NAUTICUAS

SURVEY REPORT: NAU-SR-XX-YY-0001

LEG STRUCTURE CLOSE VISUAL INSPECTION/SURVEY UTILISING DRONE (UAS)

OCTOBER 2017

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EXECUTIVE SUMMARY

A demonstration survey by UAS (Unmanned Aerial System, or “drone”) of the FORWARD LEG structure of a self-elevating drilling unit was performed on 6th October 2017 whilst the rig was moored alongside at Invergordon, awaiting mobilisation.

The motivation for the use of a UAS in this manner was to reduce the time taken to perform a visual inspection of the rig structure by minimizing (or removing) the need to mobilise rope-access personnel, or build scaffold platforms, to access the remote areas of the structure not visible from the rig. This not only improves survey efficiency (and hence asset integrity management performance) but, more importantly, significantly improves safety as the rope-access and scaffold-build operations are both inherently hazardous.

The primary purpose of the pilot was to demonstrate that a survey performed utilising a UAS to obtain high-definition digital images can be of sufficient quality and detail to meet the requirements of Close Visual Inspection. This objective was successfully demonstrated. Furthermore, the survey demonstrated that the time required to complete such a visual examination is significantly reduced compared to rope access techniques etc.

A further objective was to demonstrate that CVI-quality images could be obtained for the entire area under investigation with the UAS positioned **at all times** EXTERNAL to the leg structure, with no internal flying. This was successfully demonstrated.

Additionally, a third objective was to demonstrate that the survey could be performed entirely safely, with minimal impact on the operations on-board the rig at the time of the survey. This objective was also successfully demonstrated.

The demonstration survey also confirmed that the team composition used (UAS Surveyor plus UAS pilot and co-pilot/camera operator) represented the ideal make-up to fully deliver a safe, “dynamic” survey i.e. a survey in which the scope was modified during the survey in response to the results obtained as the survey progressed.

The demonstration survey was performed in a manner that was fully compliant with the rig owners’ Safety Management System and in accordance with the recently issued guidelines on the use of UAS’s from Oil and Gas UK.

The demonstration survey successfully demonstrated a technique that was fully aligned with the rig owners’ high values in Safety Performance and Innovation.

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' structure (in this case the legs) that would otherwise require rope access and /or scaffolding etc. to complete. Additionally, a further objective was to demonstrate that UASs' can be utilised in a safe manner, with risk to personnel managed to acceptable, ALARP, levels.

To achieve the objectives, 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. These rules were used in the absence of a rig-specific In-service Inspection Plan reference. Although the unit under investigation is classed by ABS, the critical areas of the leg structure are covered in an equivalent manner to DNV GL requirements.

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

The survey was executed on 6th October 2017 at Invergordon, Scotland, on a self-elevating drilling unit, located quayside, jacked-up out of the water.

The survey was completed in 2.5 hours, and a total of 232 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 images selected also demonstrate the ability to image, to CVI level of detail, all areas of the lattice node, including the internal areas, WITHOUT the need to pilot the UAS (drone) within the lattice leg structure. All images were obtained with the UAS positioned external to the leg structure.***

The survey was conducted in accordance with the requirements set out in the approved, revised, Survey Plan, document reference: NAU-SP-MD-001 Rev02, updated and re-issued prior to the survey. Revision was necessary to reflect the change in the launch site from the original, quayside, location to the helideck.

The UAS team would like to thank the OIM and team for allowing the access to the vessel for this survey. The UAS team further acknowledges their support in allowing for observation of the survey by a representative from the Classification Society, DNV GL.

The rig owners' 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 demonstration, 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:

Leg structure – T1-T3 (lattice nodes, splice joint, rack teeth)

Independent Observer Selected areas – T4 - Further lattice nodes, raw water pipe and fittings, marine growth areas

T5– top of leg

T6 – leg top coating wear areas

3.0 OPERATING METHODOLOGY

3.1 PRE-SURVEY

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

i) The surveys' UAS-specific risks were previously assessed and reported in document: NAU-RA-MD-001 Rev 0 - *Risk Assessment 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 with the launch location and target modifications (refer Rev 01 of the risk assessment document).

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); UAS team (pilot and co-pilot); OIM and crane operator.

In this all aspects of the survey were discussed and explained including scope (flight schedule), risk assessment/PTW interface if required, 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 there was no requirement to operate under a PTW.

References:

Survey Plan: NAU-SP-MD-001 Rev2

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.

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 safely 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 during the survey.

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. UAS team radios were given to the OIM and Crane Operator to enable direct communication during the survey.

Weather monitoring: was conducted by the UAS survey team.

Marine traffic monitoring was under the control of the OIM.

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

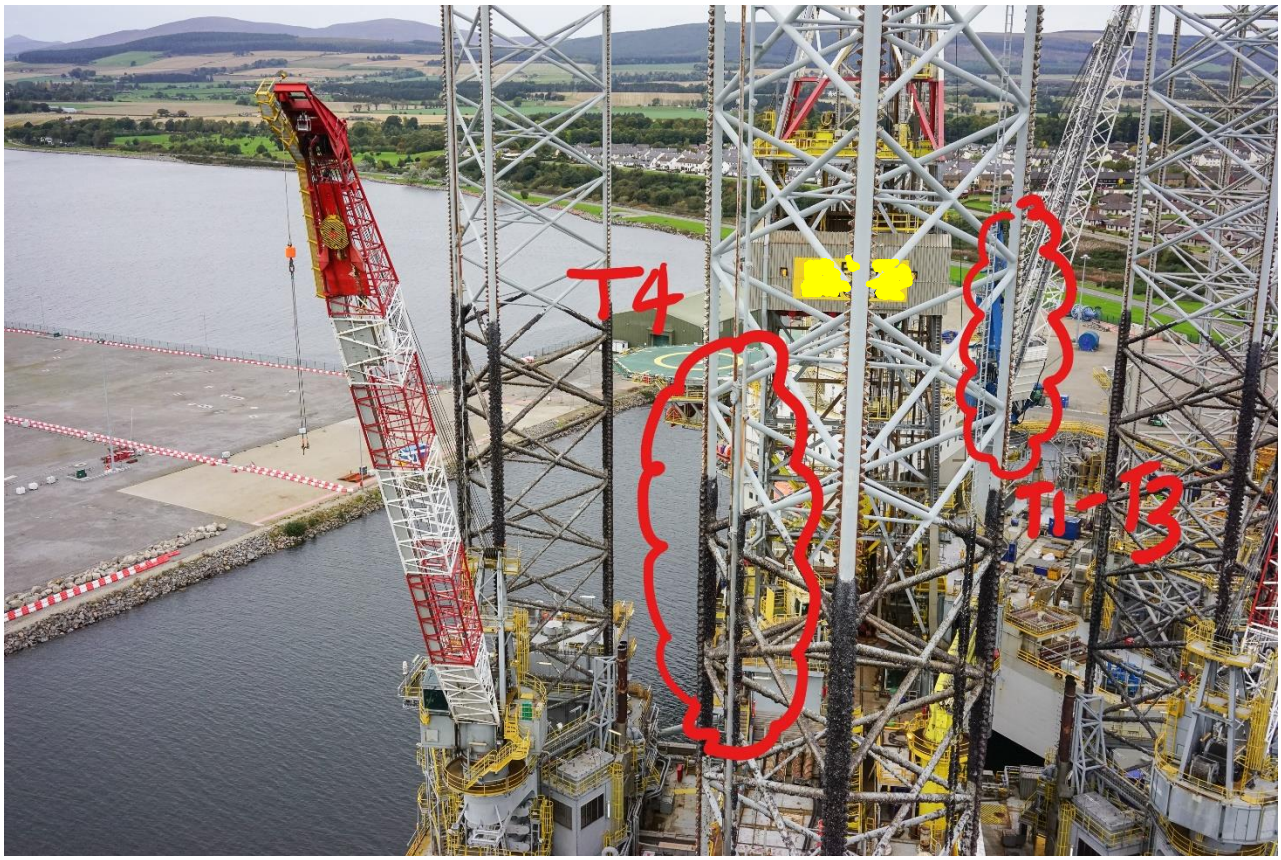
The flight schedule/record is included below:

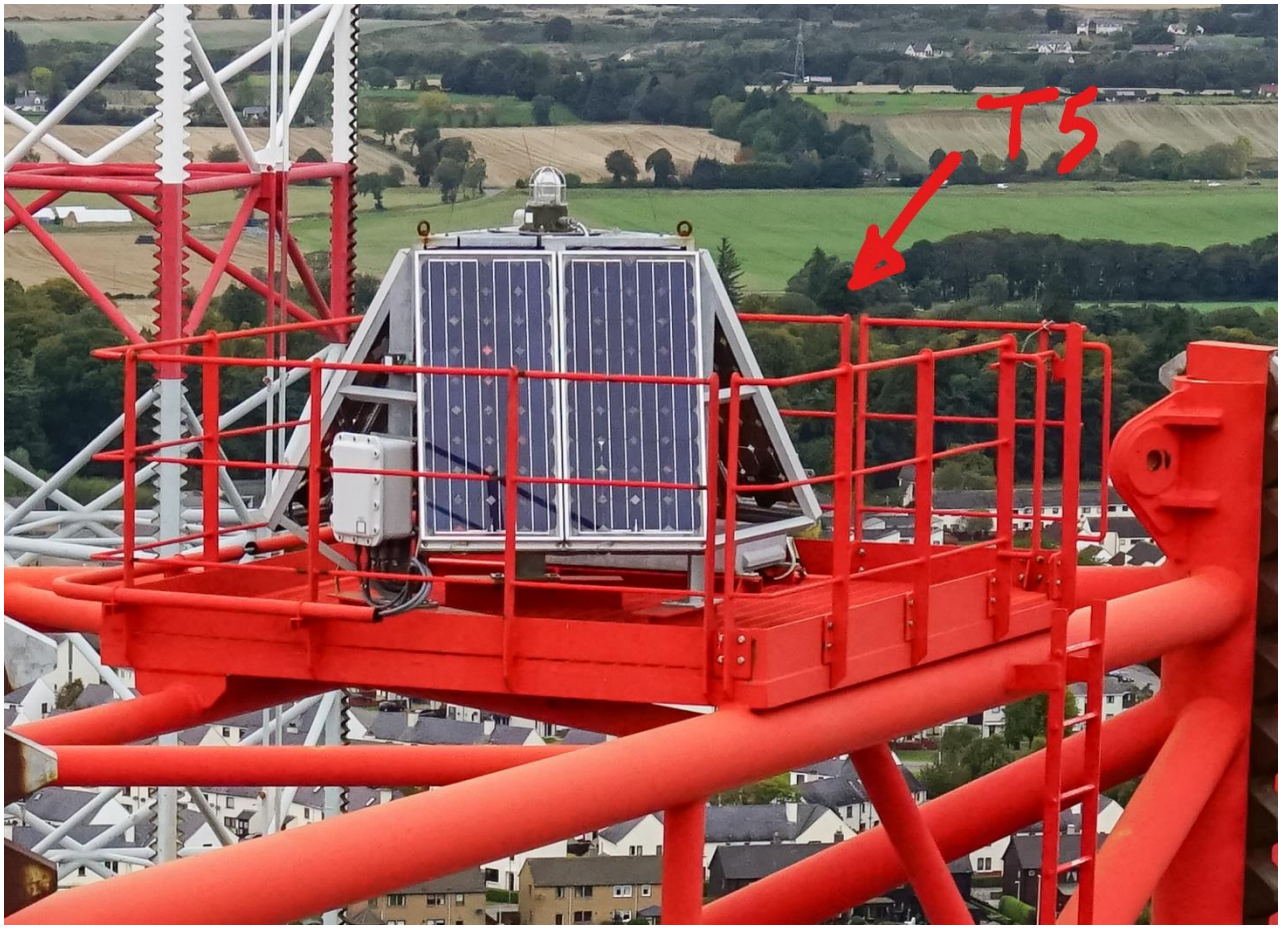
Inspection Flight Number	Target Number *	Launch Location *	Duration	Data Record Storage Folder Reference	Comments
1	T1	L1	10	Flt1	3-4m offset
2	T1	L1	10	Flt2	3-4m offset
3	T1 T2	L1	10	Flt3	3-4m offset
4	T2, T3	L1	10	Flt4	3-4m offset
5	T3, T4	L1	10	Flt5	3-4m offset
6	T5, T6	L1	10	Flt6	3-4m offset
7	General Vessel Views	L1	10	PR	Long distance images
Total Elapsed Time				[Total 232 images]	2 hours survey time
Note (1 flights)			4		Compass calibration
Date					06.10.17

FLIGHT RECORD: SURVEY – LEG STRUCTURE 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 typically issued separately to the report due to the large file size.]


T4
T1-T3


T5

TARGET LOCATIONS: PRE-SURVEY IDENTIFICATION

UAS LAUNCH LOCATION, L1, 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 objectives had been achieved.

4.0 RESULTS

4.1 PRIMARY OBJECTIVE: LEG STRUCTURE 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.

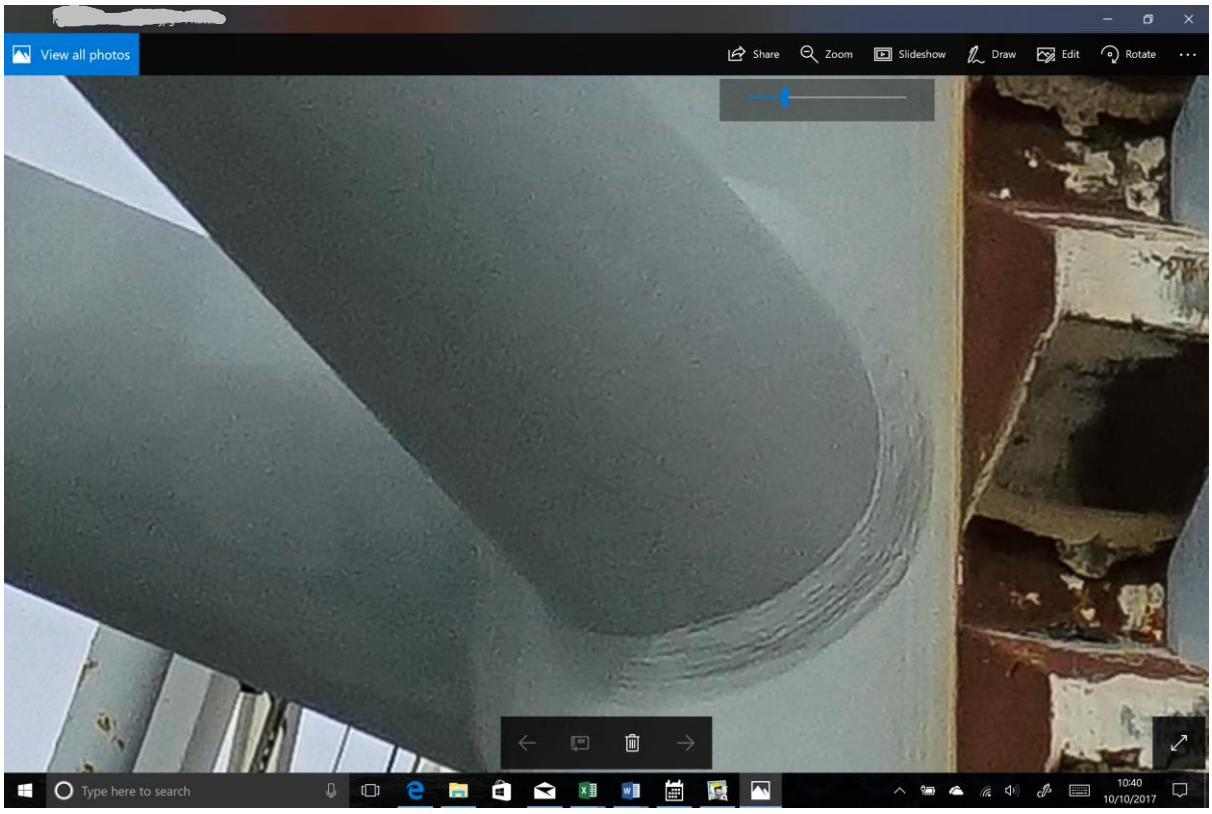
[The full set of raw images captured by the survey are contained in data storage folders.]

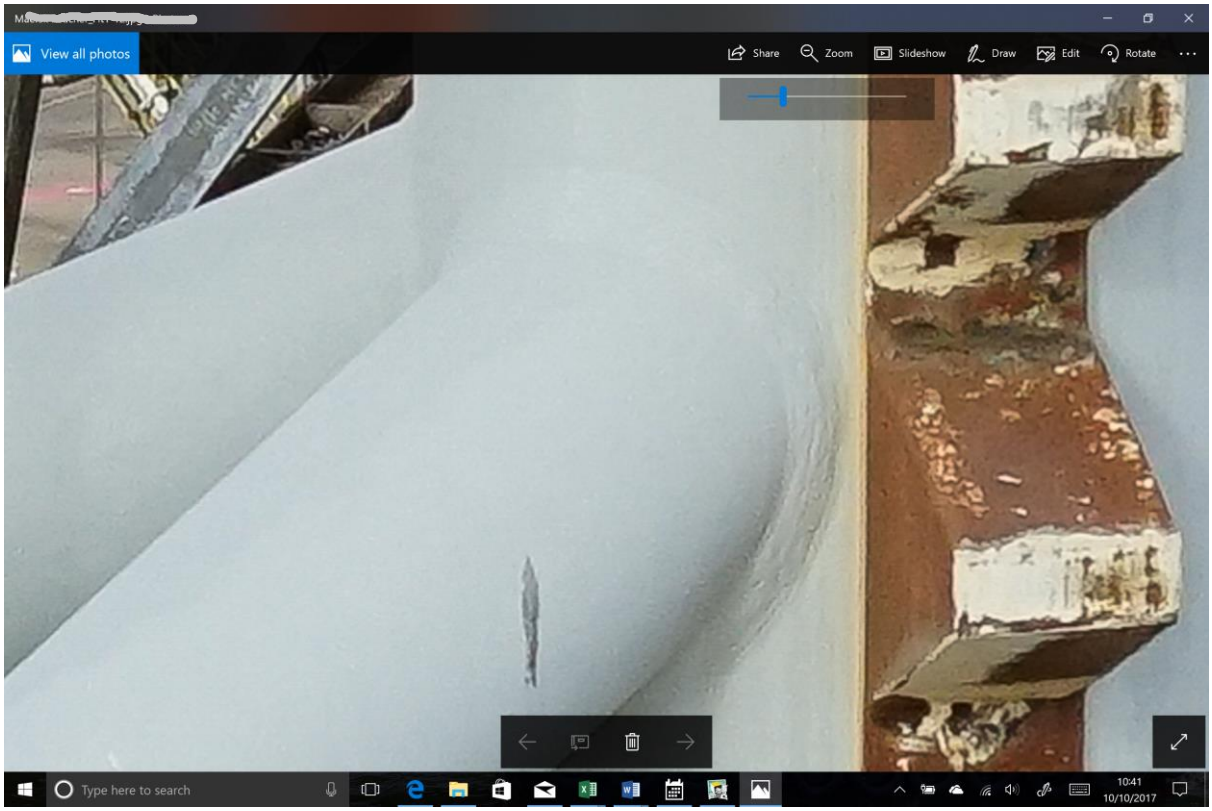
The images selected below also demonstrate the ability to image, to CVI level of detail, all areas of the lattice node, including the internal areas, WITHOUT the need to pilot the UAS (drone) within the lattice leg structure. All images were obtained with the UAS positioned external to the leg structure.

4.1.1 Leg Lattice Structural Node: Forward Leg

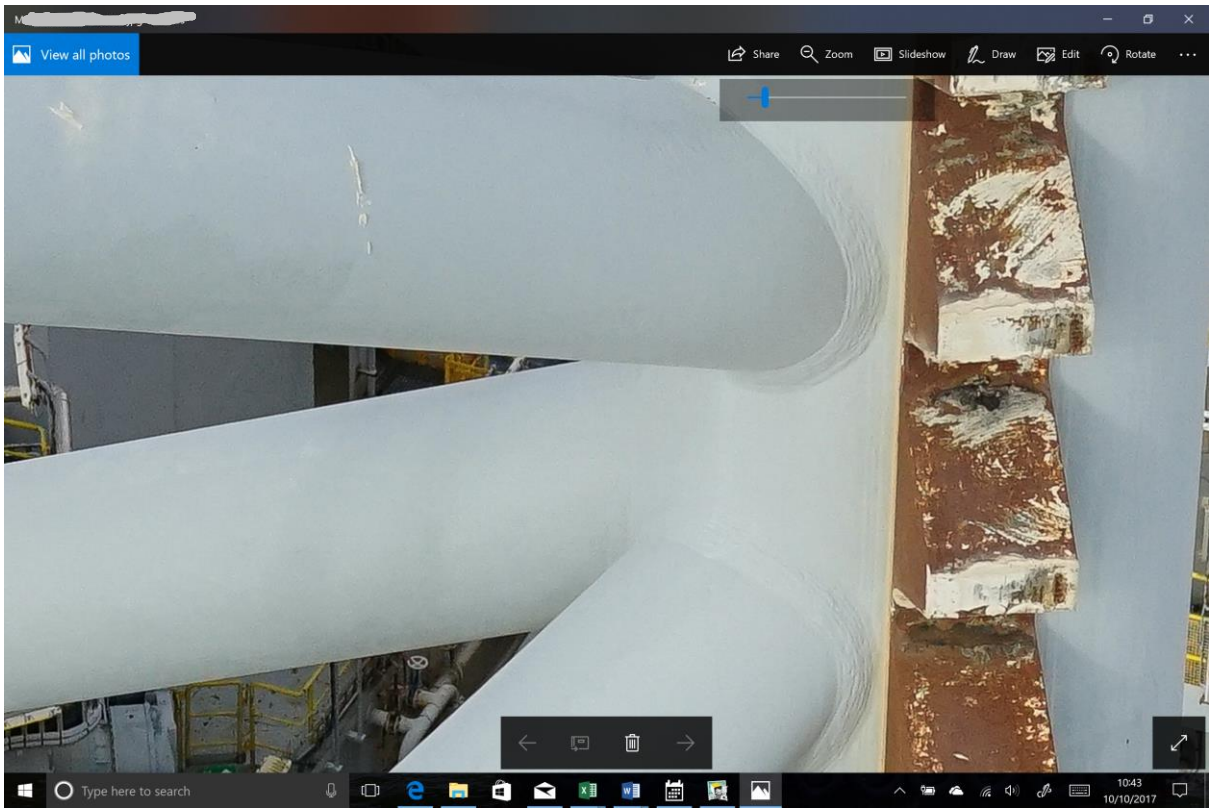
The leg nodes inspected were located just above the marine growth area, on the port vertical of the forward leg.

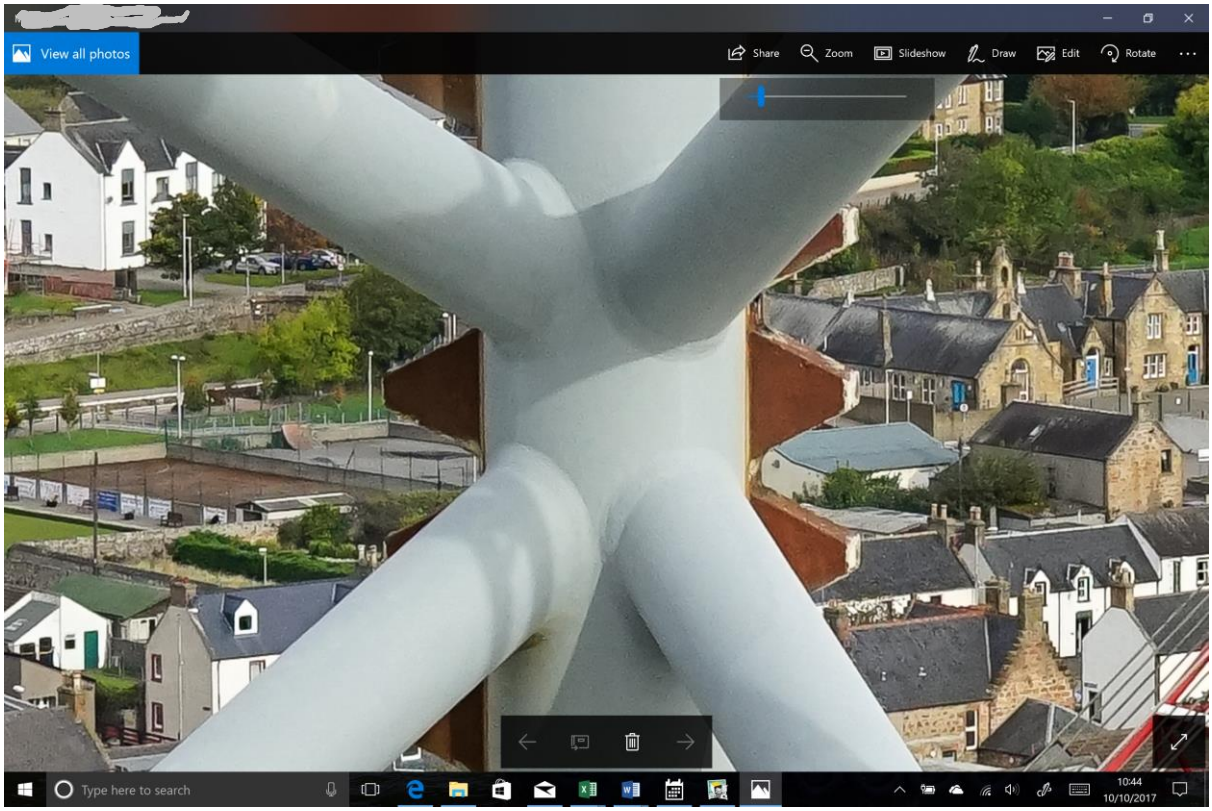
See images below for details (selected images only for demonstration purposes):





TARGETS T1 – T3 SELECTED IMAGES





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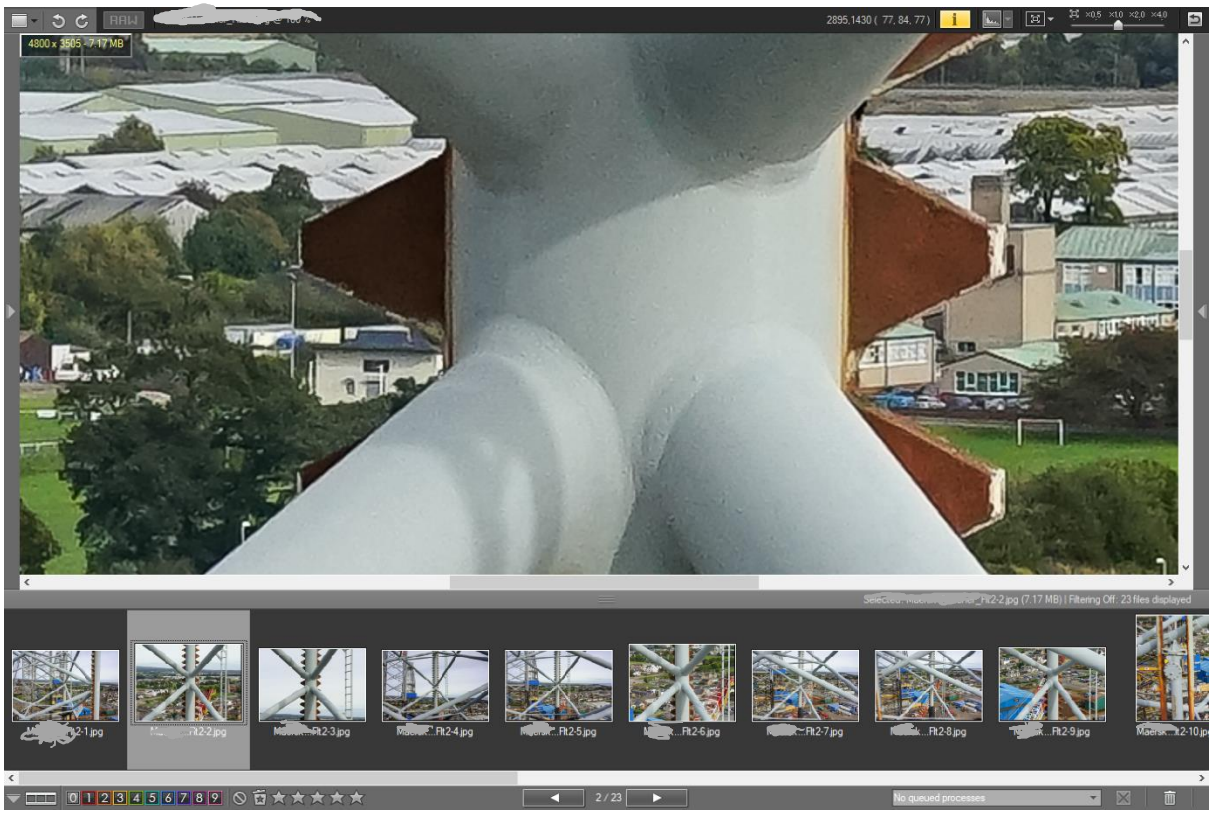
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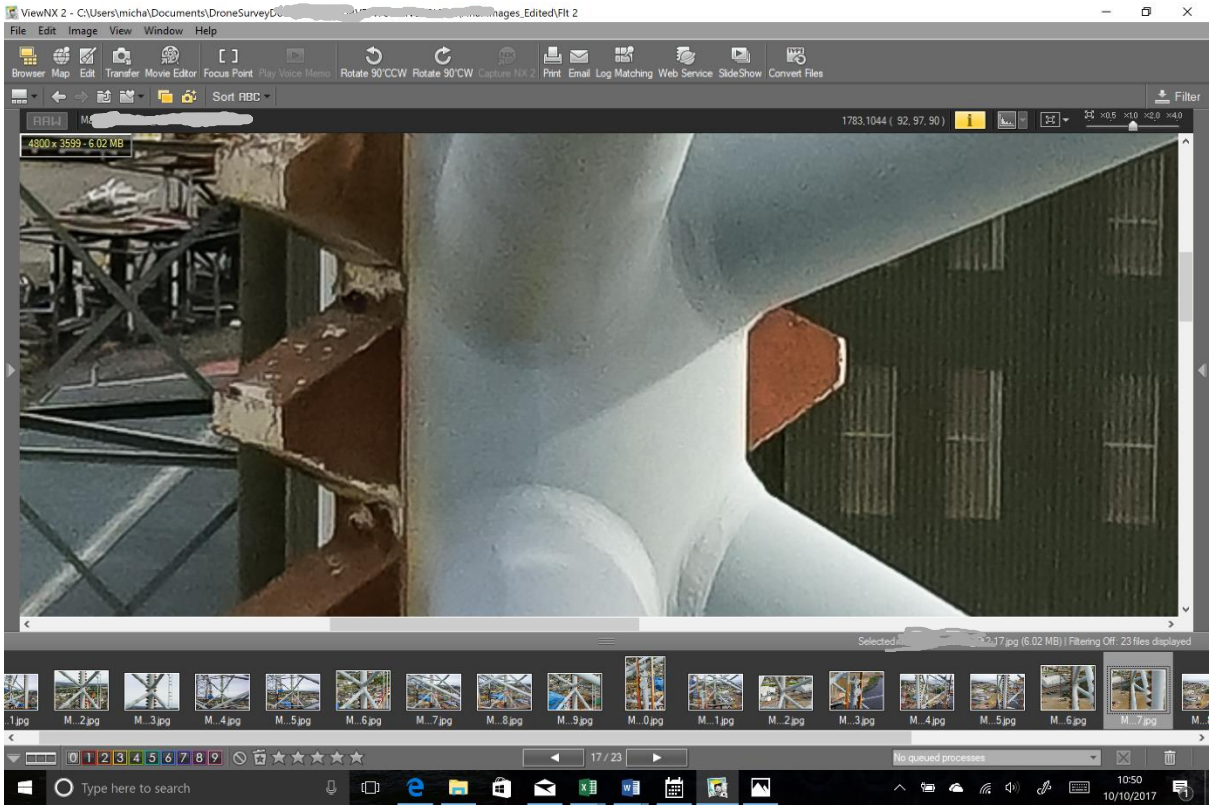
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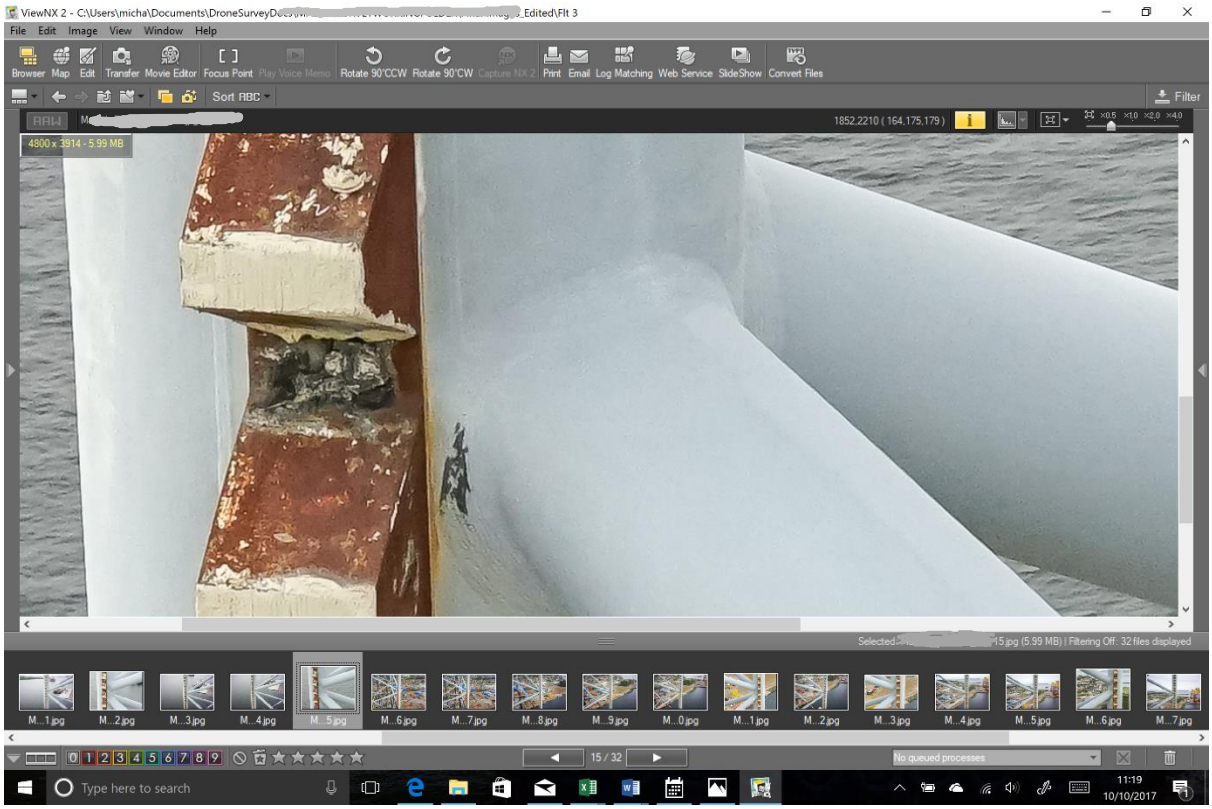
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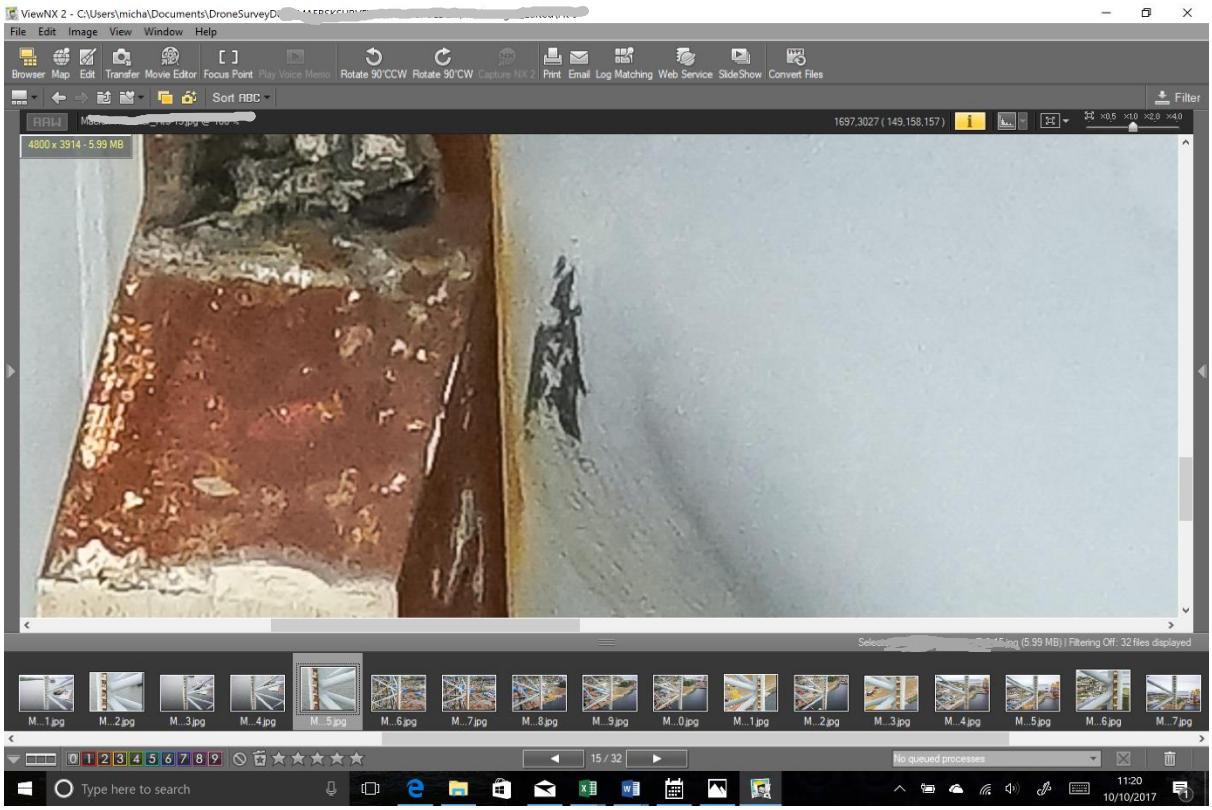
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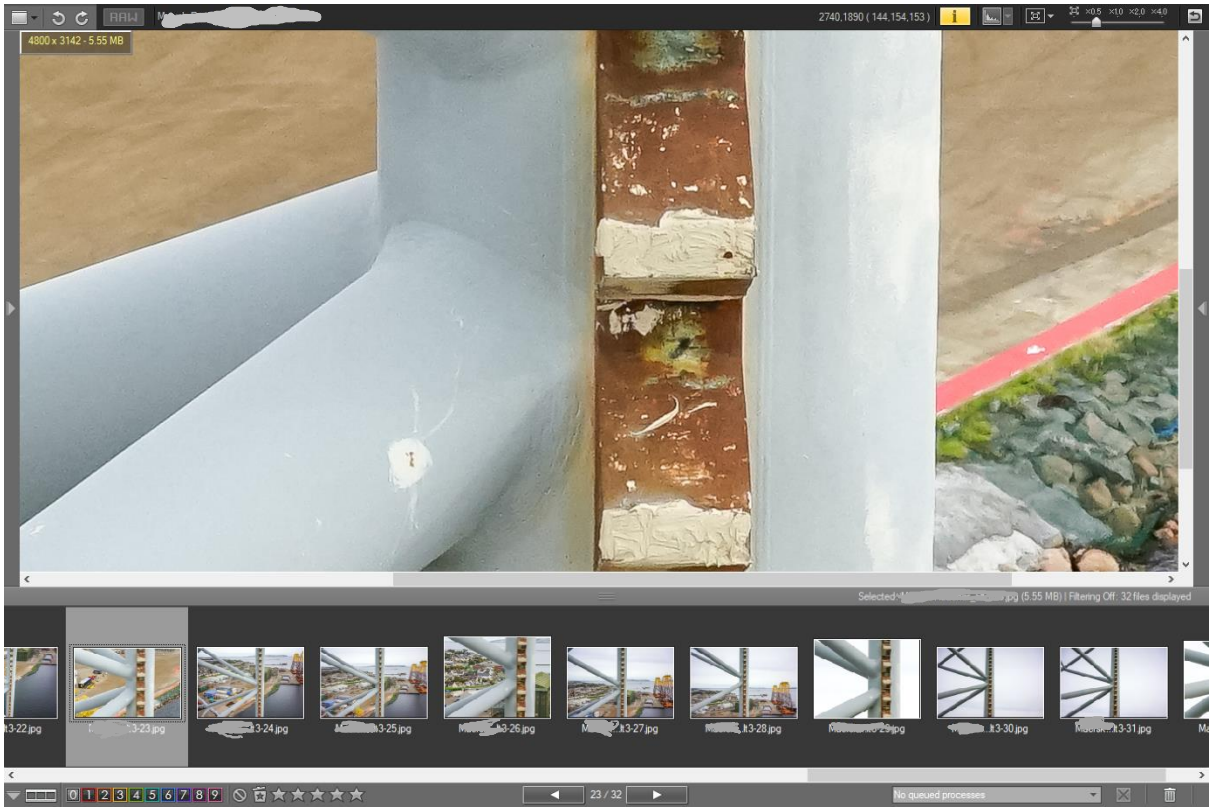

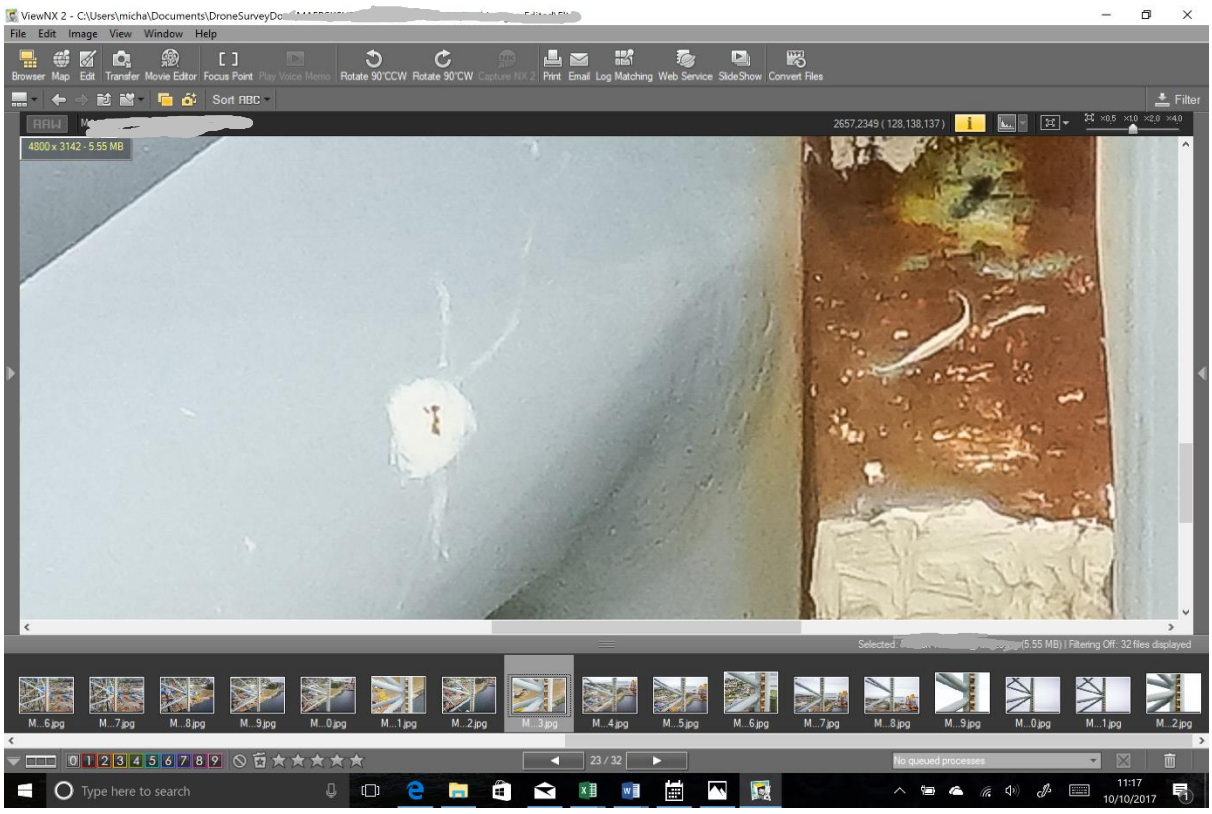

4.1.2 SUBSEQUENT TARGETS T3-T4: SELECTED RAW IMAGES

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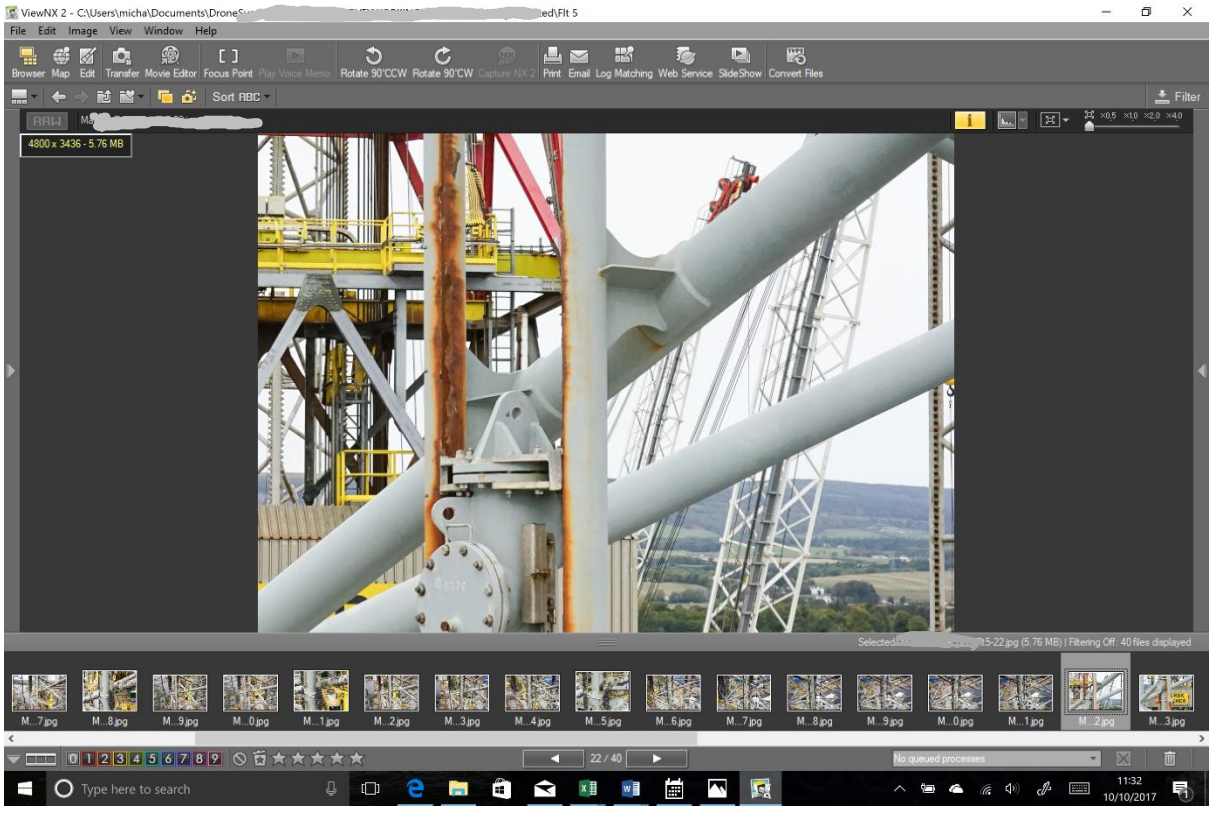
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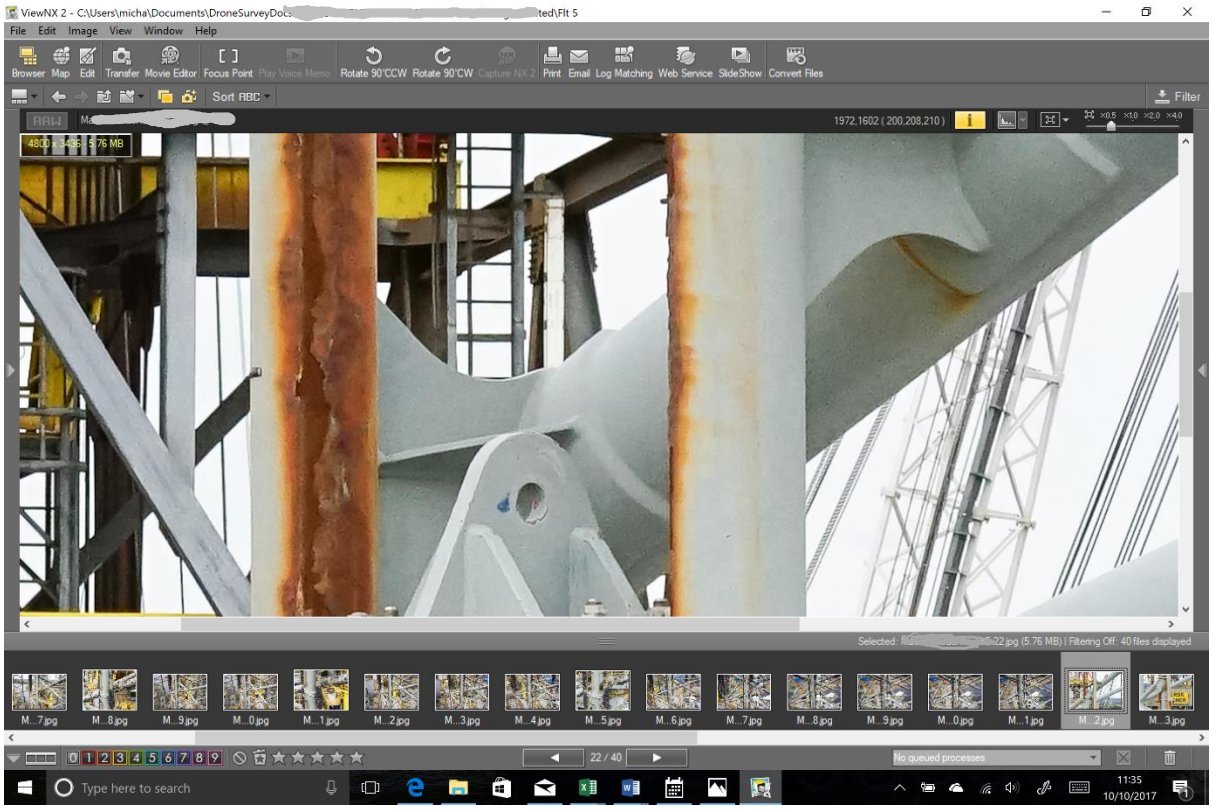

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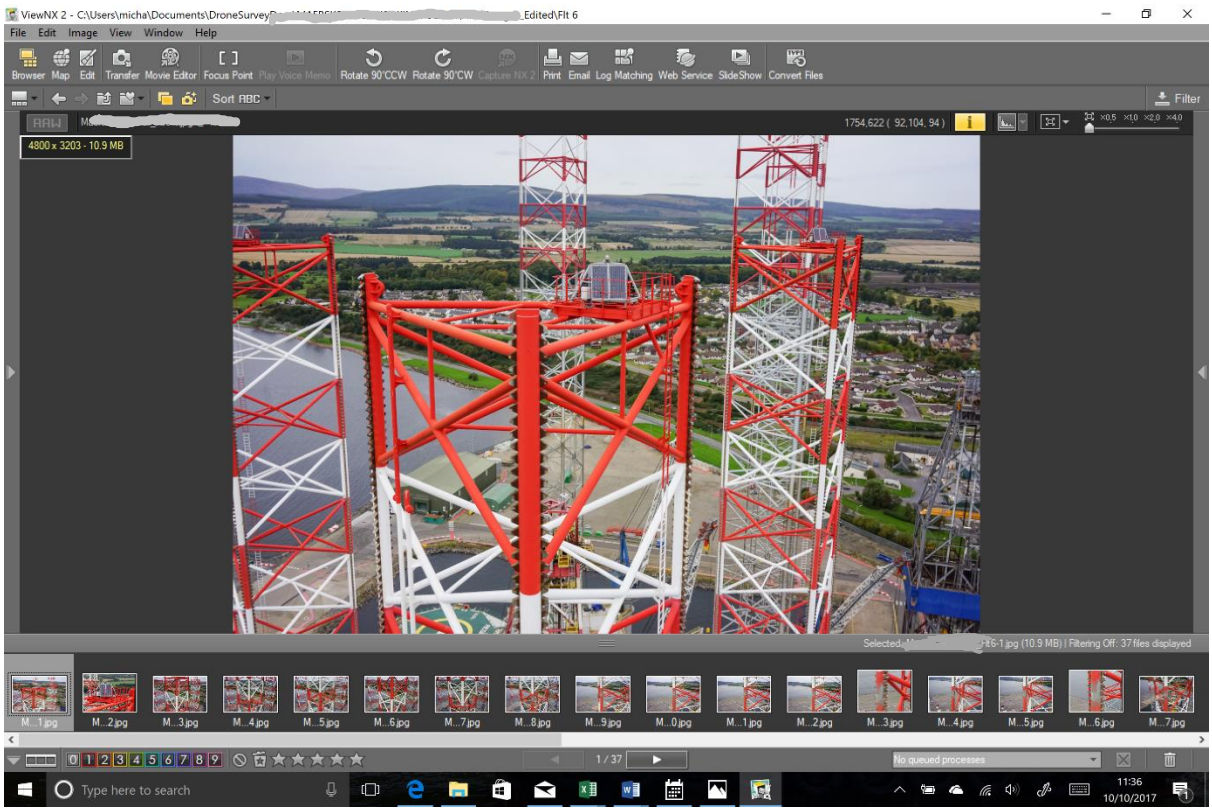

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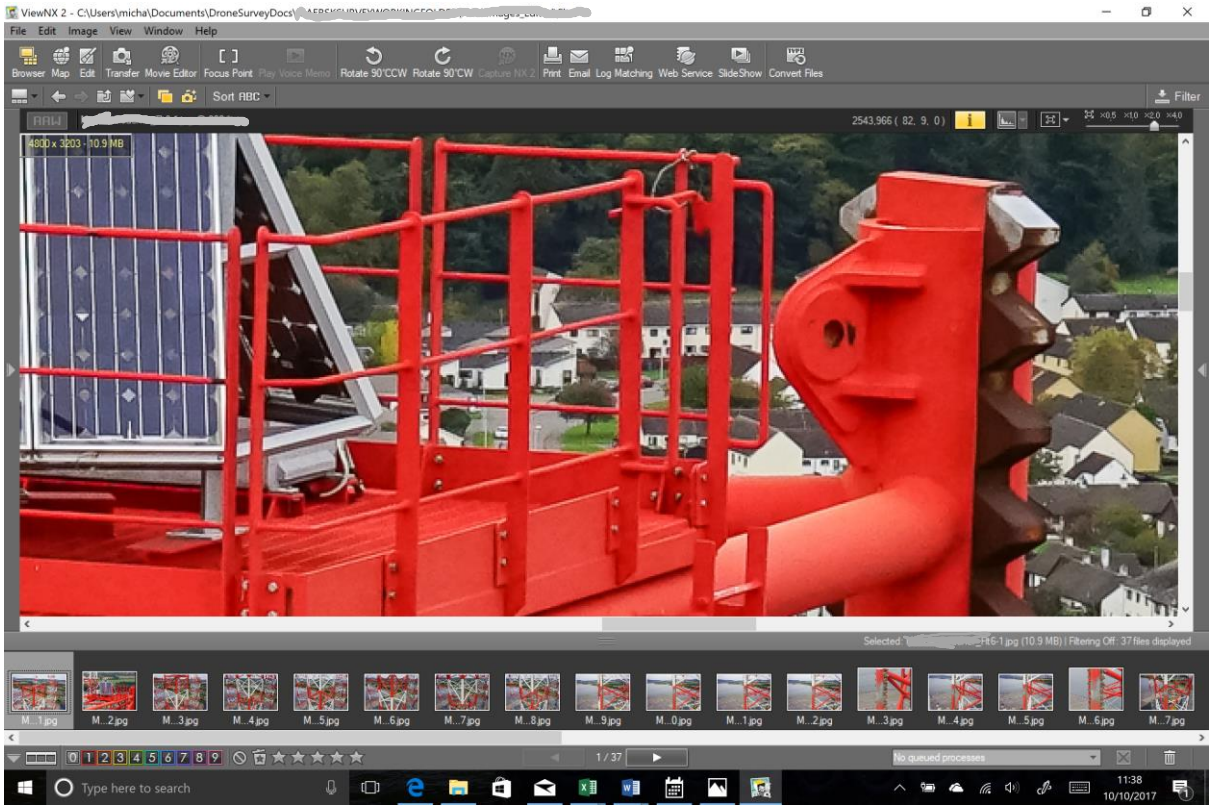
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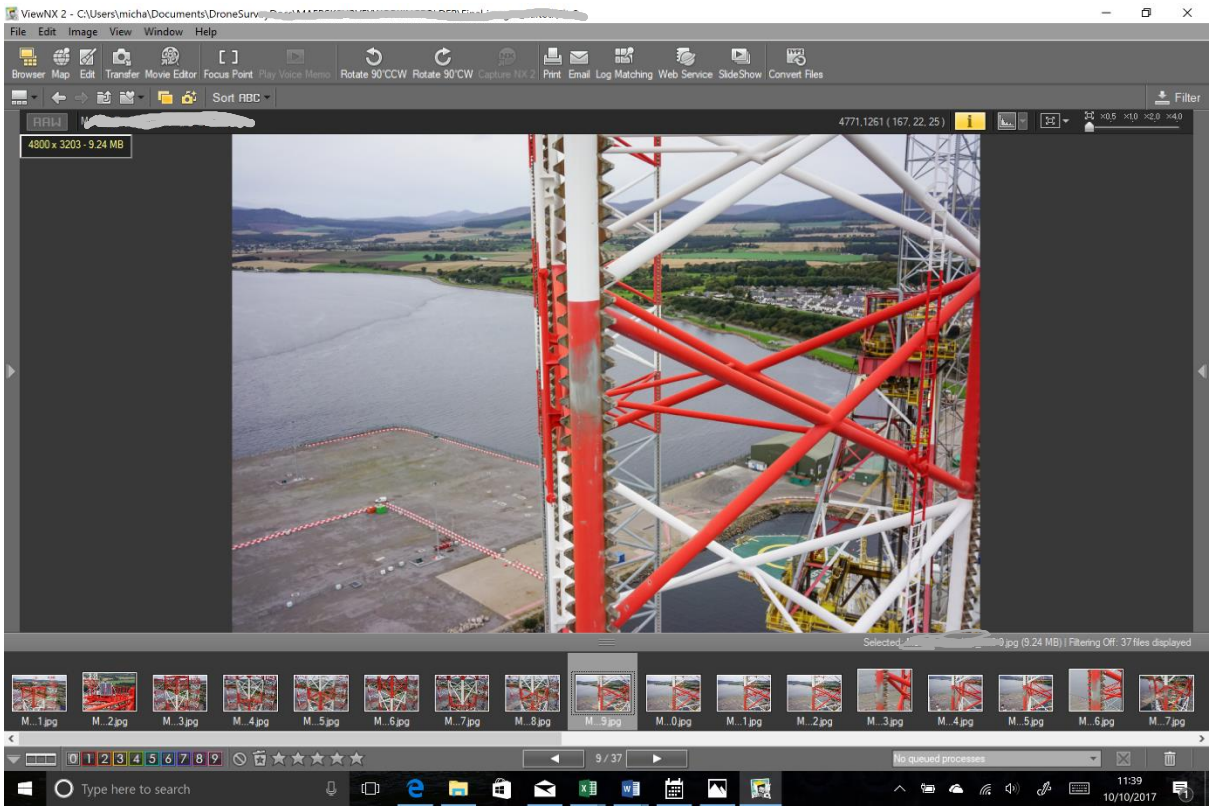
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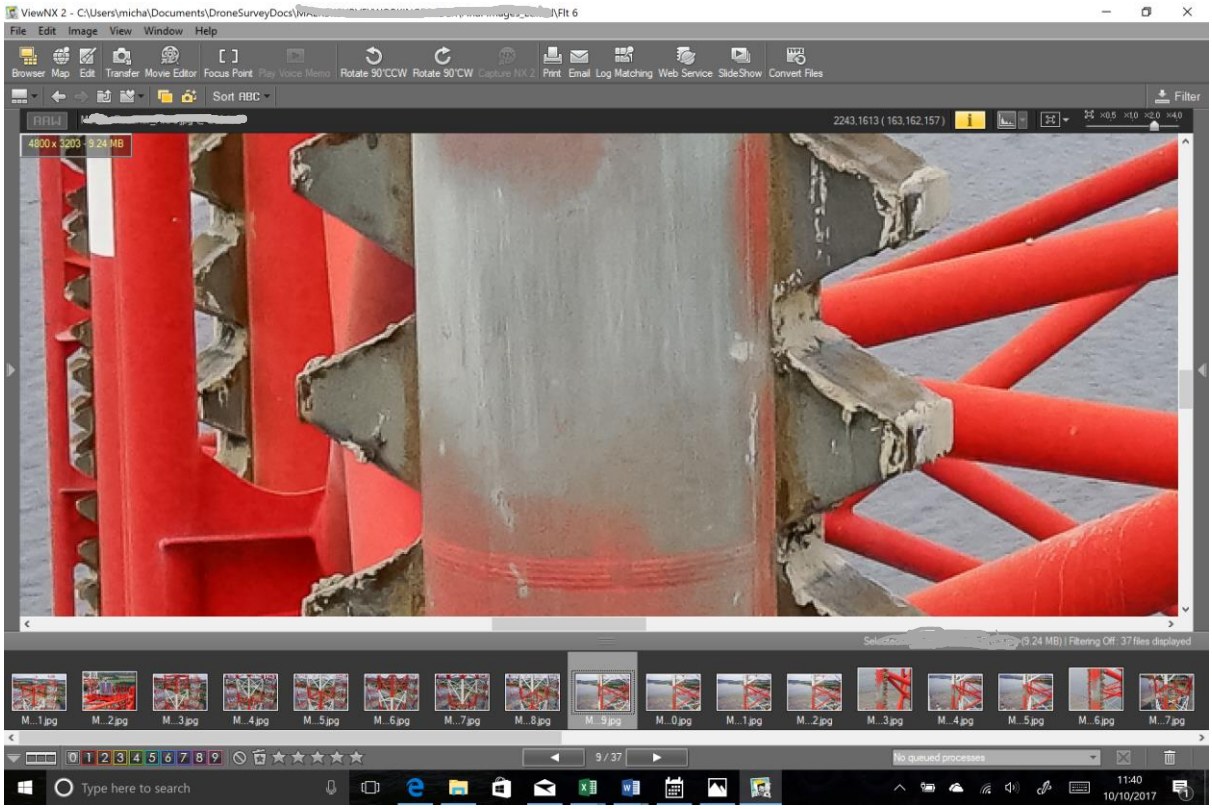
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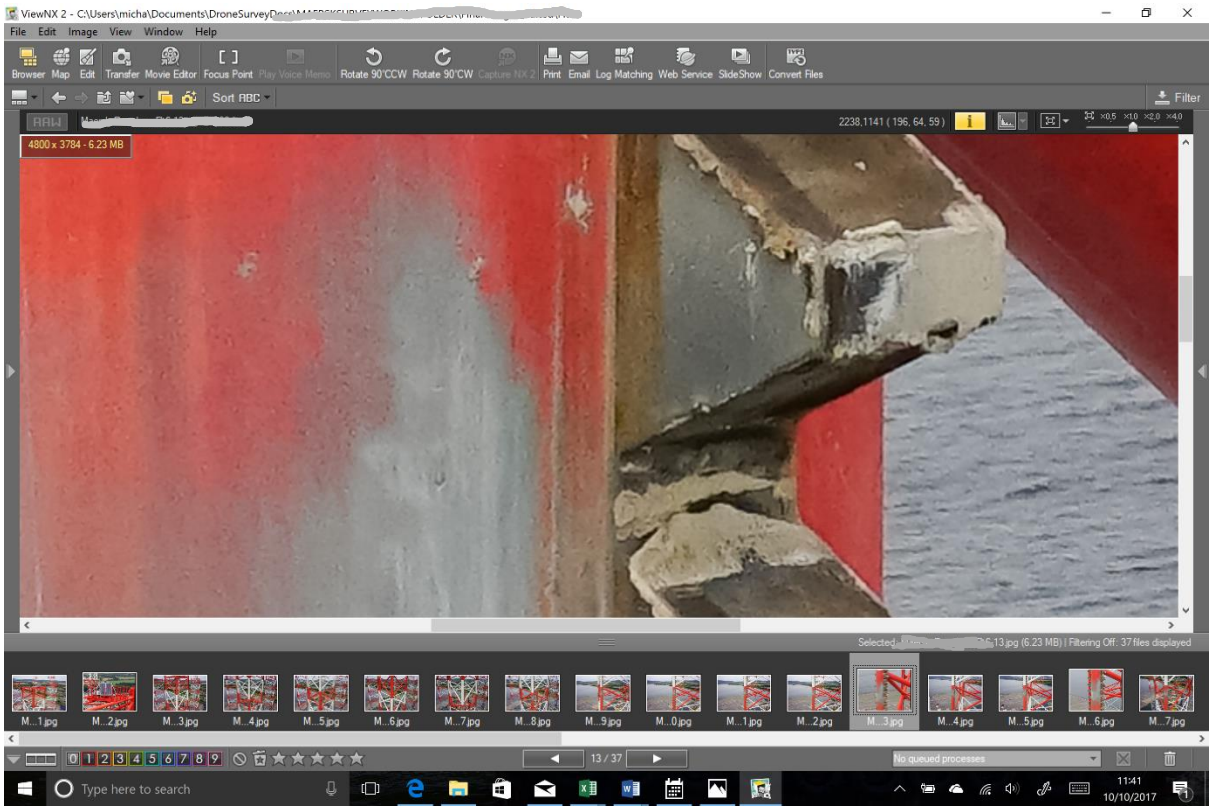
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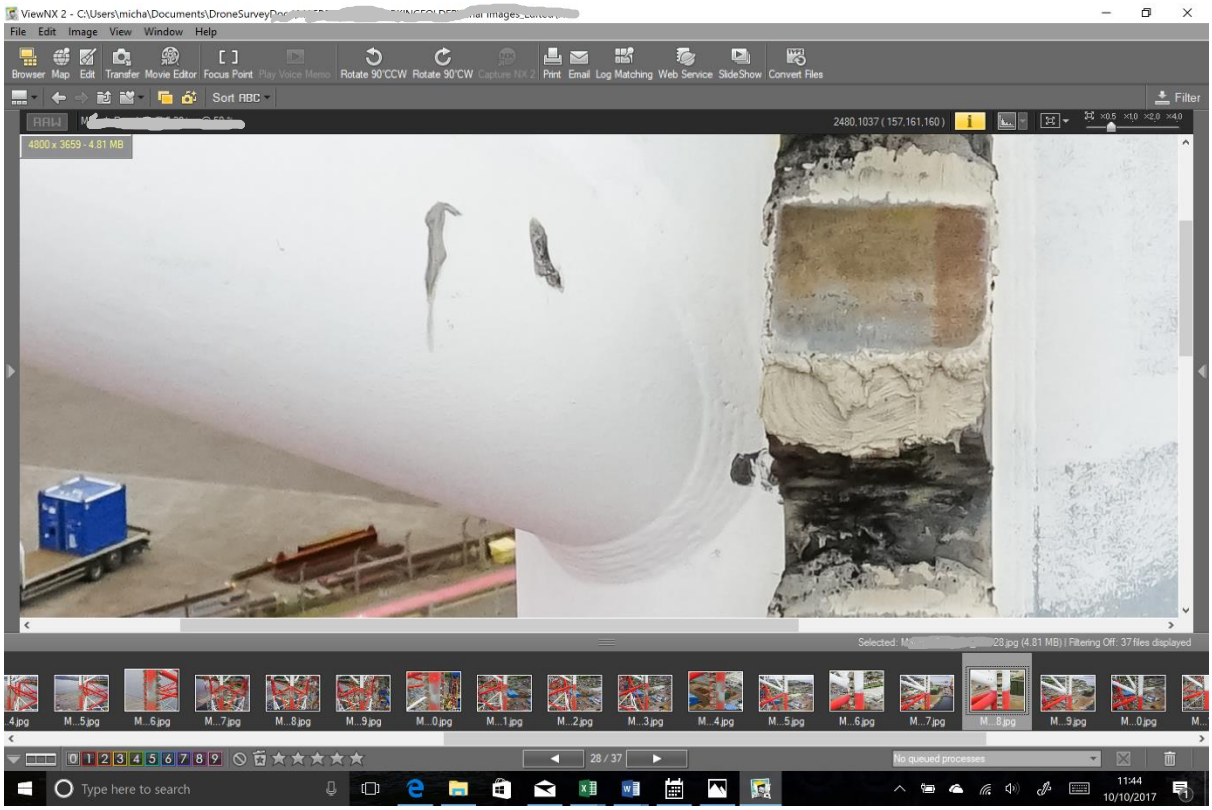
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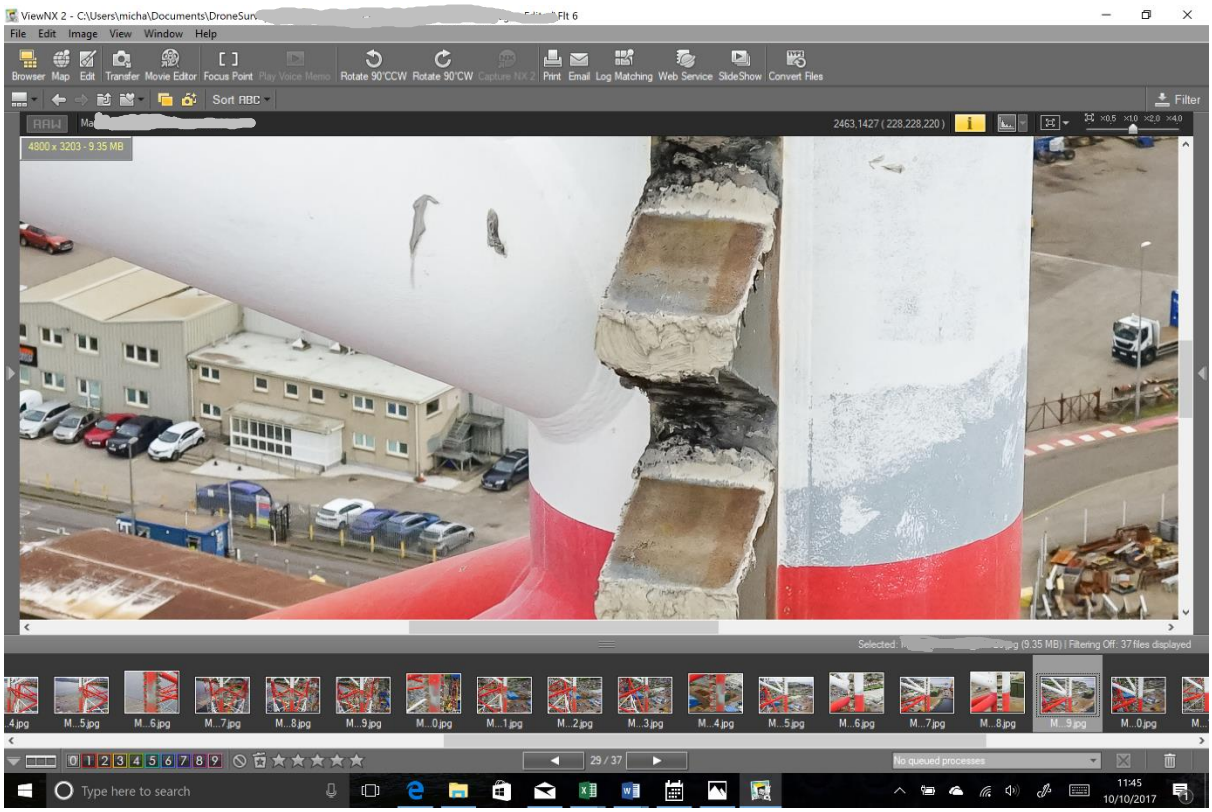
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4.2 CLIENT CONFIDENTIAL

4.2.1 AREAS OF INTEREST

Removed for Client Confidentiality