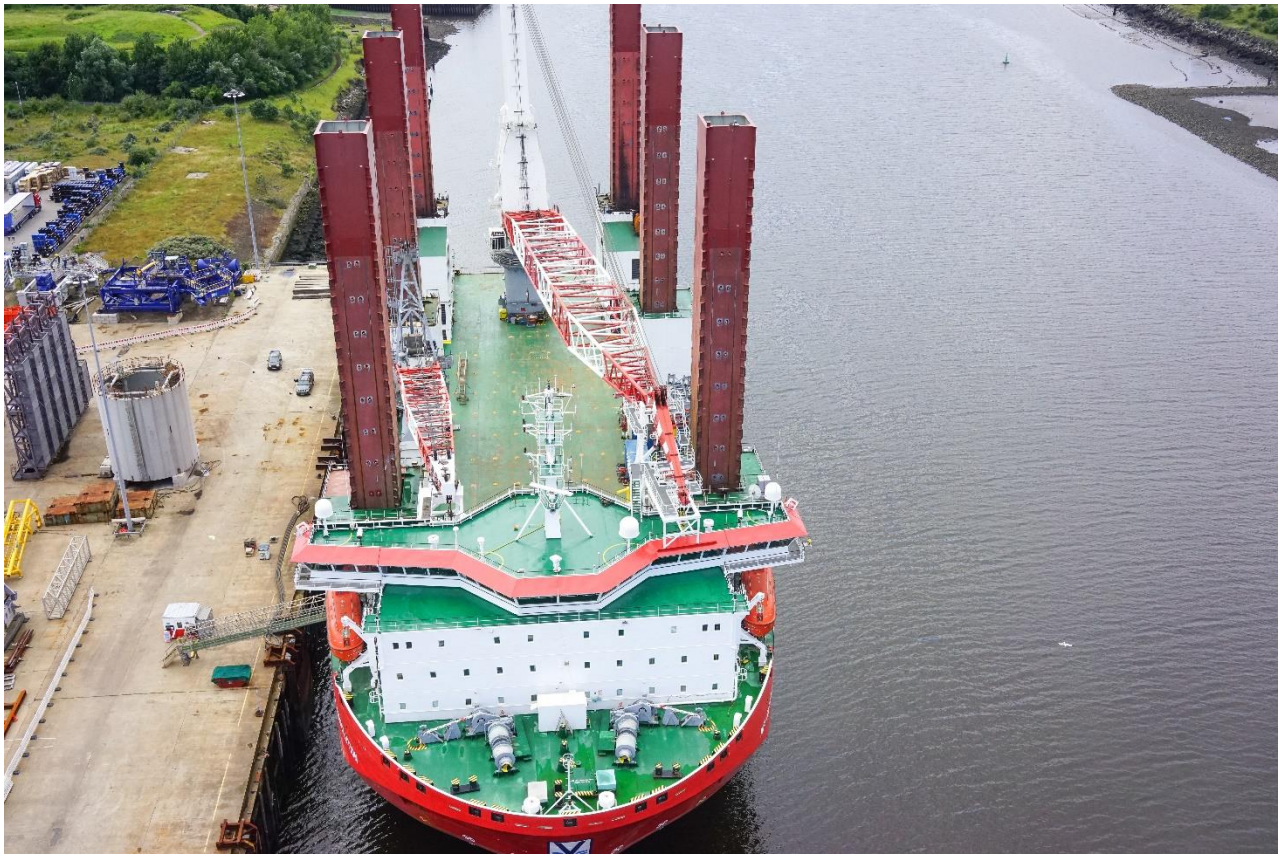
NAUTICUAS

AERIAL MEDIA Scotland



SURVEY REPORT: NAU-SR-MPI-001 Rev 02 (Abridged)

MPI RESOLUTION GENERAL CLOSE VISUAL INSPECTION/SURVEY UTILISING DRONE (UAS)

JULY 2017

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IMAGES: Aerial Media Scotland – Derek Fett

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1.0 INTRODUCTION

The prime objective for the survey was to demonstrate the feasibility of using an Unmanned Aerial System (UAS) or "drone" to visually inspect in detail the critical areas of the vessels' structural critical areas that would otherwise require rope access and /or scaffolding etc. to complete.

To achieve this objective, an inspection scope was developed, using as its basis DNV-OSS-101 Rules for the Classification of Offshore Drilling and Support Units; Chapter3 section 3: Periodical Survey extent for main class. October 2014.

Based on these, specific areas of the hull structure were identified (refer Targets list and images in Section 3.2.3) and a flight schedule developed to allow investigation utilising the drone.

The survey was executed on 12th July, 2017 at Teesport, Middlesbrough, on the wind turbine installation vessel, MPI Resolution, located quayside, jacked-up out of the water.

The survey was completed in 2.5 hours, and a total of 130 digital images were captured. Selected images are presented in this report to demonstrate that the requirements for Close Visual Inspection and the ability to examine in detail the areas under inspection, were met by the survey. These are presented in Section 4.

The survey was conducted in accordance with the requirements set out in the approved Survey Plan, document reference: NAU-SP-SD-001 Rev1, issued prior to the mobilisation to site.

The UAS team would like to thank MPI Offshore and the Resolution team for allowing the access to the vessel for this survey. Their support demonstrates their commitment to innovation and the promotion of and improvement to, safe working practices.

2.0 SCOPE OF SURVEY

2.1 PRE-SURVEY SCOPE IDENTIFICATION

In determining which areas to visually survey, Classification Rules were utilised as the guide. For this pilot, DNV-OSS-101 Chapter3 section 3: Periodical Survey Extent for Main Class is the guiding reference. This specifies areas requiring inspection, including critical areas, and from this the following general locations were selected:

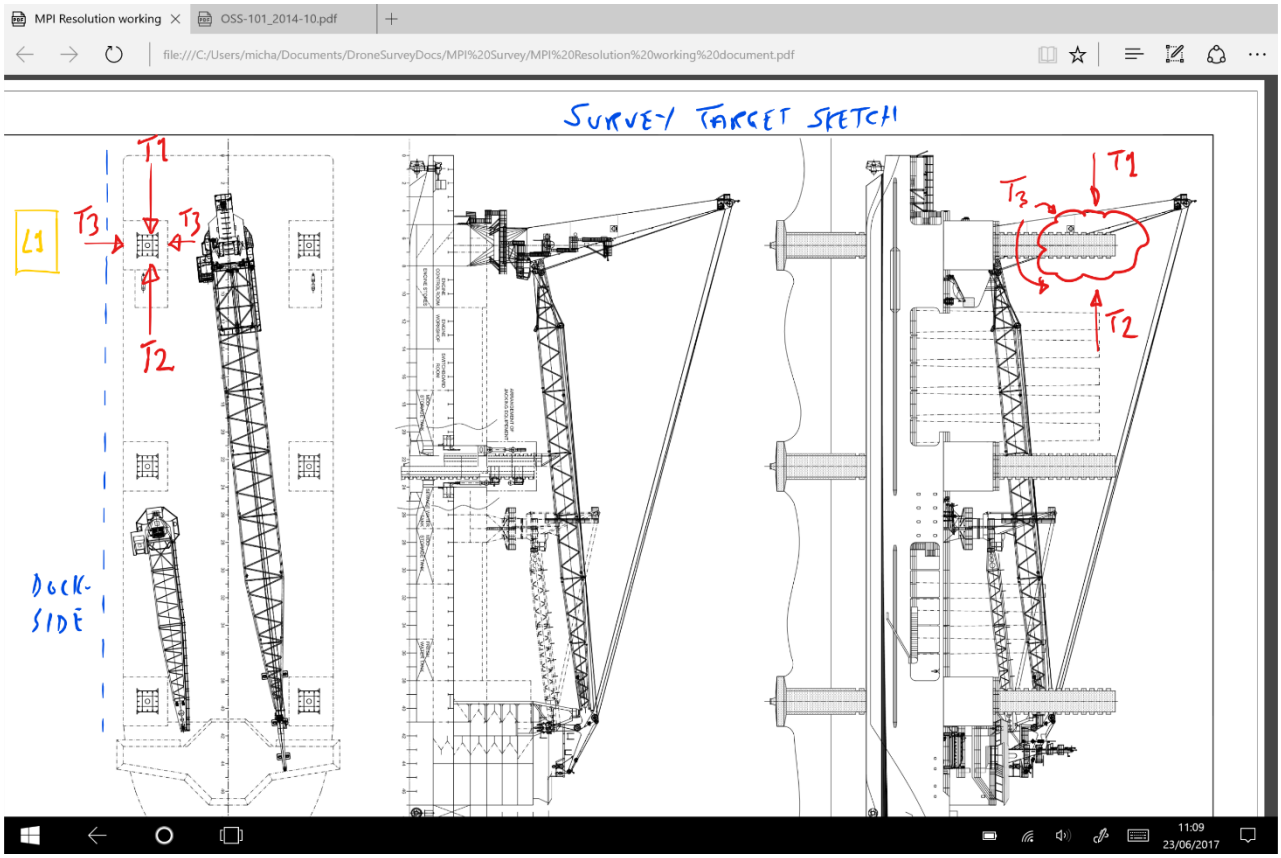
Starboard Aft Leg structure – T1-T3 (Teeth, extension piece joint and jet pipe penetrations) - refer sketch below

MPI Selected areas:

Main crane tower joints-T4

Main crane boom -T5

Thrusters-T6



3.0 OPERATING METHODOLOGY

3.1 PRE-SURVEY

Prior to commencement of the survey, the following activities were completed

i) The pilot survey UAS-specific risks were assessed and reported in document: NAU-RA-MPI-001 Rev 0 - *Risk Assessment MPI resolution et al* which was included in the Survey Plan.

ii) Prior to the commencement of the survey, at the time of the pre-survey briefing, an on-site review of the risk assessment was conducted to ensure that the risks remain relevant and to allow any other, location and time - specific risks to be identified and evaluated. The Survey Plan risk assessment was accepted without modification.

iii) Equipment preparation: the UAS team checked and prepared the UAS for flight prior to boarding/loading the survey vessel.

iv) Pre-survey briefing (Tool Box Talk -TBT) involving Surveyor (UAS Operations Manager & PTW Performing Authority); UAS team (pilot and co-pilot); MPI Safety Representative; MPI vessel management and crew.

In this all aspects of the survey were discussed and explained including scope (flight schedule), risk assessment/PTW interface, intended areas of UAS activity, potential operating effects (exhaust, turbulence etc.), operational requirements on-board (launch/capture arrangements, deck space restrictions, emergency landing requirements etc.), weather forecast, potential sources of disruption, marine deconfliction arrangements, safety briefings. It was agreed by all that, as there were no operations on-board during the survey, there was no requirement to operate within the PTW system.

References:

Survey Plan: NAU-SP-MPI-001 Rev1

DNV-OSS-101 Rules for the Classification of Offshore Drilling and Support Units; Chapter3 section 3: Periodical Survey extent for main class. October 2014

Oil & Gas UK UAS Standards and Guidelines Issue 1 January 2017

3.2 SURVEY OPERATIONS

3.2.1 TEAM COMPOSITION

The team for the survey comprised three, as follows:

Surveyor/Operations Manager: directs survey; monitors results in-survey; adjusts scope as necessary

UAS Pilot: operates the drone to requirements of Surveyor

UAS co-pilot: supports pilot, assists in launch recovery; observes flights (safety); operates camera under instruction of pilot [for team training, an additional team member was present as pilot assistant on this survey].

This team composition is considered as “exemplar” and vital to deliver the full flexibility of the UAS survey process. Direction of the image capture by the UAS by an experienced rig/ship surveyor ensures that the correct images are captured and that the scope of the survey can be managed “dynamically” and modified in-survey to ensure that all areas of interest are captured without the need for additional mobilisations.

This was demonstrated comprehensively during the survey, as Targets were identified that were additional to the areas identified pre-survey, following review of the images captured on-board the survey vessel.

3.2.2 FLIGHT OPERATIONS

Flight operations were performed in accordance with the Operations Plan defined by the UAS team – Document Title AMS Vol1 Operating Manual.

In addition, the following vessel operating procedures were followed:

Communications with the rig were conducted by the UAS team pilot assistant, at the request of the UAS Pilot.

Weather monitoring: was conducted by the vessel captain and crew

Marine traffic monitoring was under the control of the vessel captain.

For this demonstration survey, a conservative “offset” (i.e. physical distance between UAS and asset) of 3 to 4 metres was maintained. The survey confirmed, however, that in similar conditions, a minimum “offset” of 1.5 to 2 metres was achievable without compromising the UAS or asset under examination.

3.2.3 FLIGHT SCHEDULE

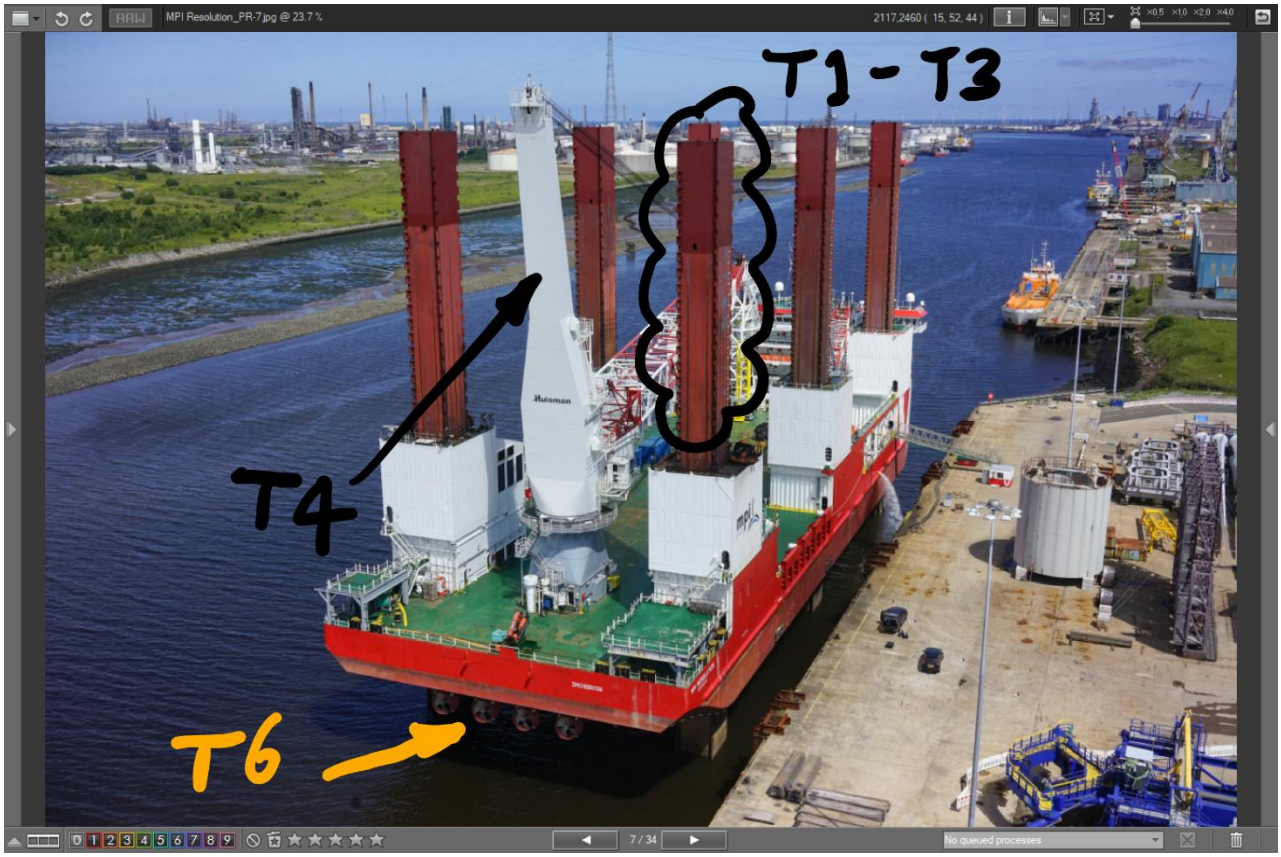
The flight schedule/record is included below:

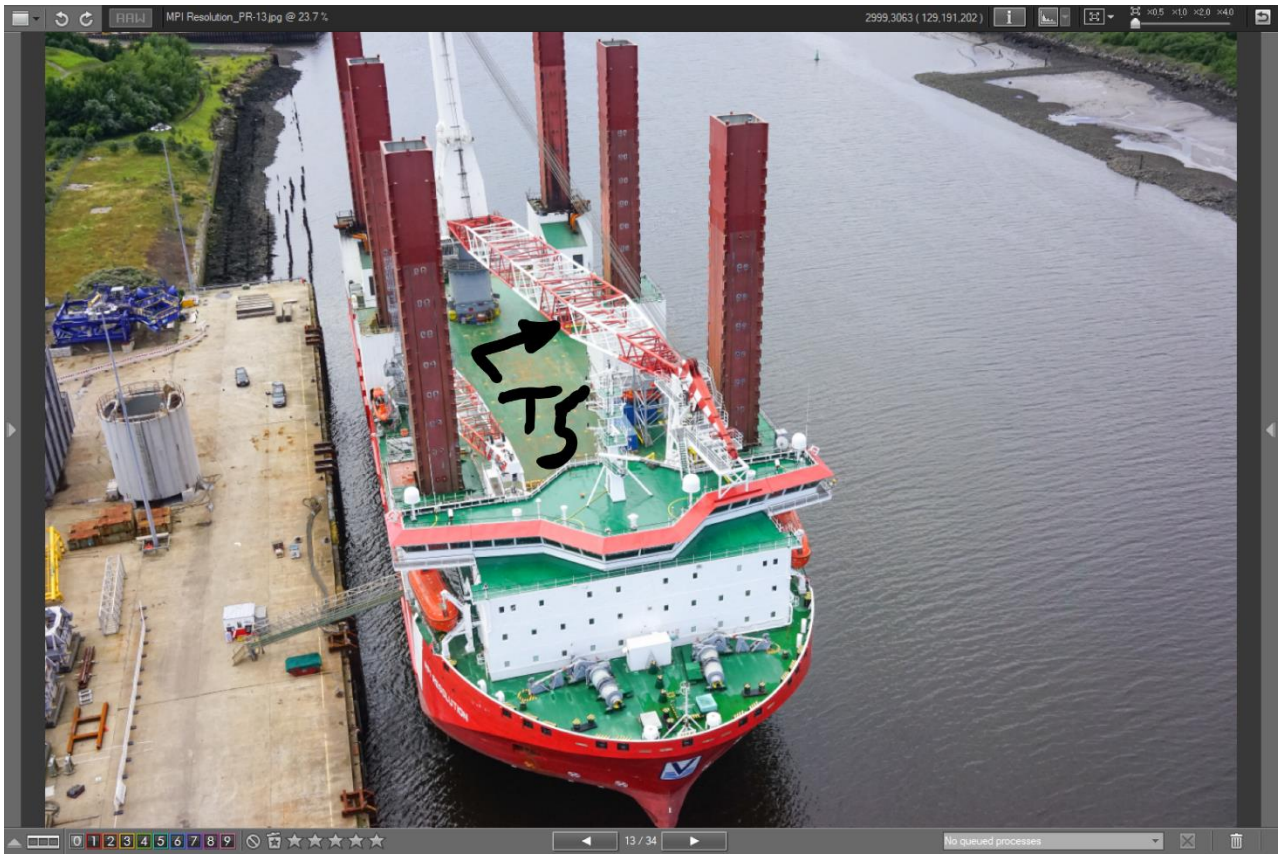
Inspection Flight Number	Target Number *	Launch Location *	Duration	Data Record Storage Folder Reference	Comments
1	T1-T3	L1	10	Flt1	3-4m offset
2	T4&T6	L1	10	Flt2	3-4m offset
3	T5	L2	10	Flt3	3-4m offset
4	General Vessel Views	L3	10	PR	Long distance images
Total Elapsed Time				[Total 130 images]	2.5 hours survey time
Note (2 flights)			10 total		Compass calibration/recalibration
Date					12.07.17

FLIGHT RECORD: SURVEY MPI – MPI RESOLUTION GENERAL CLOSE VISUAL INSPECTION SURVEY

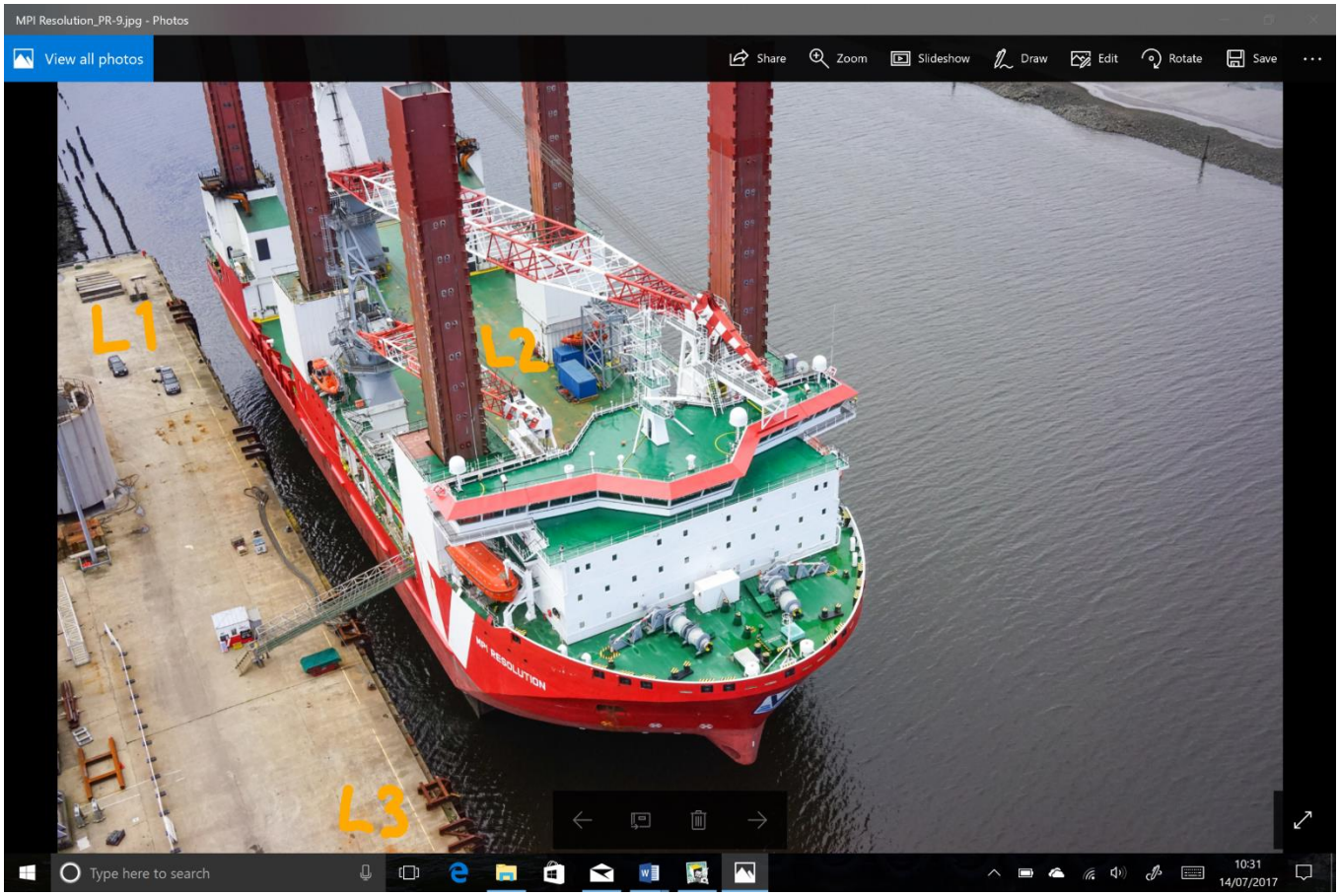
*Refer Target and Vessel Location images below.

[Note: The Data Record Reference refers to the folders in which the survey images are located for detailed reference. These are issued separately to this report due to the large file size.]





TARGET LOCATIONS: PRE-SURVEY IDENTIFICATION



UAS LAUNCH LOCATIONS DURING SURVEY

3.2.4 AFTER ACTION REVIEW

Upon return to the shore base, a post-survey review was performed with all the on-board team to capture lessons learned from the survey. Following review of all the images it was concluded that the survey objective had been achieved.

4.0 RESULTS

4.1 PRIMARY OBJECTIVE: CLOSE VISUAL INSPECTION (CVI) DEMONSTRATION

The following, selected, reporting images demonstrate the degree of resolution obtainable after post-processing. This delivers a level of detail which is equivalent to observation with the naked eye at 1-2m and so meets the generally accepted criteria for CVI.

[The raw images captured by the survey are contained in data storage folders issued separately due to file sizes.]

4.1.1 Leg Jet Pipe Penetrations: Starboard Aft Leg

Penetrations inspected were the bulkhead penetrations from the 30m to 46m elevations, as indicated by the white paint markings on the leg.

See images below for details (selected images only for demonstration purposes):

Starboard Aft Leg: Jet Pipe Penetrations; Elevation Marking 34m: Flight 1; Image 22

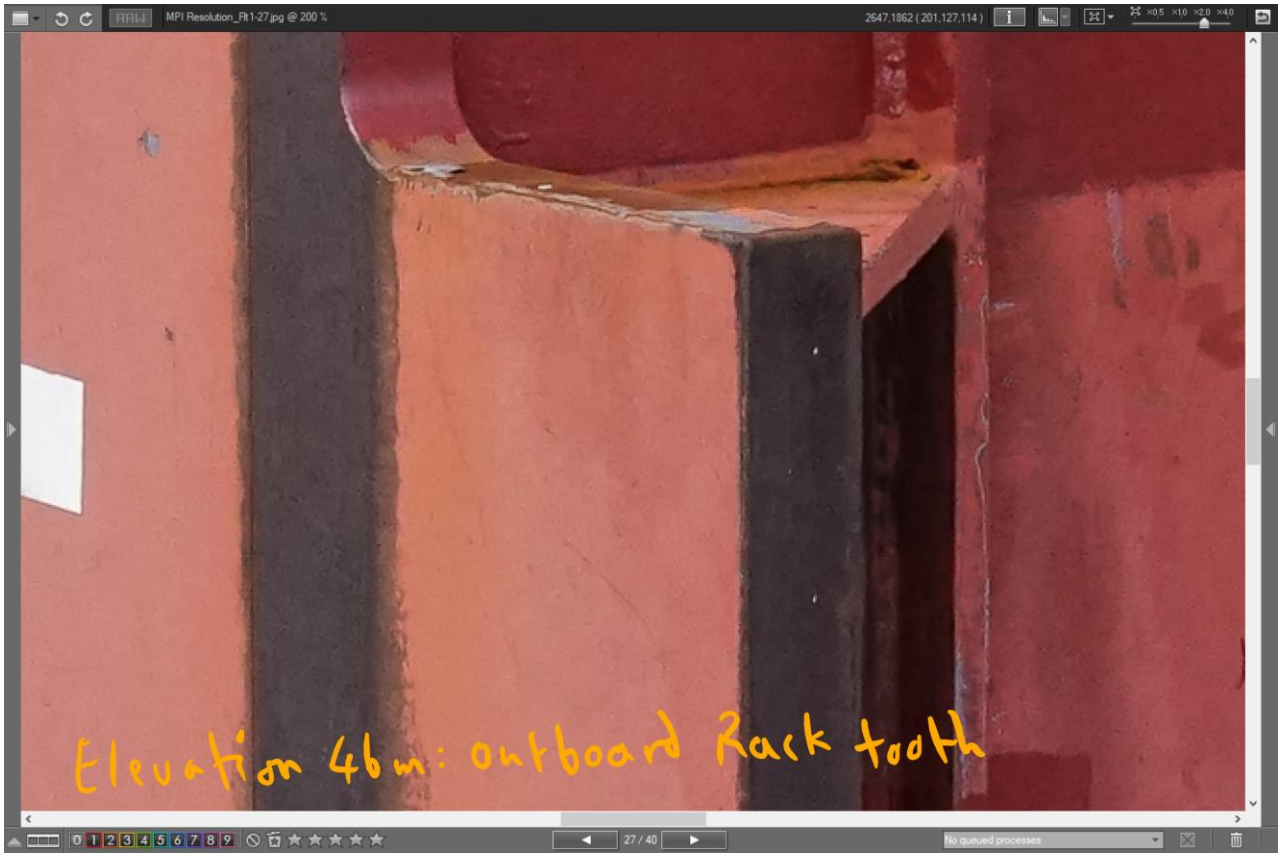
Starboard Aft Leg: Jet Pipe Penetrations; Elevation Marking 46m : Flight 1; Image 30

4.1.2 Leg Rack Teeth: Starboard Aft Leg; Inboard and Outboard

Rack teeth surveyed were from the 29m to 48m elevations, as indicated by the white paint markings on the leg.

See images below for details (selected images only for demonstration purposes):

Starboard Aft Leg: Inboard Rack Tooth; Elevation Marking 46m: Flight 1; Image 30



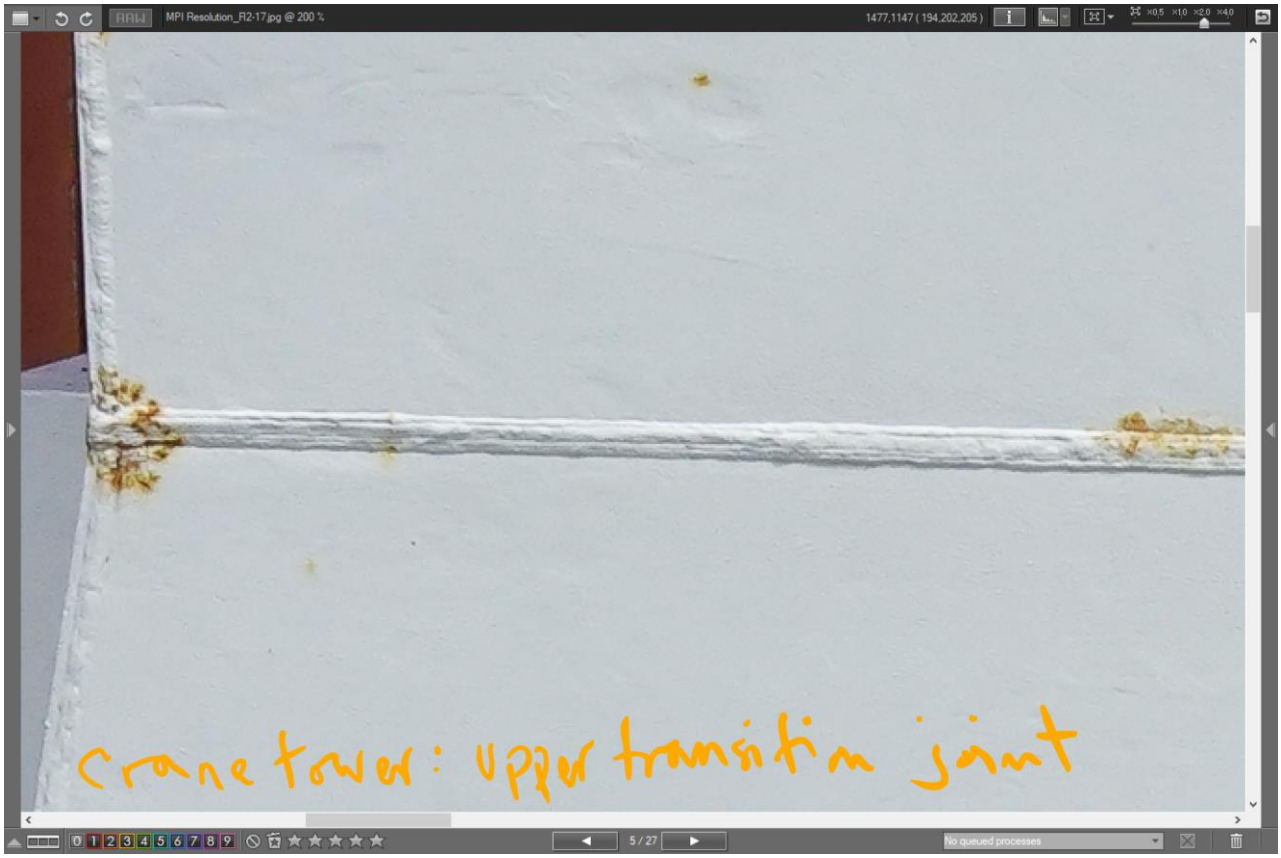
Starboard Aft Leg: Outboard Rack Tooth; Elevation Marking 46m: Flight 1; Image 27

Starboard Aft Leg: Outboard Rack Tooth; Elevation Marking 46m: Flight 1; Image 28

4.1.3 Main Crane Tower Joints

The aft-facing welded joints were surveyed.

See images below for details (selected images only for demonstration purposes):



Main Crane Tower: Aft face; Upper Transition Joint: Flight 2; Image 17

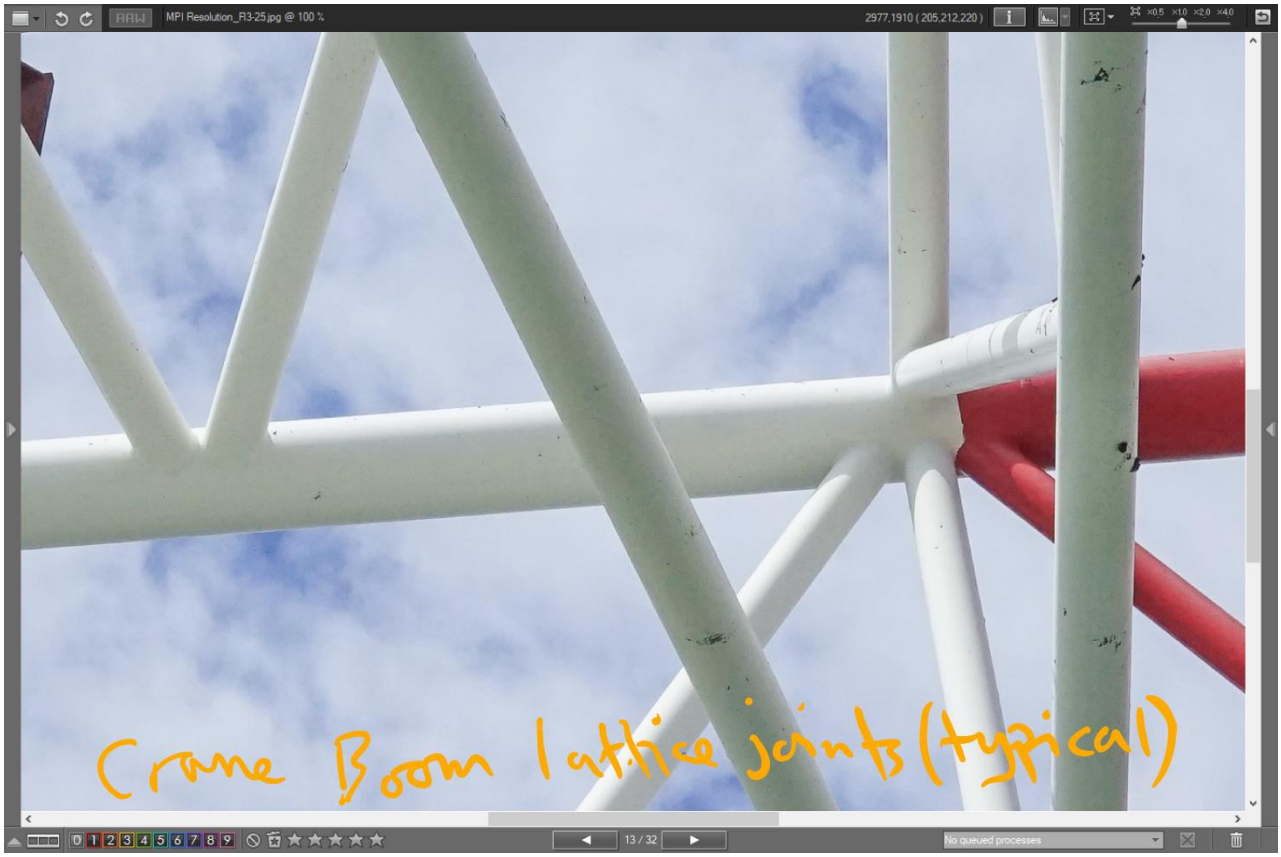
Main Crane Tower: Aft face; Upper Transition Joint: Flight 2; Image 17

4.1.4 Main Crane Boom

A section of the main crane boom was surveyed to demonstrate the level of coverage of the structure that is possible from one UAS position, relative to the boom.

The UAS was operated from a launch position on the deck of the vessel, adjacent to the crane boom.

See images below for details (selected images only for demonstration purposes):



Main Crane Boom Lattice: Flight 3; Image:25

Main Crane Boom; Lattice Joint Detail: Flight 3; Image:13

Main Crane Boom; Cable Guide: Flight 3; Image: 19

4.1.5 Aft Thrusters

As the vessel was jacked-up out of the water, the opportunity was taken to survey the aft thruster pods and stem.

See images below for details (selected images only for demonstration purposes):

Starboard Aft Thruster; Flight 2 Image 2