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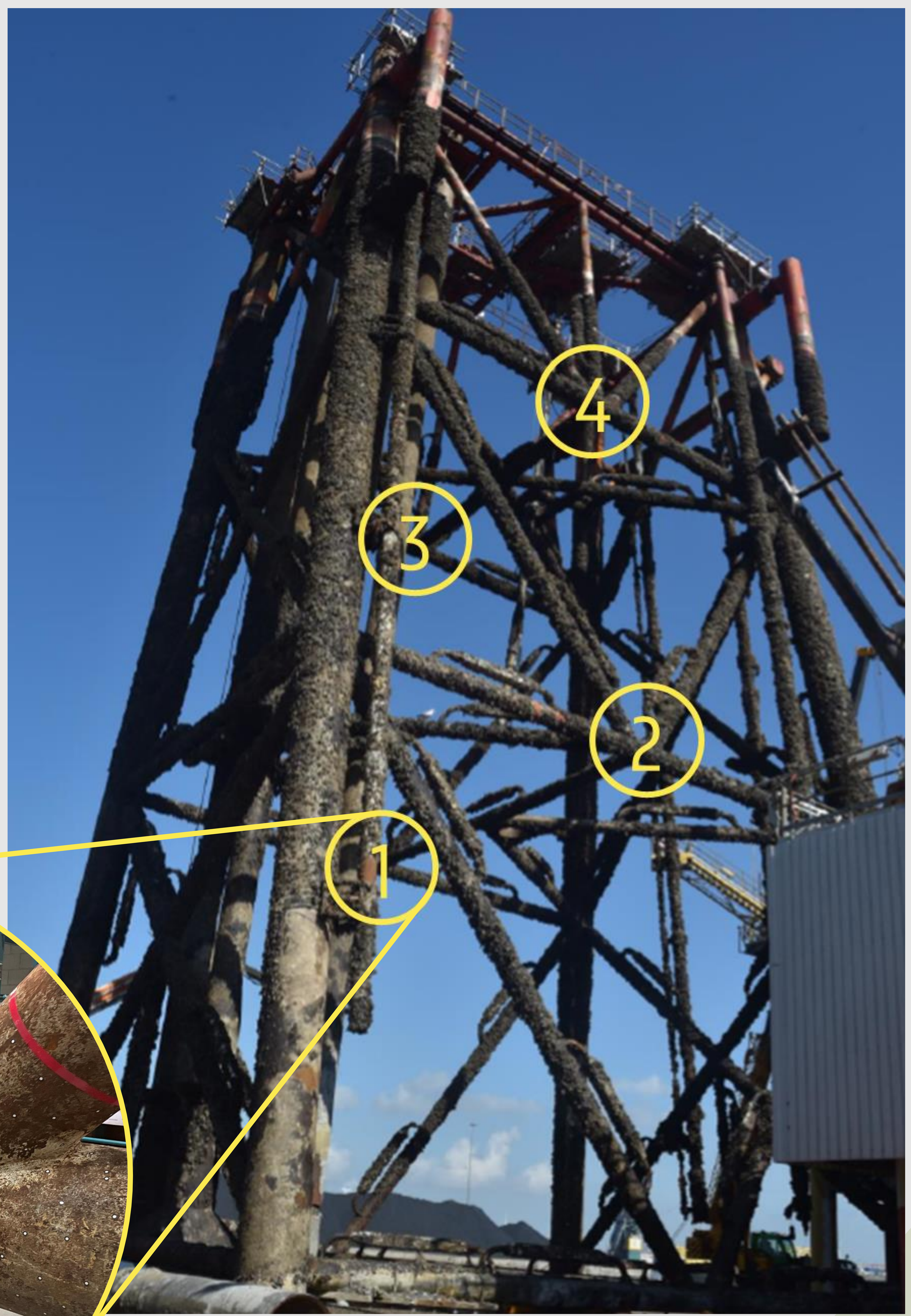
CONVERTING LASER SCANS OF TUBULAR JOINTS TO FINITE ELEMENT MODELS

Motivation

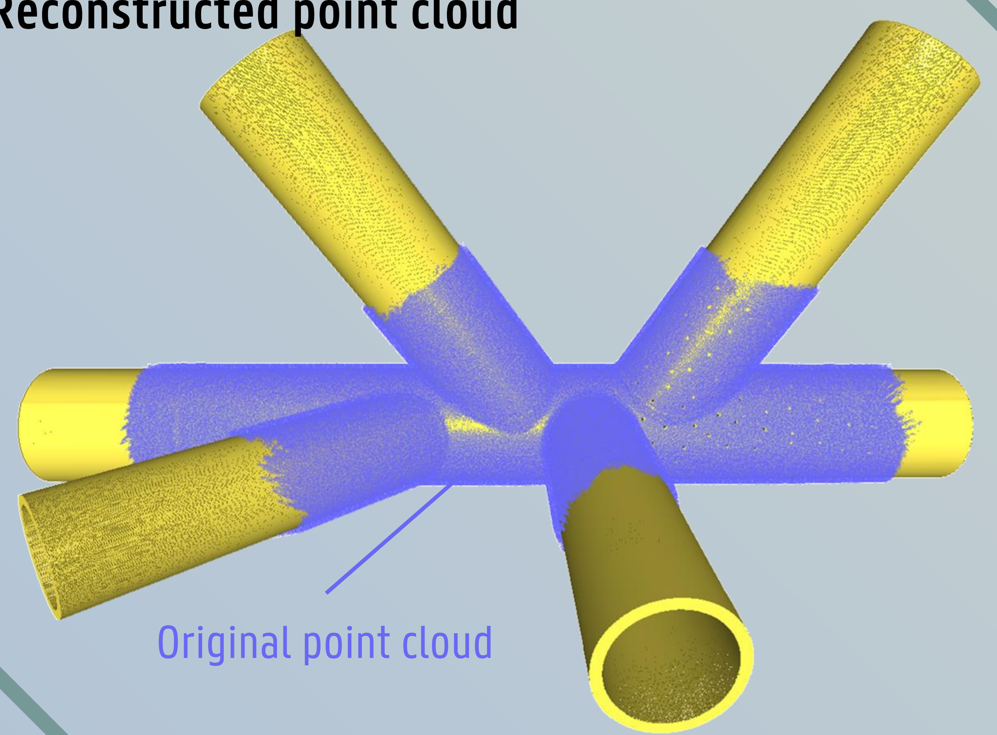
- The welds are the most fatigue-critical locations of offshore jacket substructures.
- The real weld geometry has a strong influence on local stress concentrations and therefore on the fatigue life of the structure.
- In current design practice, the fatigue governing stresses are determined assuming perfectly cylindrical tubular members and idealized welds.
- The FlexWind project aims to develop algorithms to incorporate the influence of the as-built global and local geometry into the fatigue assessment of tubular joints.



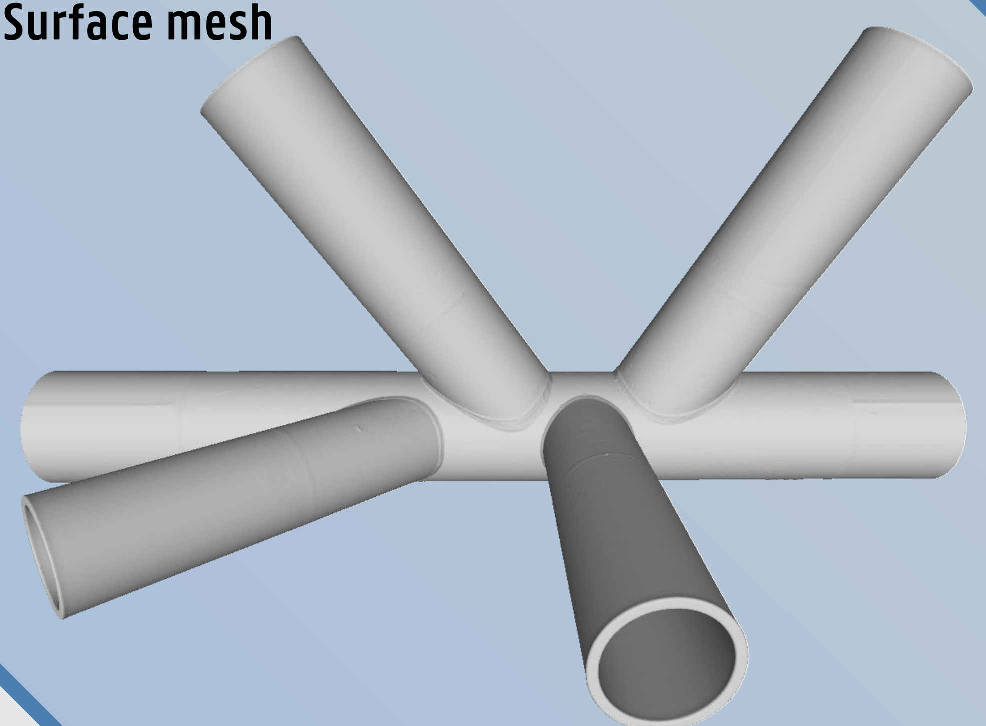
Case study

- Decommissioned gas platform jacket.
- Installed in the North Sea in the 1980s and removed in 2023.
- Four full-scale tubular joints were cut out of the jacket.
- Joints were scanned and will be fatigue tested.

Reconstructed point cloud



Surface mesh

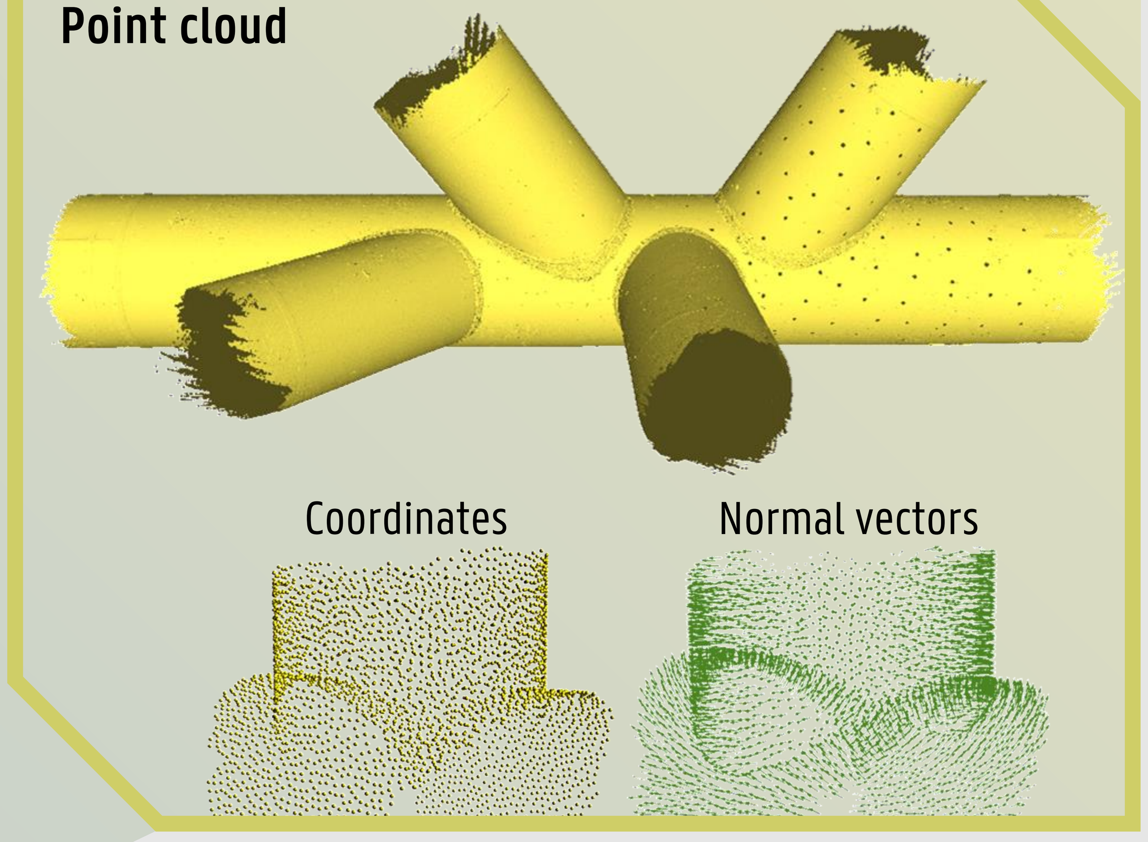


Approach

3D laser scanning

A handheld 3D laser scanner projects a light pattern on the surface and captures its deformation. Using the triangulation principle, this yields a point cloud corresponding to the scanned surface and a collection of outward-pointing normal vectors can be determined. The scanning principle is based on the reflection of light, so only the outer surface can be scanned.

Point cloud

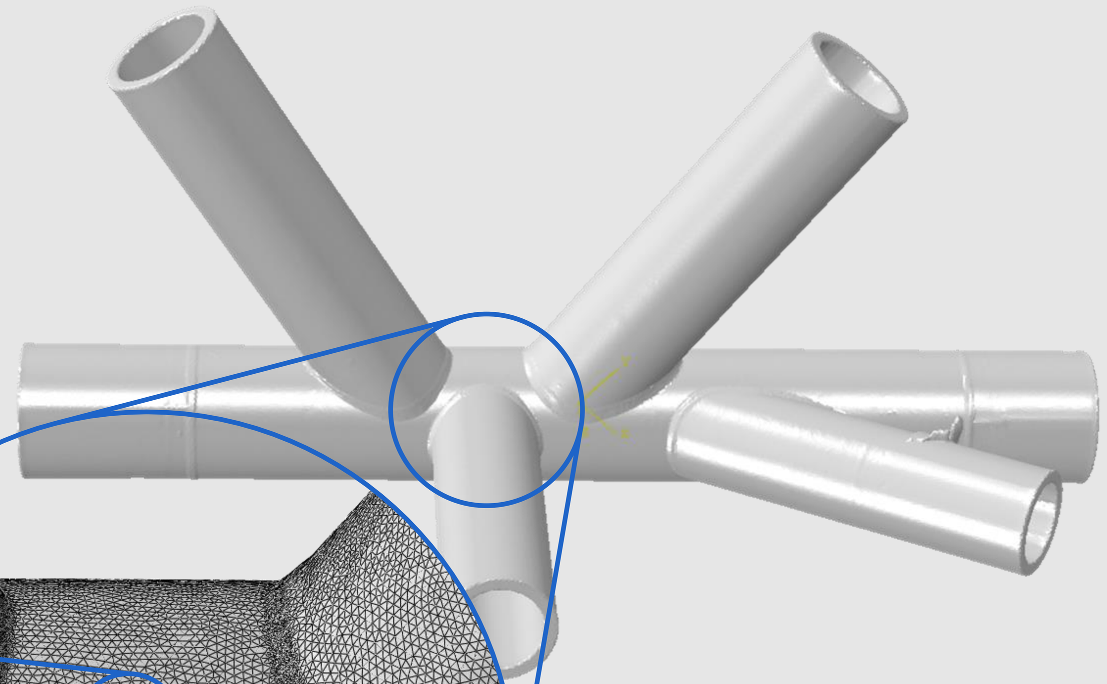


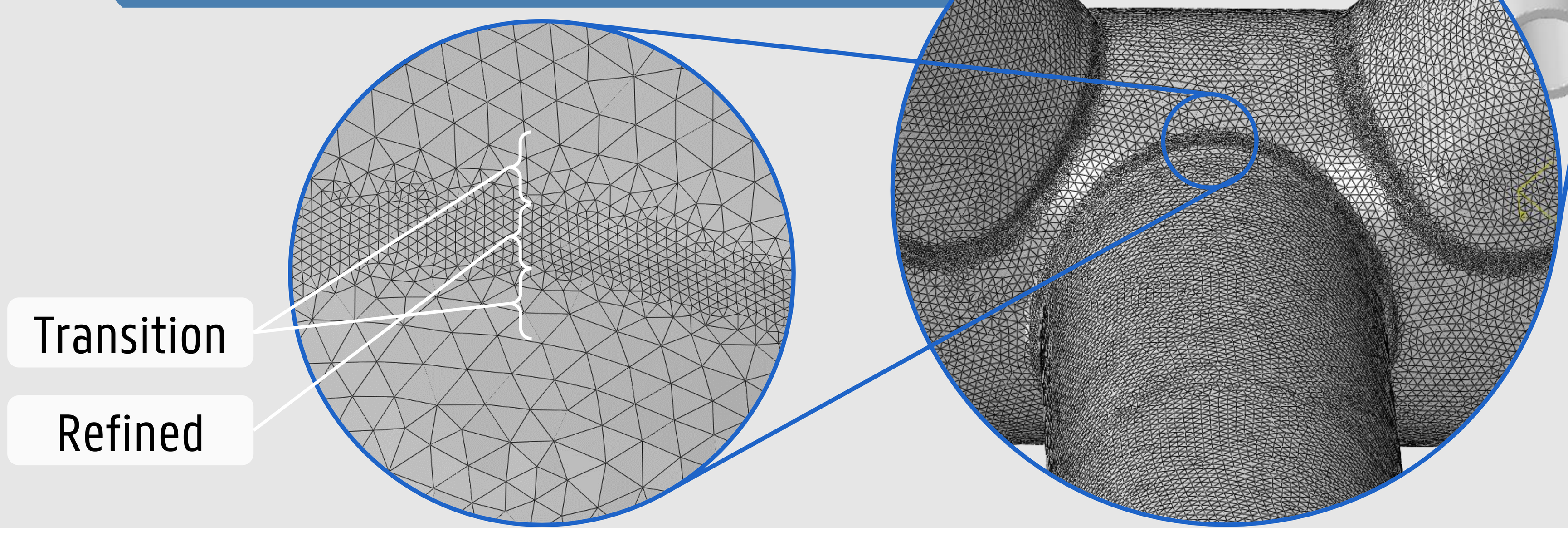
Reconstruction framework

A framework is being developed to automatically convert the 3D scan data of welded tubular joints to finite element models. The tubular members are extended and the unscanned inner parts reconstructed. These unscanned parts include the inner walls, the plug zone and the weld root. The weld root geometry is reconstructed based on the AWS D1.1 standard.

Resulting model

A tetrahedral volumetric mesh is generated based on the surface mesh. The former can be used in finite element simulations to determine the stress concentrations and ultimately the remaining useful fatigue life of the joint.





The finite element mesh is refined at the weld toes, the most critical regions, to strike a balance between computational cost and accuracy.

Take-away messages

- A framework was developed that can reconstruct the unscanned inner parts of tubular joints. In this way, surface imperfections at the weld toes can be considered without simplifications.
- The framework generates tetrahedral volumetric meshes from 3D scan data, enabling finite element simulations for accurate stress analysis.
- The detailed finite element models will allow more accurate remaining lifetime calculations of offshore jacket substructures.

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