ADDRESSING COMPLEXITY AND QUALITY IN 3D DIGITAL DOCUMENTATION OF IMMOVABLE CULTURAL HERITAGE:

THE FORTH BRIDGE UNESCO WORLD HERITAGE SITE CASE STUDY

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HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

THE FORTH BRIDGES

3D e-CULTURE

DIGITAL DOCUMENTATION & DIGITAL INNOVATION @HES

Use a range of digital technologies to document our heritage in 3D

Apply digital documentation data to assist in conservation, site management, learning, interpretation & accessibility

Apply innovative digital techniques for the benefit of the historic environment

Participate in applied scientific research of relevance to the heritage sector

Collaborate with local, national and international partners

Participate in training programmes, community engagement and outreach

Provide advice and guidance to the heritage sector

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Defining Complexity and Quality in Digital Documentation: Historic Environment Scotland Perspective

Definition of degrees of complexity for Immovable Objects

- Accessibility & Logistics
- Surface Geometry
- Material properties
- Risk
- Scale
- Physical and environmental obstacles
- Weather
- Lighting conditions
- Project deliverables e.g. CAD, 3D models

Quality of the digital documentation project is dependent on how well you address the degrees of complexity.

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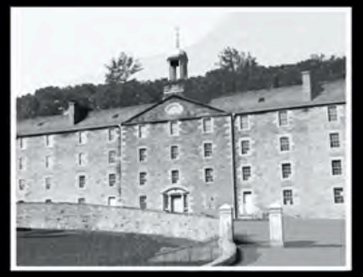
SCOTTISH TEN



New Lanark

The Antonine Wall

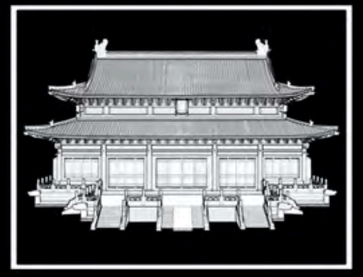
Heart of Neolithic Orkney

St Kilda

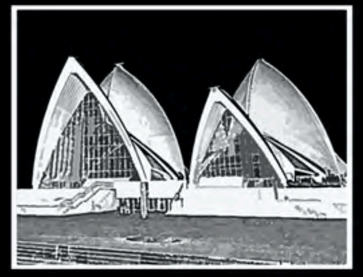
Old and New towns of Edinburgh

Mt Rushmore

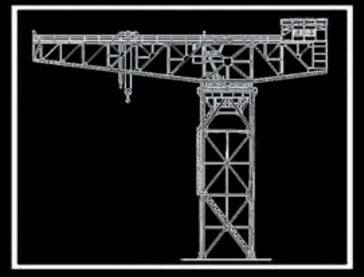
Rani Ki Vav
The Queens Stepwell



Eastern Qing Tombs



Sydney Opera House

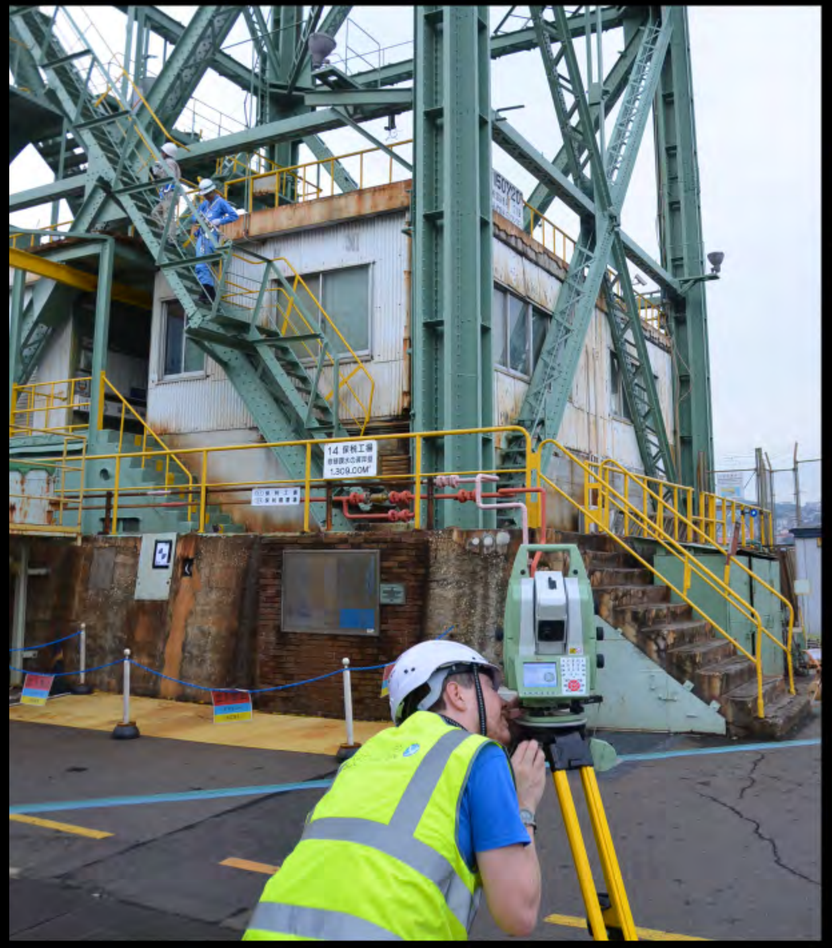


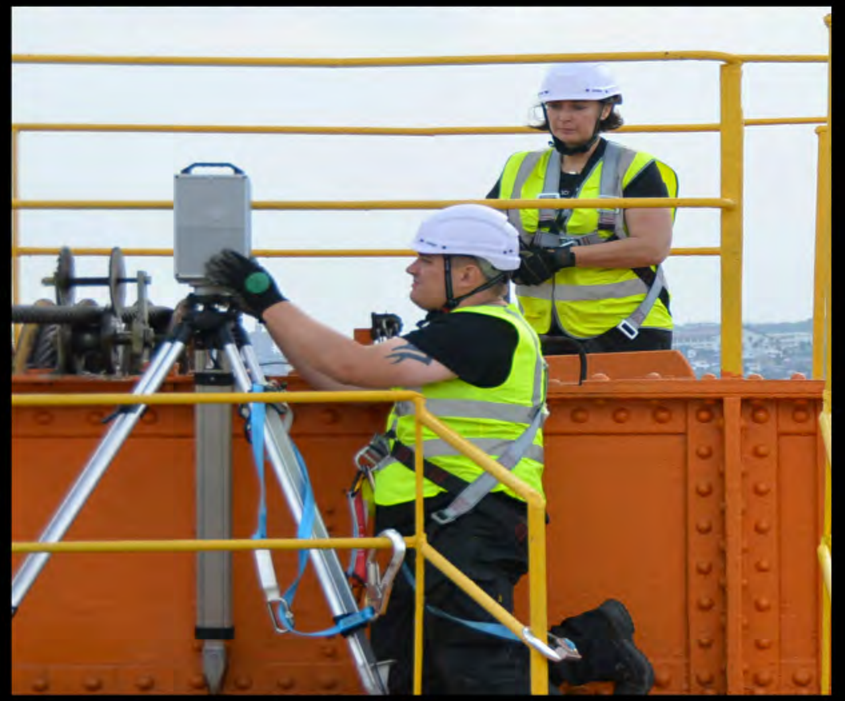
Nagasaki
Industrial Heritage

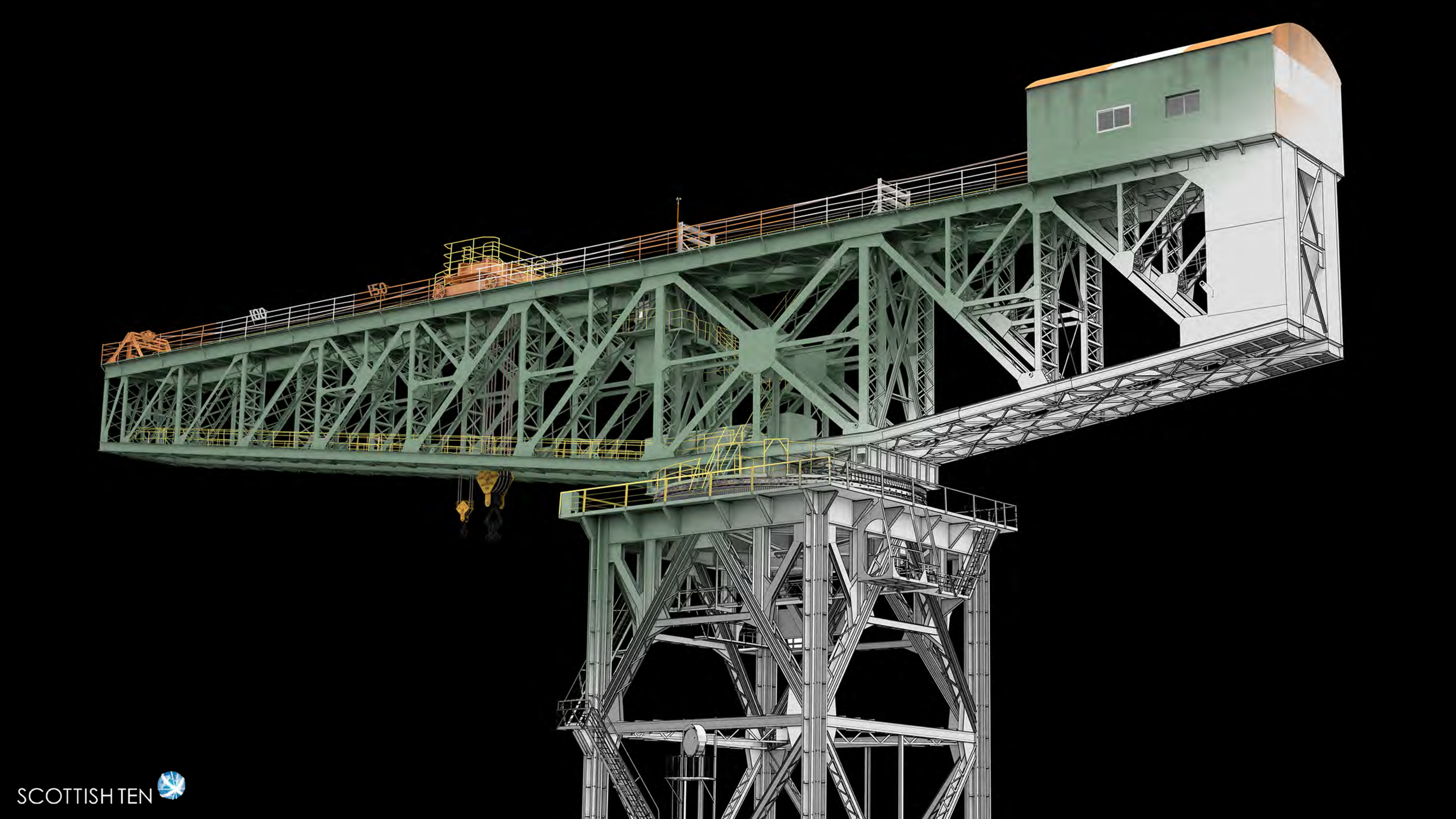
Our five year project using cutting edge technologies to create exceptionally accurate 3D digital models of Scotland's five UNESCO World Heritage Sites and five international heritage sites in order to better conserve and manage them.

Sites of Japan’s Meiji Industrial Revolution

Nagasaki, Japan







SCOTTISH TEN

Digitally Documenting The Forth Bridge

The Brief

To digitally document the Forth Bridge ensuring as much coverage as possible at a resolution which allows for condition monitoring and to aid ongoing maintenance work.

Challenges

- Spans over 1.5 Km of tidal water
- Is 2.5 km long in total length
- Is 110m tall at its highest point
- Is a live operational railway line
- Is subject to extreme weather conditions
- Has complicated and dangerous access issues
- Is owned and operated by different companies
- How to make the data accessible
- Extremely complicated repetitive geometry
- The resulting 3D survey should be made accessible to every school child in Scotland.

The Scottish Government

TRANSPORT SCOTLAND
CÒMHDHAIL ALBA

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

Network Rail

vital

Balfour Beatty

amey

FORTH ROAD BRIDGE

Calypso Marine

FCBC
Queensferry Crossing

Geckotech Solutions Ltd
Quality Access Services

CDDV
Centre for Digital Documentation and Visualisation

Survey Control

Primary Control Network

Navigator

Library
- Points
- Scans
- Traverses
  - MAIN
  - MAIN2

Source
- 150601_FB_MAIN
  - P2 (Set orientation)
  - P3 (Known Backsight)
  - P5 (Known Backsight)
  - P4 (Known Backsight)
  - P4 (Known Backsight)
  - P6 (Known Backsight)
  - P7 (Known Backsight)
  - P8 (Known Backsight)
  - P9 (Known Backsight)
  - P10 (Known Backsight)
  - P11 (Known Backsight)
  - P1 (Known Backsight)

Archive
- Exported Files

Inspector

Points, Lines & Areas | Processing | Surfaces | Sca

Points | Lines | Areas

Points

Point Id	Point Rol
P4 (01/06/2015 11:04:04)	TPS Setup
P5 (01/06/2015 10:40:52)	TPS Setup
P6 (09/06/2015 10:44:56)	TPS Setup
P7 (09/06/2015 12:05:59)	TPS Setup
P8 (09/06/2015 13:07:29)	TPS Setup
P9 (12/06/2015 10:13:07)	TPS Setup

Property Grid

P3 (Known Backsight)

Station

Position Source	P3
Point Role	TPS Setup
Date/Time	01/06/2015 10:06:24
Instr Hgt	1.6220 m
Instr Type	MS50 1" R2000 368276
Color	By Layer

Station Coordinate

Easting	825.3745 m
Northing	1474.6760 m
Height	52.8680 m
Ellips. Height	- m
Geoid Separation	- m

Orientation

Setup Method	Known Backsight
Azimuth	18° 23' 15.26"
Orientation Correction	0° 00' 00.00"

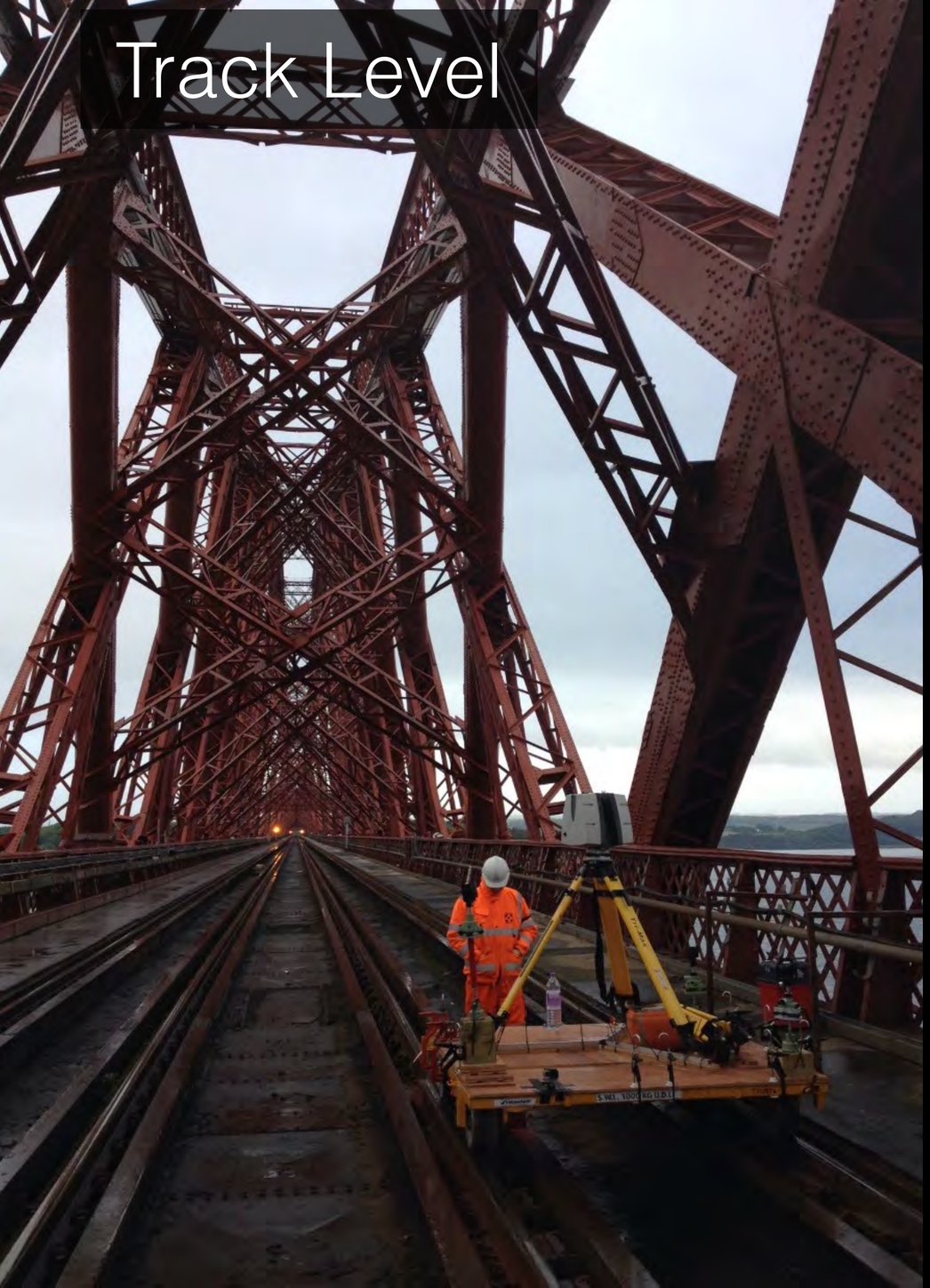
Station Target

Target Point	P2
Point Role	TPS Setup
Target Hgt	1.6070 m
Target Type	Leica Circ Prism
Easting	1000.0000 m
Northing	2000.0000 m
Height	50.0000 m
Ellips. Height	- m
Geoid Separation	- m
Δ Hz Dist	-0.0004 m
Δ Ht	-0.0037 m

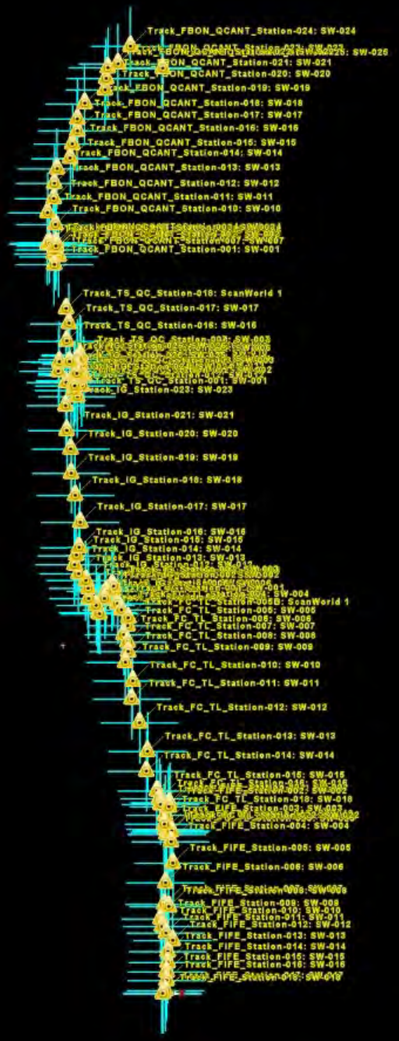
Cancel | Apply

Meter | DMS | None

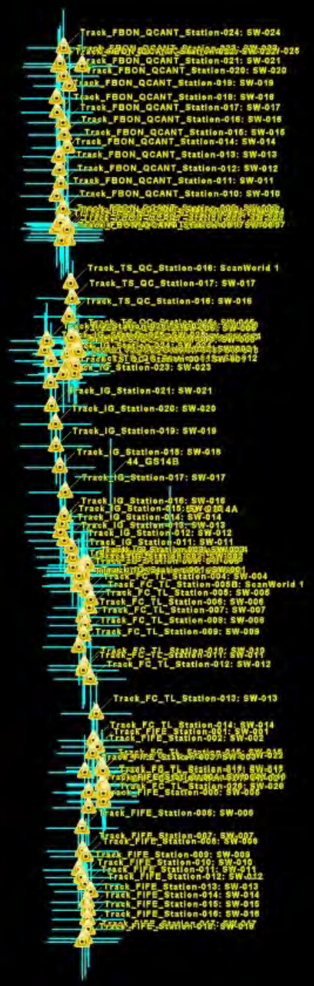
Track Level



Improving Track Level Spatial Data Alignment



Before GNSS control



After GNSS control

Rope Access

Rope Work

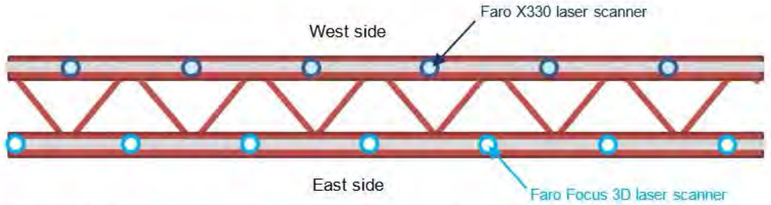


Figure 1: Schematic plan view of parallel top members shows the two scanner positions in ideal offset positions

Where it is possible and safe to access the top outer surface of the top members (at crossover locations between the two parallel walkways) the Geckotech teams will setup the longer range scanner (the Faro X330 in long range mode – see CDDV Faro X330 user guide) to scan at key positions looking (up and down) along the top members. For each up or down section of cantilever this will be a minimum of 3 scans per walkway (See Figure 2 below) i.e.12 scans per cantilever

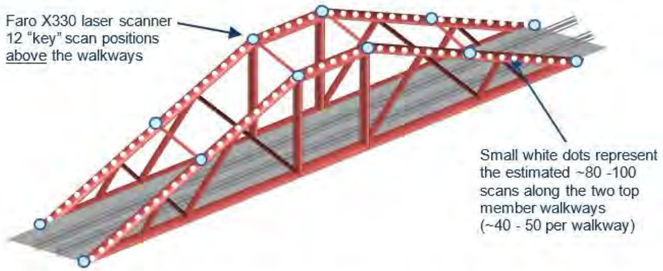


Figure 2: Schematic view of parallel top members shows suggested scanner positions per cantilever when scanning from the recommended positions on the walkways and above the walkways

(xi) When working on the top members and above, the survey tripods will be setup to be stable with three points of contact between the tripods and surface that they are resting upon. The scanner tripods will have harness attachments to temporarily secure them to bridge – this will be undertaken by Geckotech in accordance with their recommendations. When the scanners are moved along the walkways they will be secured by multiple safety lines as recommended by Geckotech. Each scanner will be securely fixed to a tripod with an additional safety line to secure the scanner to the tripod. When moved, each scanner will be covered in a secured padded bag or carefully removed from the tripod and placed into a padded transport rucksack. The scanner should never be detached from the tripod without a safety line connecting it to something/someone else.

CDDV Forth Bridges Project
Safe System of Work 5 All survey work on the bridge THAT REQUIRES ROPE ACCESS

(xii) When working on each set of caissons the Faro X330 scanner will be positioned on the lighting rigs to capture as much of the East and West outward facing sides of the bridge as possible. The Faro Focus 3D (a shorter range machine) will be used to scan the tops of the caissons and between the caissons (See Figure 3, below). The pattern of scanning depicted in Figure 3 should be repeated for each set of caissons on the bridge.

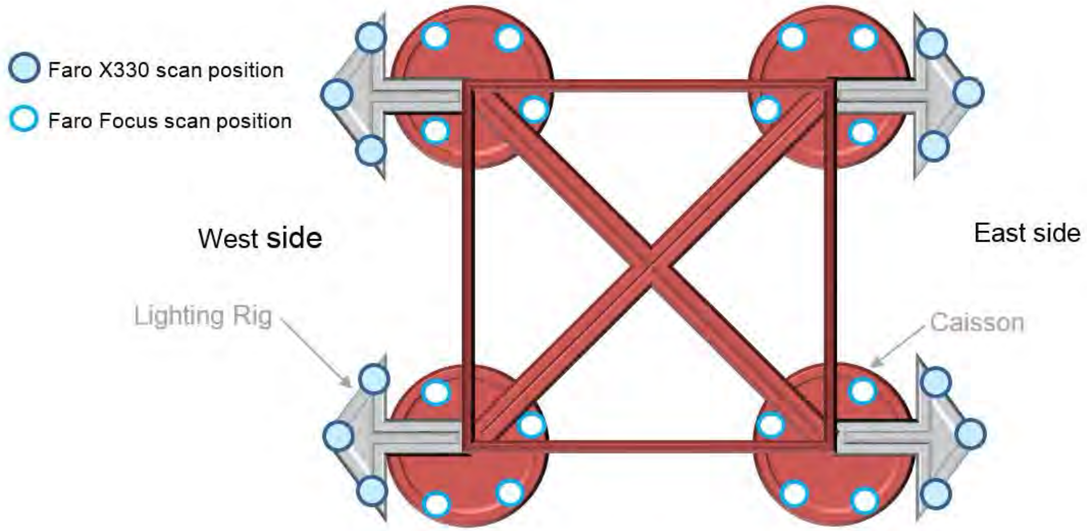
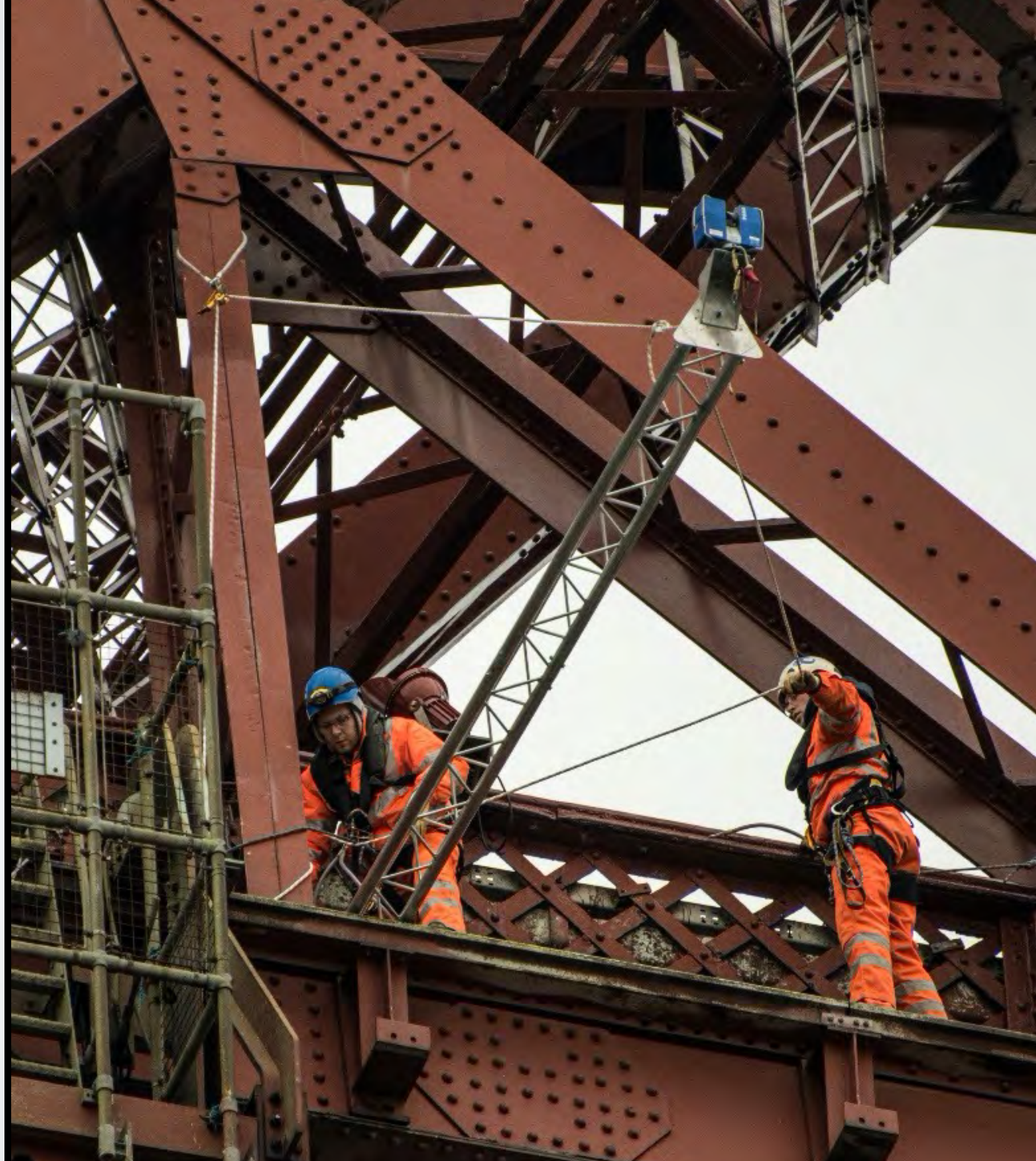


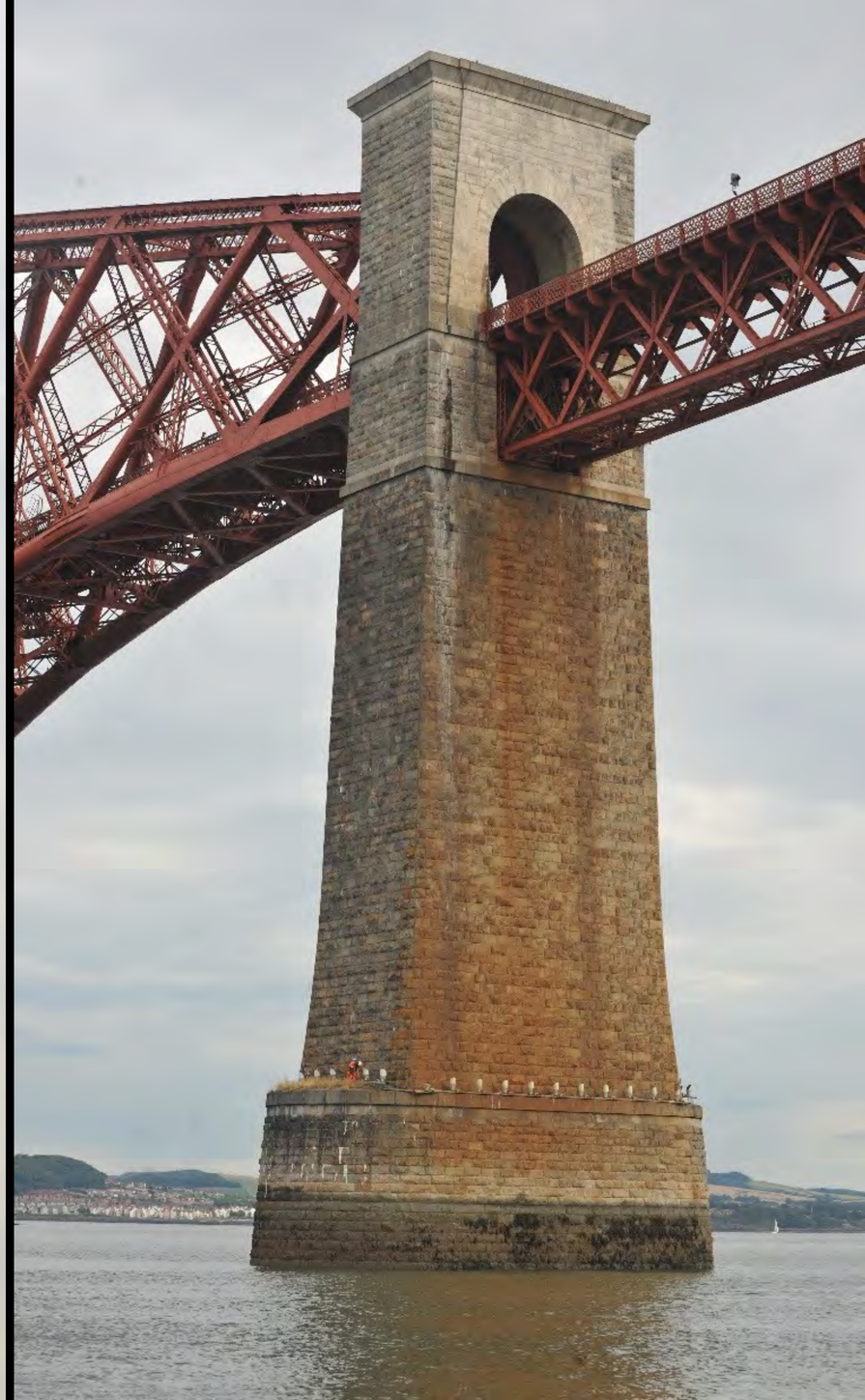
Figure 3: Schematic plan view of one set of four caissons, shows suggested scanner positions from each caisson with the Faro Focus 3D laser scanner (16 scans) and from the lighting rigs mounted on each caisson on the East and West sides of the bridge with the Faro X330 laser scanner (12 scans)

(xiii) The Calypso Marine safety boat will be operational for the duration of the caisson survey work. Access to the caissons will either be by boat (Calypso Marine) or from track level. When accessing the caissons from track level a Vital lookout and COSS will be on duty to allow the Geckotech team to get to caissons below the Queensferry, Inchgarvie and Fife cantilevers.





Caissons and Towers



Mobile Mapping

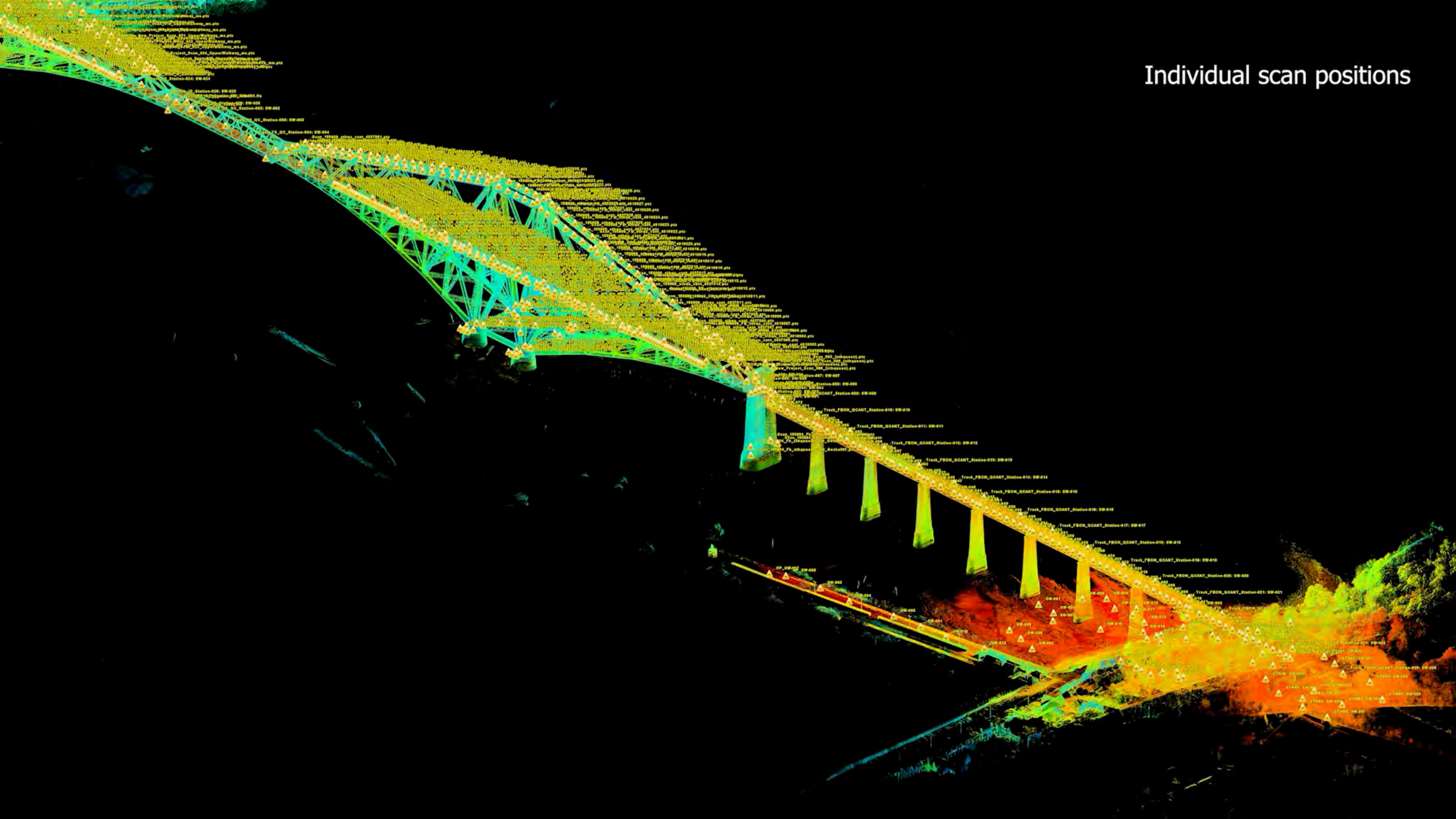

Individual scan positions

Image Ref: NRS BR-FOR-4-34-116

GO FORTH!

A major new educational resource is now available to all Scottish schools, using 3D digital documentation of the three Forth Bridges to support the teaching of STEM subjects and the Curriculum for Excellence.

The recording of all three Forth Bridges commenced in 2015 with funding from the Scottish Government, creating photorealistic 3D models from the accurate point cloud data. With digital models for all three Forth Bridges complete, work commenced on generating learning resources designed to inspire school pupils, the aim being to generate an interest in the bridges themselves, and to stimulate an enhanced take-up in associated science and technology subjects.

Working with the assistance of technical teaching expertise from Dundee City Council, the Centre for Digital Documentation and Visualisation (a partnership between Historic Environment Scotland and The Glasgow School of Art) has created several teaching packages all of which are available through Education Scotland's Glow network:

- Go Forth and Discover
- Go Forth and Design
- Go Forth and Create
- Go Forth and Explore
- Go Forth, See and Hear

Go Forth and Discover

An interactive game to develop awareness and knowledge of The Forth Bridge, its place in Scotland's history and the life of the people who created it.

Curricular Focus: Curriculum for Excellence Social Studies

THE FORTH BRIDGES®

TRANSPORT SCOTLAND CÒMHDHAIL ALBA

C D D V Centre for Digital Documentation and Visualisation

United Nations Educational, Scientific and Cultural Organization · The Forth Bridge inscribed on the World Heritage List in 2015

THE BRIGGERS

FORTH BRIDGES FORUM

National Records of Scotland

NetworkRail

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

UNIVERSITY OF ABERDEEN

Go Forth and Design

A range of CAD resources which support understanding in design and engineering, raising awareness and knowledge of the Forth Bridges and their place in Scotland's history.

Curricular Focus: Curriculum for Excellence Technologies

THE FORTH BRIDGES®

TRANSPORT SCOTLAND CÒMHDHAIL ALBA

C D D V Centre for Digital Documentation and Visualisation

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HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

UNIVERSITY OF ABERDEEN

Go Forth and Create

A resource to support the teaching of Computing Science using Scratch and based on the Forth Bridges.

Curricular Focus: Curriculum for Excellence Technologies

THE FORTH BRIDGES®

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UNIVERSITY OF ABERDEEN

BUILDING ENGINEERING KNOWLEDGE, COMPUTER AIDED DESIGN AND PROBLEM SOLVING SKILLS ON & OFFLINE

Pupil Objectives

I can identify key structural features on a bridge.

I can create a sketch and digital representation of a bridge using my knowledge.

I can solve an engineering problem using physical and digital tools.

I can build and test a range of physical models which I have planned using 3D drawings and software.

Copy of Copy of FB_1

What's New

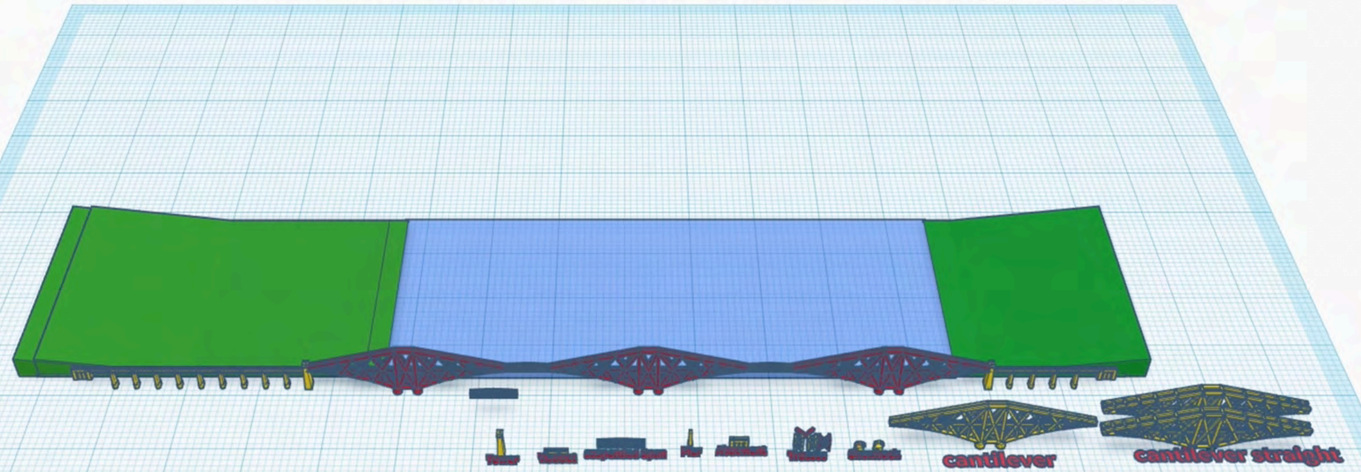
Import Export Send To

TOP
FRONT
Home view

Workplane Ruler

Tinkercad
Basic Shapes

Box Cylinder
Box Cylinder
Sphere Scribble
Roof Cone
Round Roof Text
Wedge Pyramid
Half Sphere Polygon
Paraboloid Torus



Edit Grid
Snap Grid 1.0 mm

Conclusion

- Complexity and quality are more than just achieving a particular resolution of data.
- Planning and organisation is essential for successful projects.
- Understand the limits of the technology and plan accordingly.
- Beneficial to have multi-skilled team members who understand full project workflow.