Development of the High Voltage Substation Digital Twin

eFORT Demonstrator 4 – Case Study 2

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From operational need to digital implementation

Operational challenge

- Fragmented information
- Limited spatial context
- High cognitive workload
- Wartime operating pressure

Controlled visualisation environment

Digital Twin response

- Visual context
- Interaction
- Information access
- Safe demonstration environment

- Not a SCADA replacement
- Not live grid control
- An additional visual and contextual layer

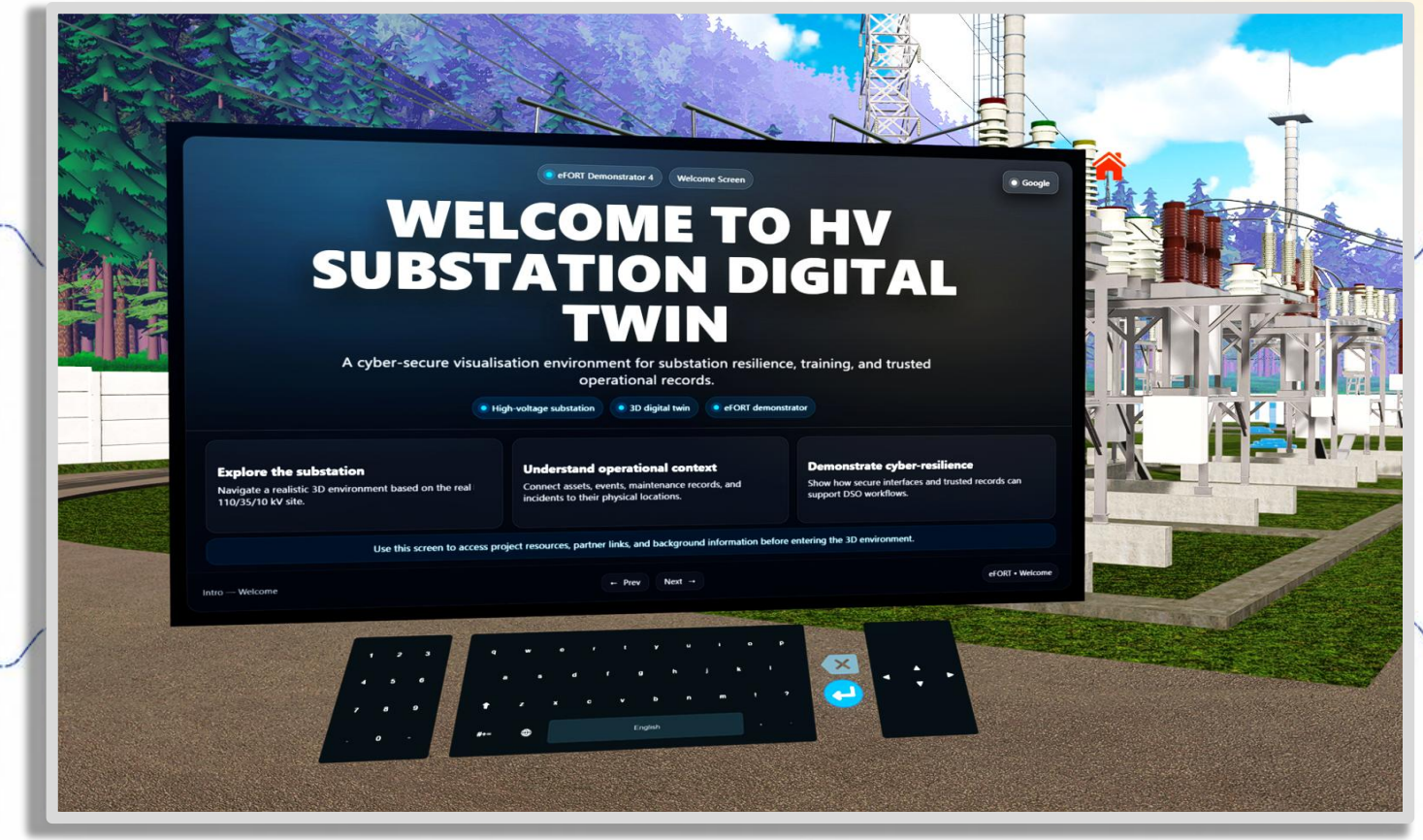
What was developed in eFORT D4 Case Study 2

Real substation context

Built from the real Itlsi 110/35/10 kV substation for authentic training and operations.

Embedded WebView screens

Contextual web interfaces integrated directly inside the application.



Interactive 3D environment

Navigate assets in a high-fidelity Unity 3D environment with real-time exploration.

Blockchain-backed maintenance records

Trusted maintenance records linked to physical assets.

A standalone Unity-based application representing a real DSO substation

Development pipeline

1. Real substation

2. Laser scanning

3. Point cloud processing

4. BIM modelling

5. 3D model preparation

6. Unity integration

7. HV Substation Digital Twin

From validated infrastructure data to an interactive visual environment

Capturing the real substation

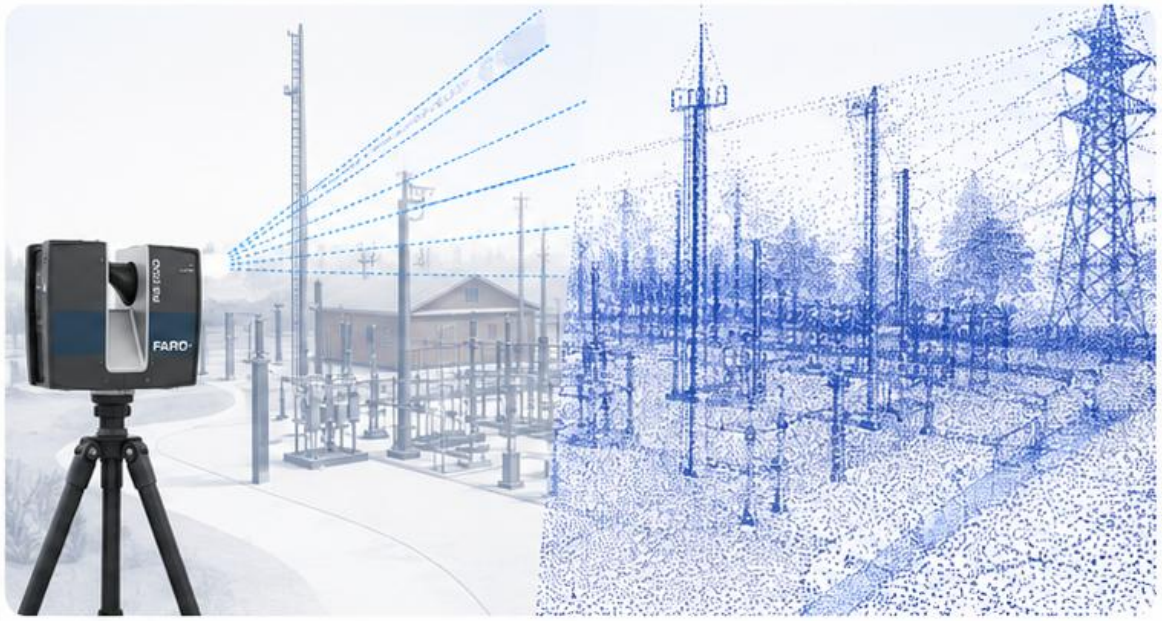
Real site

Real infrastructure data

Site layout

Equipment placement

Scanning and spatial capture



Laser scanning

Spatial structure

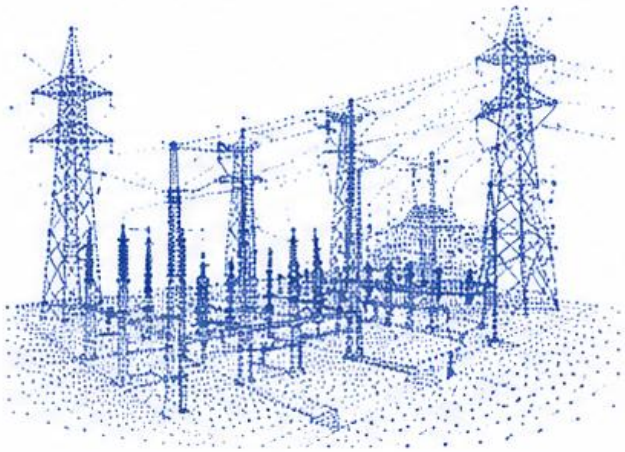
Point cloud reference

Laser scanning preserved the real spatial logic of the site.

From point cloud to structured engineering model

1

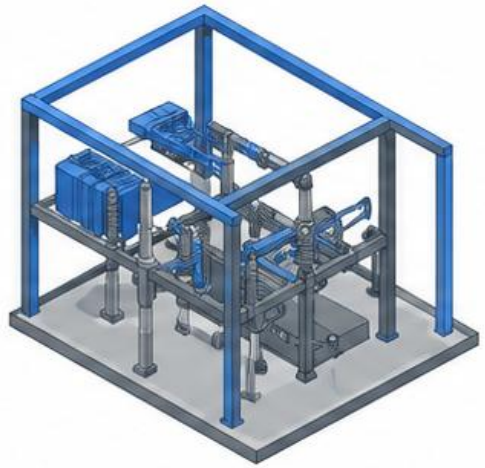
Point cloud reference



Spatial basis of the model

2

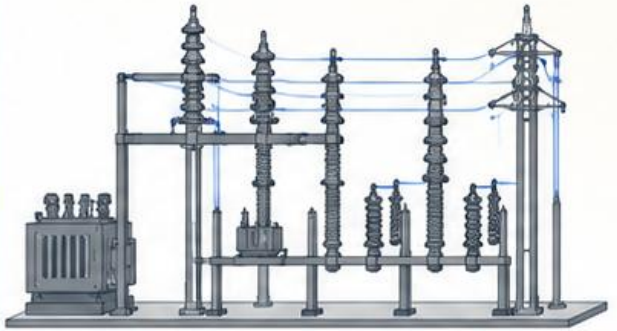
BIM model



Structured engineering model

3

Structured engineering representation



Assets organised for further development

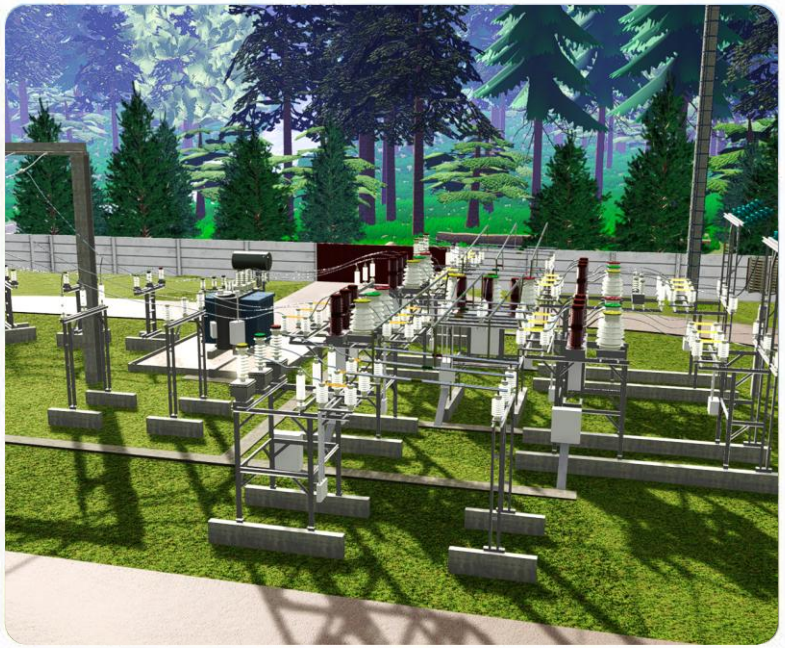
Point cloud is not the final model. It is the spatial basis for structured modelling.

Preparing the model for real-time visualisation

Engineering model

- Cleaning
- Optimisation
- Materials
- Scene structure
- Asset preparation

Real-time ready scene



Technical fidelity | Runtime efficiency

The model had to be technically meaningful and light enough for real-time use.

Unity-based implementation

Unity Editor view

Compiled application view

From development environment to usable software product

- URP rendering
- Scene hierarchy
- Interaction logic
- Labels and hints
- Virtual screens

Unity was used not only as a viewer, but as the environment where the digital twin became a software product.

Navigation and interaction inside the digital twin

Walk and look around
W, A, S, D + mouse
Move through the substation and inspect the environment at human scale.

Observation mode
F1
Toggle observation mode for easier scene inspection.

NoClip / flight mode
F2
Enable free movement for elevated viewpoints and rapid movement between areas.

Environment toggle
F3
Hide or show surrounding environment elements.

FPS / statistics overlay
F4
Show performance information during testing or technical review.

Zoom
Mouse wheel
Zoom in and out to focus on selected assets, labels and equipment details.

Object interaction
F
Use selected doors, cabinets, and scene elements when interaction is available.

Virtual monitors and the WebView layer

In-scene virtual monitors present WebView-based maintenance cards, keeping asset information accessible directly within the 3D environment.

Transformer repair record

Example of a transformer maintenance card shown on a virtual monitor in the scene.

High-frequency barrier record

High-frequency barrier record displayed next to the protection equipment.

Fire cleaning record

Area maintenance record shown at the location of the cleaned support zone.

Embedded WebView screens

HTML / WebView interfaces are displayed directly on virtual monitors inside the 3D scene.

Asset-context display

Each screen is placed near relevant equipment, linking records to physical location.

Structured maintenance cards

Users can open detailed asset records, repair history, and maintenance logs.

In-scene information access

The digital twin uses virtual monitors as an information access layer without leaving the 3D environment.

10 virtual monitors in the scene

Optimisation and deployment

Optimisation work

- Geometry cleanup
- Static batching
- Selective LOD
- Text and label optimisation
- Scene hierarchy and materials

Deployment result

- Standalone Windows build
- Splash screen
- Main menu
- Graphics settings
- Compiled application

Prepared 3D scene for smooth real-time use

Compiled application — main menu

The result is a deployable application, not only a Unity project.

Thank you for your attention

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