# BOF

# NR Panoptic Examination Update

# In2Track2: Sub task 5.3.2 Optical monitoring methods for geometry and digitalisation

…to create digital twins of existing structures to be studied over time to provide objective information of visible changes.

- *Which technologies are suitable for identifying defects in masonry and which defects?*
- *Is the accuracy of the surveys sufficient to meet the requirements in our standards?*
- *Is it viable to use these technologies always in the railway environment?*
- *Are multiple technologies required to survey different aspects of the bridge and how the outputs of these can be linked?*

# Project Scope:

Develop a practical workflow and associated technologies to monitor bridge condition with UAVs.

## Deliverables

- *3D digital models of 6 bridges*
- *Digital capture requirement for masonry bridges*
- *Tools and technologies for data processing, including 3D scanning data and thermal imaging data*
- *Workflow document for bridge monitoring using airborne photogrammetry, cost-benefit analysis and recommendations for further development*
- *Specification for generic data capture and storage*
- *Data specification for future machine learning approach for surface defects identification.*

# Step 1: Data Acquisition

UNDERTAKE ONSITE RISK ASSESSMENT → UNDERTAKE THERMAL SURVEY → SET OUT GROUND CONTROL POINTS → UNDERTAKE VISIBLE SPECTRUM SURVEY → CHECK DATA COLLECTED → SURVEY GROUND CONTROL POINTS

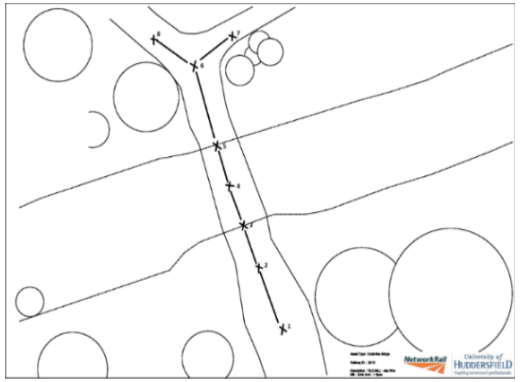
- UAV

The structures were surveyed using thermal and visible spectrum UAV mounted sensors

*Equipment :*
*DJI Matrice M210 Quadcopter fitted with two different sensors.*

- *Zenmuse XT2 Thermal Sensor (640x512 30Hz, with a 13mm lens) for the thermal survey*
- *Zenmuse X5S RGB 20MP camera with a 45mm lens (35mm Equivalent = 90mm) for the visible spectrum survey .*

- Terrestrial Laser Scanning

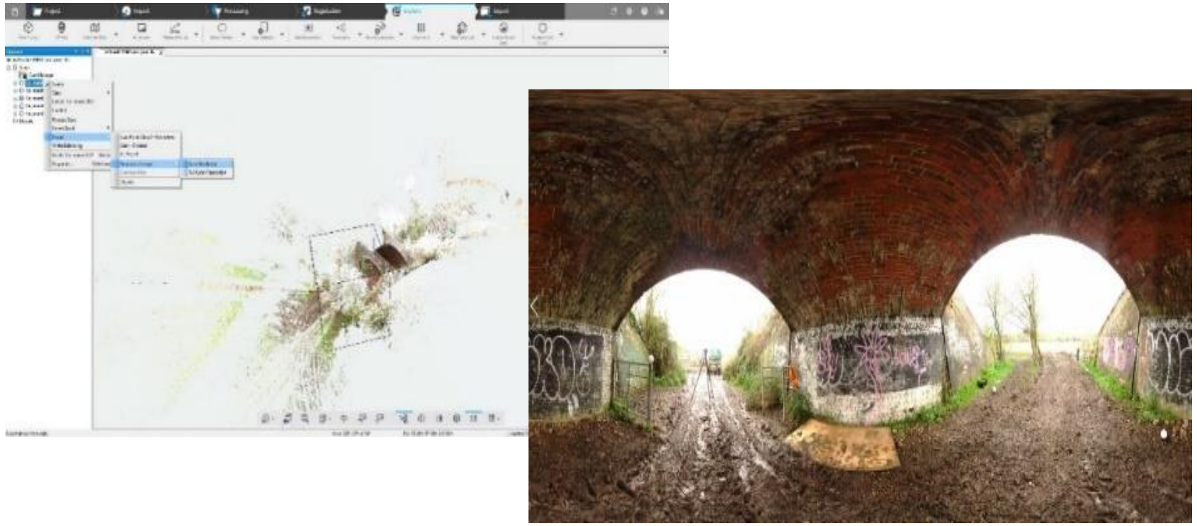


Generation of Scan Map


Setting the Laser Scanner on Site (Inclinometer, Quality, Resolution)

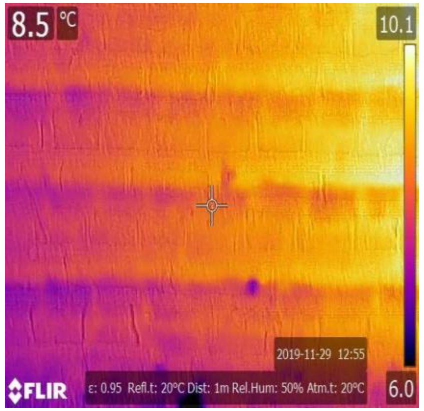
Scanner and Target Placement

- Panorama imaging using terrestrial laser scanner



- Panorama imaging using 360 imaging camera (iSTAR)

- Thermal Imaging

# Digital capture requirement for masonry bridges

## Examples of the proposed digital capture requirements

| DEFECT TYPE | REQUIRED MEASUREMENT | DATA ACQUISITION | DATA ANALYSIS |
|---|---|---|---|
| BULGING (Bulging) | • Estimated % of the visible surface<br>• Area or principal dimension<br>• Affected<br>• Square area (m2)<br>• Length (mm)<br>• Width (mm) Magnitude of distortion (Degrees) | • Panorama Imaging<br>• TLS (point cloud) | • Point cloud analysis (comparison)<br>• Point cloud analysis (surface analysis) |
| CRACK/ FRACTURE (Crack) | • Estimated % of the visible surface<br>• Area or principal dimension<br>• Affected<br>• Square area (m2)<br>• Aperture (mm)<br>• Length (mm)<br>• Step (mm) | • Panorama Imaging<br>• TLS (point cloud) | • Machine Learning – image classification<br>• Point cloud analysis (comparison)<br>• Point cloud analysis (surface analysis) |

# Step 1 Additional innovative examination technologies

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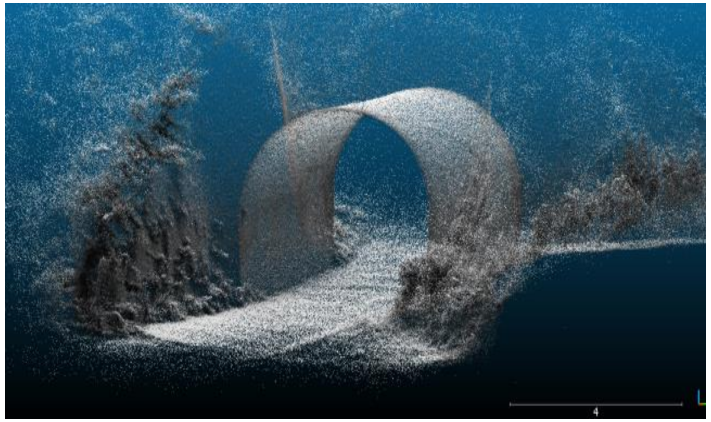
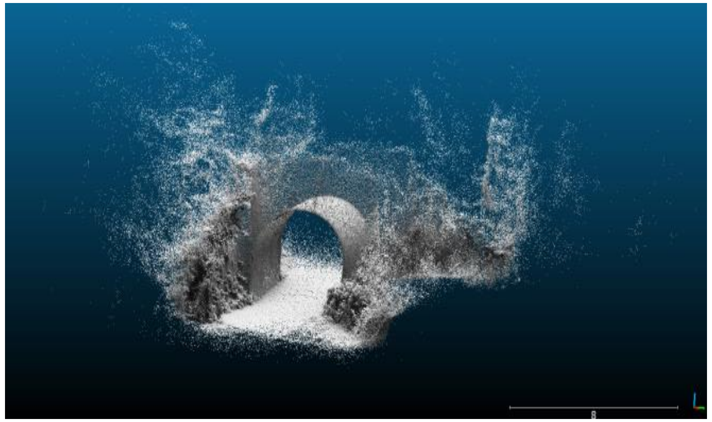
## Matterport

Faster but no single capture


## Geo Slam Horizon

Faster but low density





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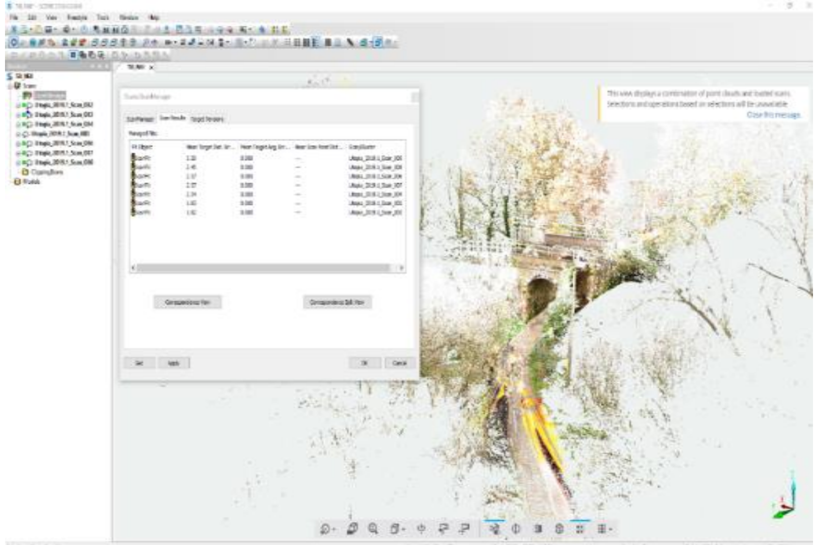
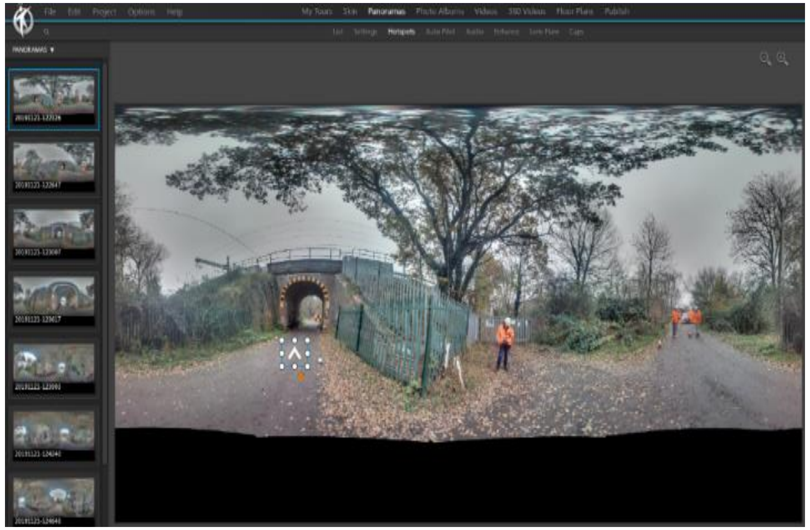
# Step 2&3 Data processing and analysis

- TLS



- Data processed using FARO SCENE software
- Target based registration to achieve required accuracy

- Panorama Images



- Data processed using 3D Vista Software
- Hotspots (i.e. active field within the panorama) required to link two or more images.

- UAV images

Collate Images into 4 groups

↓

Process RGB images using PIX4D

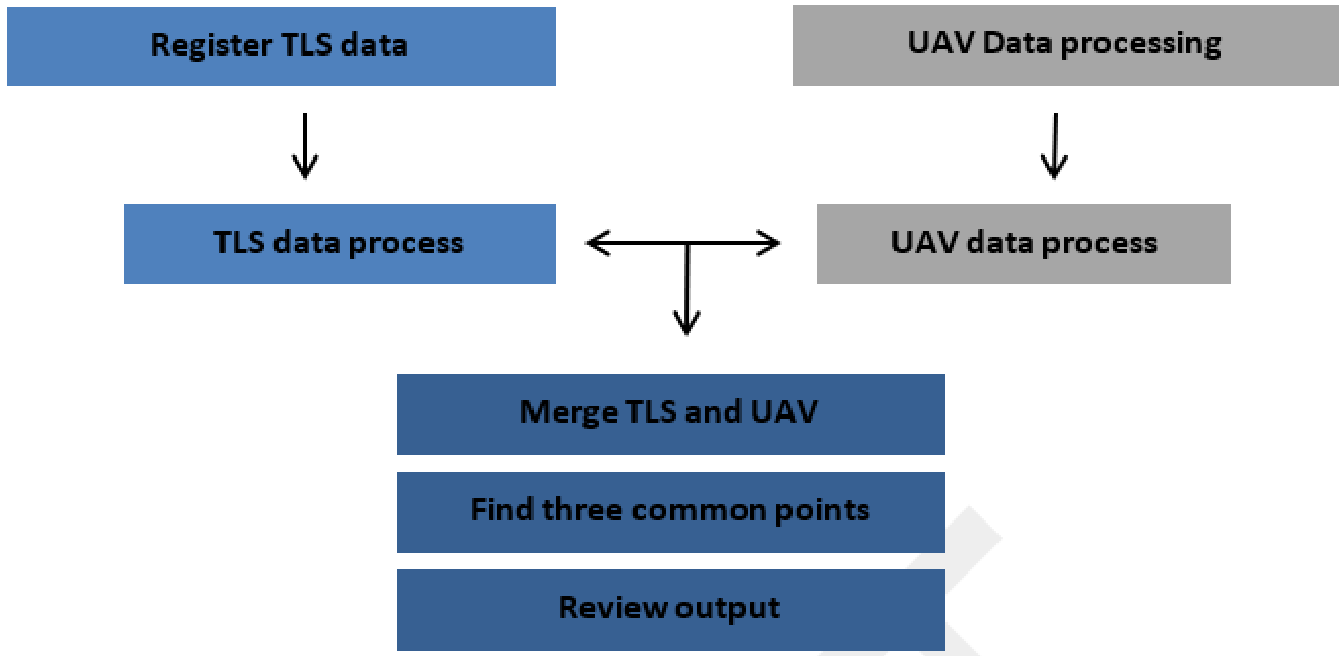
↓

Review Outputs

↓

Issue Data

# Data processing for merging UAV and TLS

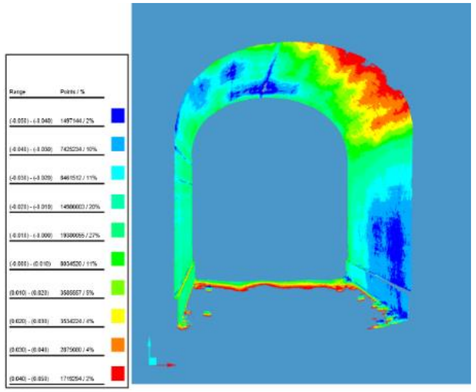


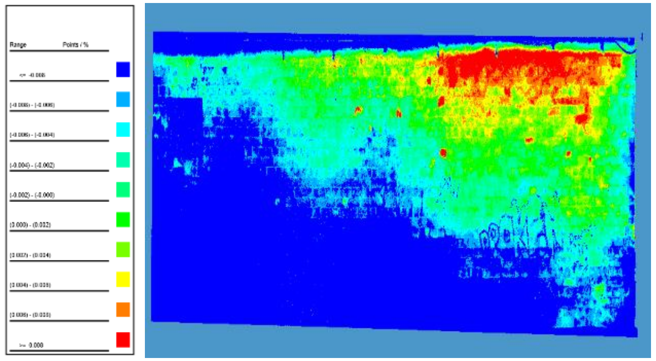

*Ground control points suitable for TLS and UAV were identified in advance. This allowed with the use of coordinates from the Ordnance Survey National Grid the two surveys to be linked.*
*The two point cloud surveys were imported in Recap Pro and three common points aligned.*

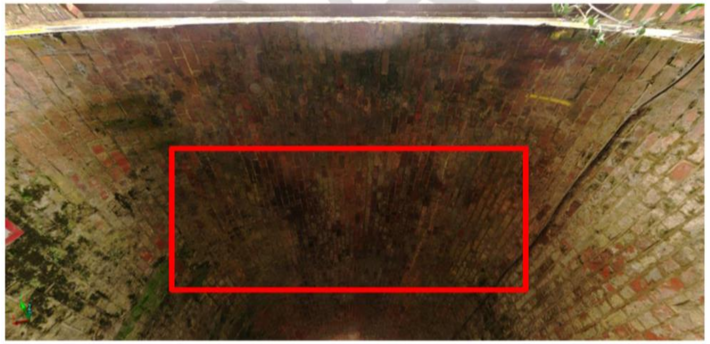
# Step 3 Point Cloud Data Analysis

1. Surface Analysis
2. Creation of bridge surface
3. Creation of alignment
4. Creation of section
5. Generation of the surface
6. Run the surface analysis
7. Interpret the results

*Vision Lidar software used for the analysis.*

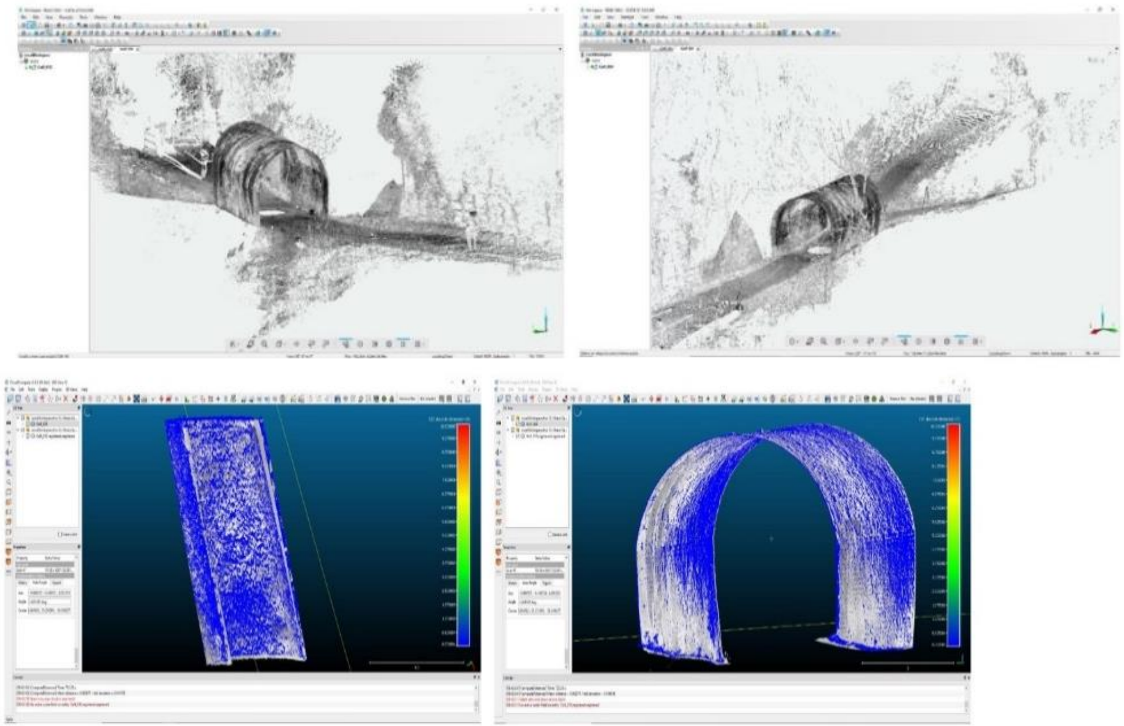






# Step 3 Data Analysis

- Point Cloud Analysis *Comparison of multiple scans*

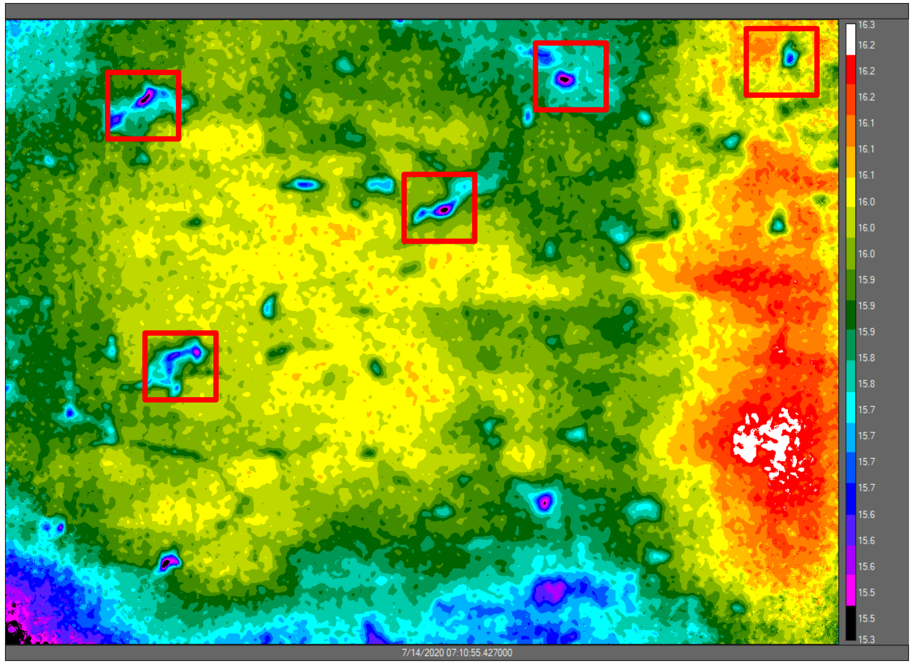


*CloudCompare software used.*

- *Selected scans should be in the middle of the bridge*
- *Noises around scans should be removed*
- *Scans should be aligned using 'Translate/rotate' functions and 'Finely register already alignment entities' functions;*

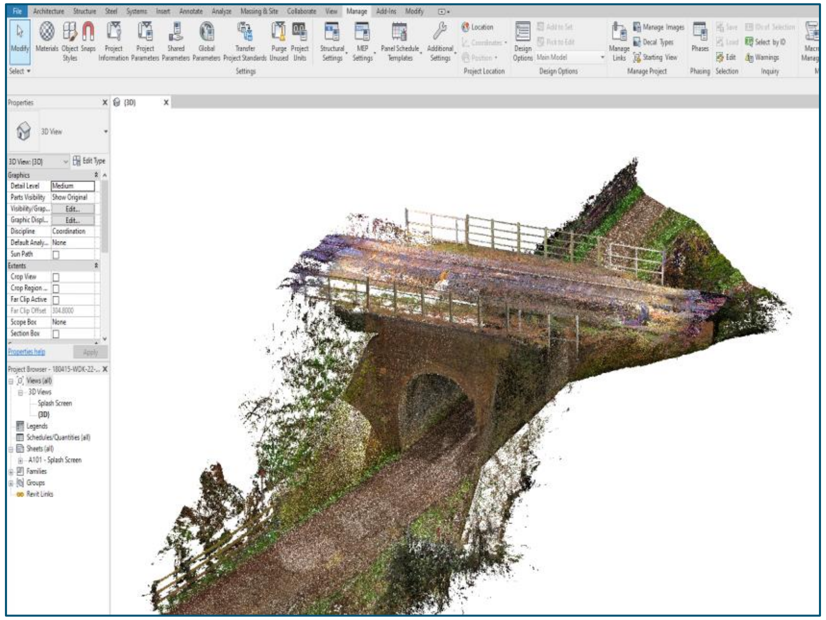
- Thermal Images

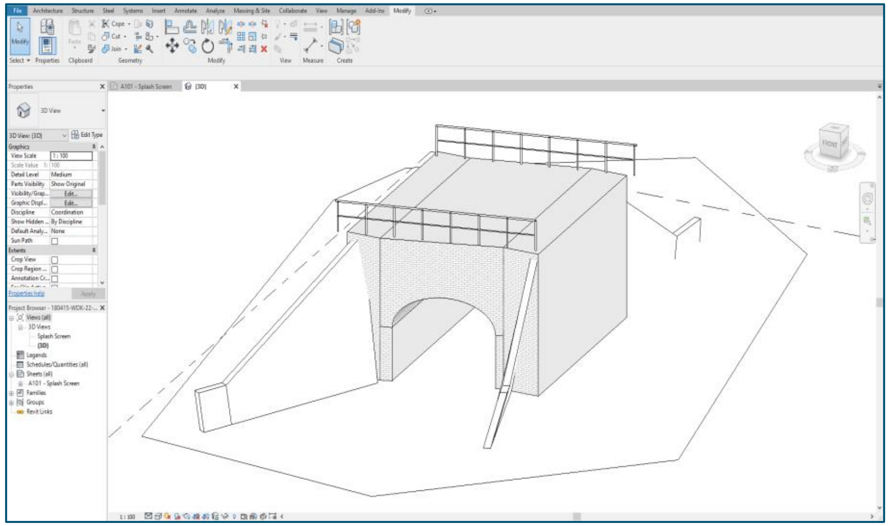
*Detection of moisture and dampness*



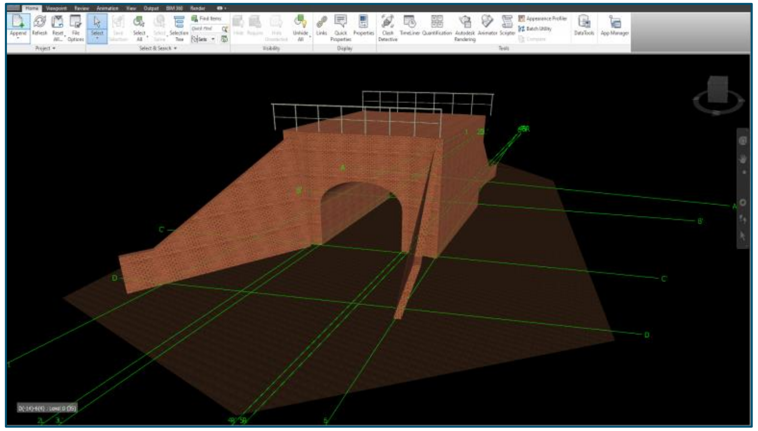
*Flir ResearchIRMax software used.*

# BIM Generation (Scan to BIM)





*Digital twin with standard NR bridge component created based on TLS survey.*



*AutoDesk Revit 2020 software used.*

# Specification for generic data capture and storage & Resource requirements

- Examples of the proposed specification for data capture and storage

| DEVICE | FUNCTION | CONFIGURATIONS | RESOLUTION | APPROX. SCAN DURATION PER SCAN [MM:SS] | OUTPUT TYPE & FILE FORMAT | APPROX. FILE SIZE [MB] | STORAGE CAPACITY [GB] |
|---|---|---|---|---|---|---|---|
| FARO Focus 3D (X330) | Terrestrial laser scanner | Point distance [mm/10m] 6.136 | 10240 × 4267 pt | 06:00 Scan duration depends on configuration and resolution settings. | (fls) is the file format for the RAW data from Faro Focus, see example section for more details | ºThe file size of each scan using previous configuration and resolution settings is approx. (250 MB). | Storage capacity depends mainly on scan size and number of scans, the RAW data size of (7) scans is approx. (1.72 GB) |
| ISTAR | 360 panoramic cameras | Env. Outdoor Light: Normal Exposure: ¼ ISO: 400 HDR: Auto | 2748 × 3664 px | 03:00 Scan duration depends on configuration settings | (nctri) see example section for more details | The file size of the RAW data of each scan before processing is (370 MB) | Depends on the number of scans, the size of (10) scans is approx. (3.60 GB) |

- Data processing time

| DATA PROCESSING | | |
|---|---|---|
| **TERRESTRIAL LASER SCANNER** | 3 hours | Target-based or target-less registration should be performed using the appropriate software such as FARO SCENE |
| **PANORAMA IMAGING USING ISTAR** | 2 hours | 360 virtual tour can be created using software such as 3D Vista, in which hotspots should be created to stick images together. |
| **PANORAMA IMAGING USING MATTERPORT** | 30 minutes (Automatically, without human intervention) | The captured data should be uploaded to Cortex AI, and then 360 virtual tour will be generated. |
| **THERMAL CAMERA** | 1 hour | Images should be inserted to the Flir ResearchIRMAX, appropriate palette and setting (temperature, humidity, emissivity) should be selected. |

# Step 4: Key Findings & Recommendations

- Data Acquisition
  - TLS is an efficient and reliable technology to digitalise the bridge condition and generate BIM compatible model from could data;
  - Panoramic images can be obtained from TLS;
  - UAV offers significant advantages capturing topside. The resultant images can be integrated with TLS data;
  - Thermal imaging is efficient to detect certain defects related to moisture and water penetration;
  - Other emerging technologies offer rapid capture of panoramic images and low resolution point cloud which could be used for BIM generation;
- Data processing
  - Time consuming;
  - Digital twin creation from point cloud can be automated;
  - Small surface changes can be detected through point cloud analysis.
- Recommendations
  - Development of visual inspection visualiser to integrate various datasets in a single platform;
  - Develop digital model further to enable attachment of inspection data;
  - Develop reliable surface training sets for machine learning;
  - Deploy machine learning tools as an aid to support evaluation of bridges.

# Thank you for listening