



JIP MoorLife (2025 – 2027)

JIP phase 1

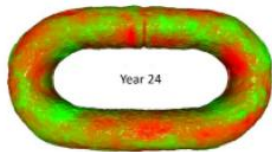


JIP MoorLife

A framework for corrosion and fatigue life monitoring of mooring chains

JIP MoorLife objectives (phase 1)

- Establish an objective corrosion grading tool that is highly correlated with remaining fatigue life.
- Provide a model for the entire crack life development at the critical cross section for real-world corroded links.
- Investigate the effects of real-world load sequences on damage accumulation in chain links.



Project background (LifeMoor 2018-2022)

Inspections of used mooring chains often reveal non-uniform corrosion loss and corrosion pitting after years in service (which is not properly accounting for in Industry standards). This can decrease fatigue capacity dramatically and should be closely monitored, understood and taken into account during design and life extension assessment.

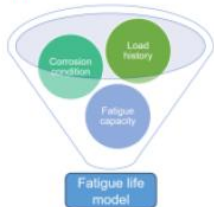
An approach to monitoring mooring chain condition with reliability updates was proposed in the research project LifeMoor supported by the Research Council of Norway and an industrial consortium.

A framework was therefore established by the research partners SINTEF and NTNU, to link in-service load monitoring, inspection data and reliable fatigue models, developed and calibrated from fatigue laboratory testing data.

This framework has been further refined and built upon in four subsequent projects: Hywind (FOWT load history), Objocorr (corrosion assessment tool), Eddy.C (crack detection) and SeeMoor (chain cleaning and assessment).

LifeMoor achievements

- Material behavior and fatigue parameters for R4 steel were characterized. [1][2]
- Residual stresses in mooring chains were measured before and after years of service. [1]
- FE Fatigue models accounting for the effect of residual stresses and local mean loads on the lifetime at critical hot spots.
 - Energy-based damage approach for fatigue crack initiation at corrosion pits. [1]
 - Fracture mechanics approach for fatigue crack growth (mode I). [3]
- An algorithm using 3D scans was created for accurate and fast corrosion grade assessment (corrosion loss and pitting) of chain links, suitable for onshore and underwater inspections. [4]
- A neural network processing for rapid stress calculations due to pitting. [5]
- A database with over 200 fatigue tests and 500 3D scans was established.
- Empirical SN-curve formulations were developed to include mean load and corrosion pitting effects on fatigue. [6]
- 62 years of metocean data were analyzed for mooring line tension histories in case studies. A fatigue reliability damage mode (Miner's rule) showed fatigue life dependency on mooring line position of a semi-submersible. [7]



- Project manager : SINTEF

- Industry consortium :



Statens vegvesen



- Other relevant academics interaction include : NTNU, UoA and UFRJ

- Sponsor fees per participant:

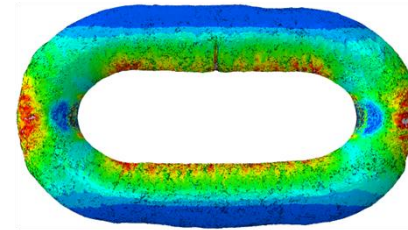
- 600 kNOK per year for Energy companies
- 200 kNOK per year for Contractors/Suppliers
- 150 kNOK per year for Engineering companies
- In-kind contribution from the classification society

JIP MoorLife (2025 – 2027)

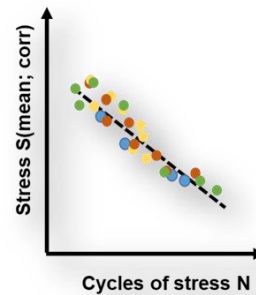
WP1: Objective corrosion grading of chain links



WP2: Fatigue crack initiation and crack growth at hot spots

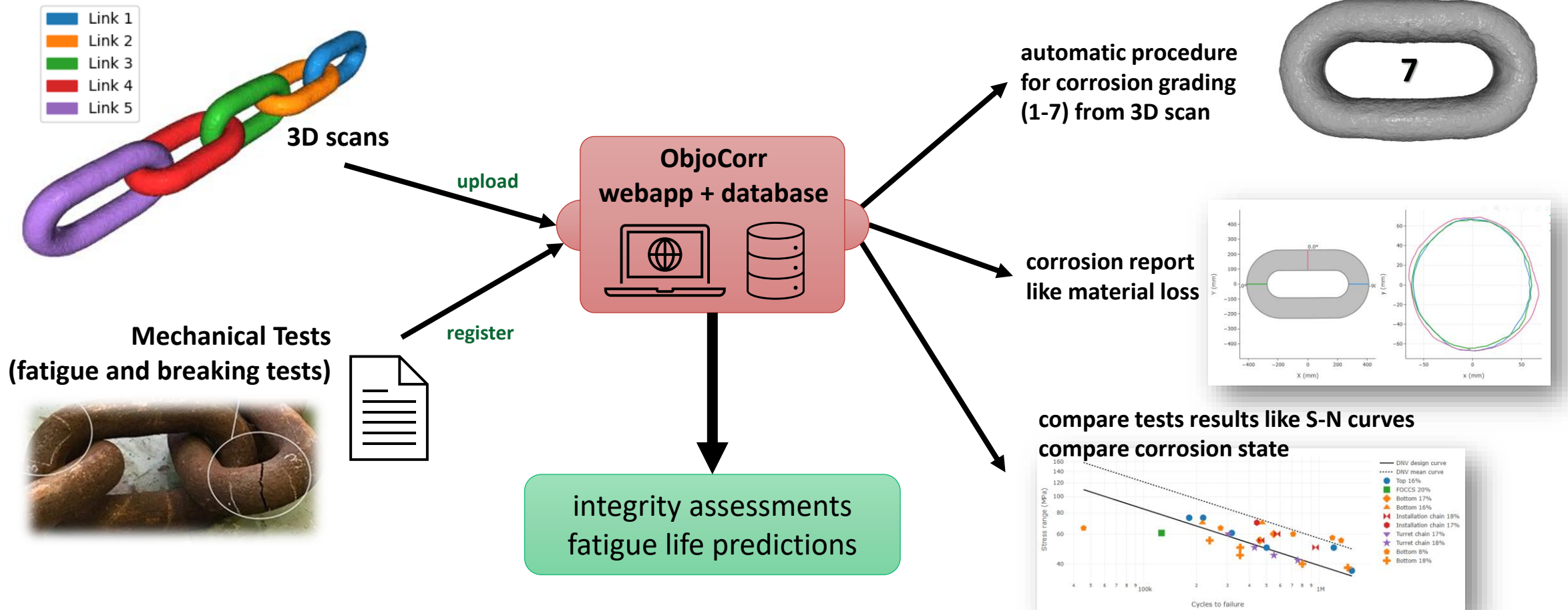


WP3: New insights for SN-based model



WP1 Objective corrosion grading of chain links: Task 1.1 New corrosion grades

ObjoCoor: Objective evaluation of corrosion grades on mooring chains

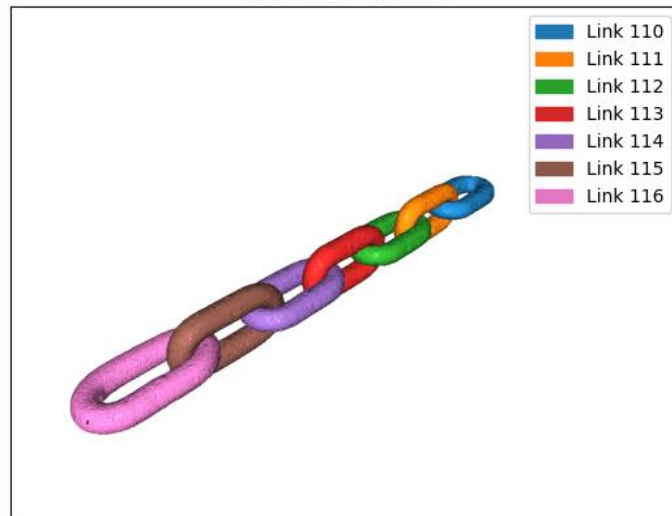


WP1 Objective corrosion grading of chain links: Task 1.1 New corrosion grades

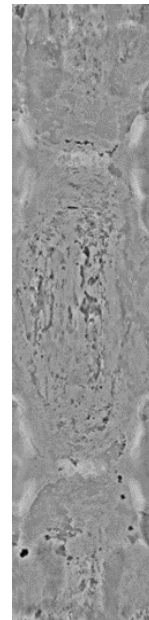
- New corrosion grades considering pits, material loss and position on the chain link: enhanced unwrapping algorithm and geometrically based corrosion criteria

3D scan of corroded Chain links (Point clouds)

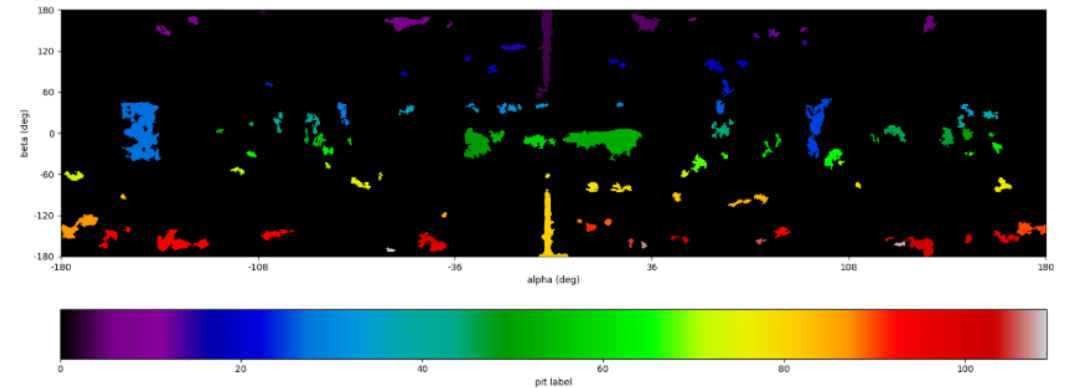
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Texture unwrapping

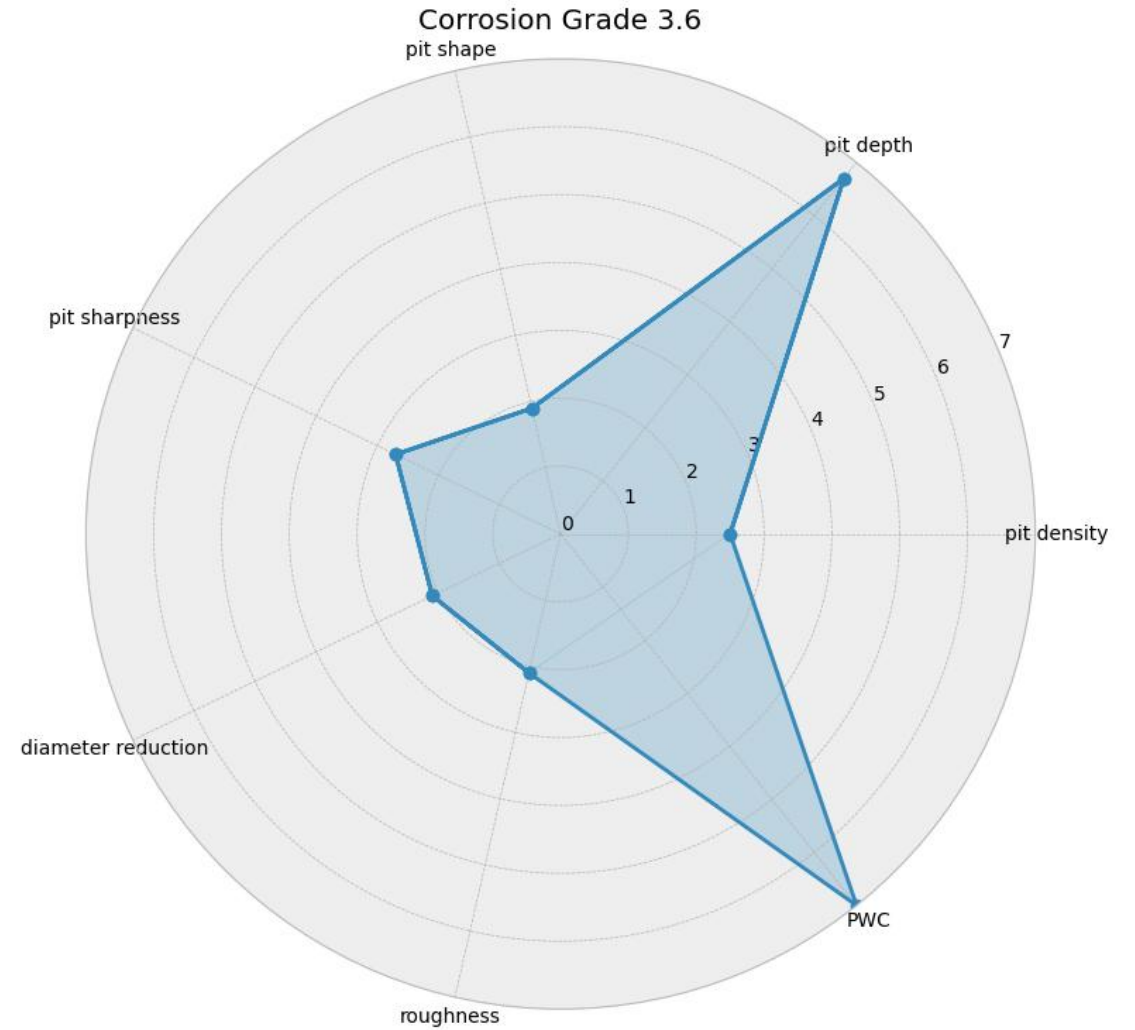
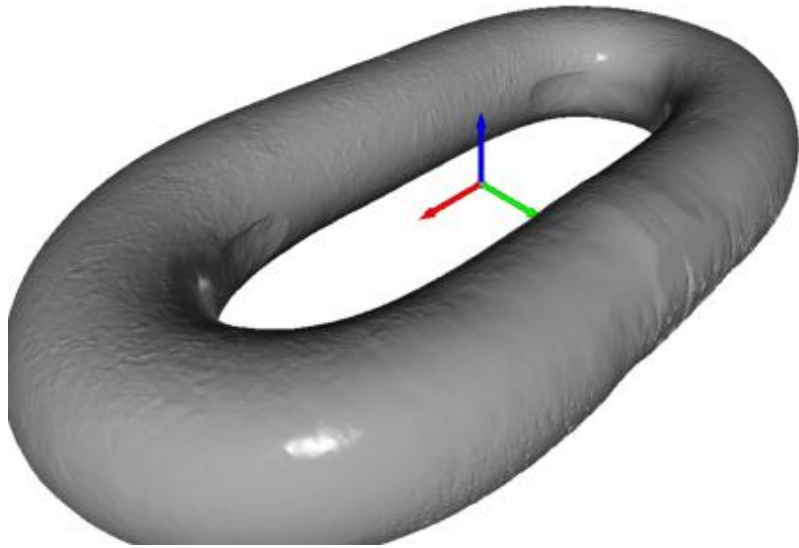


Ex: detected pits in given chain link



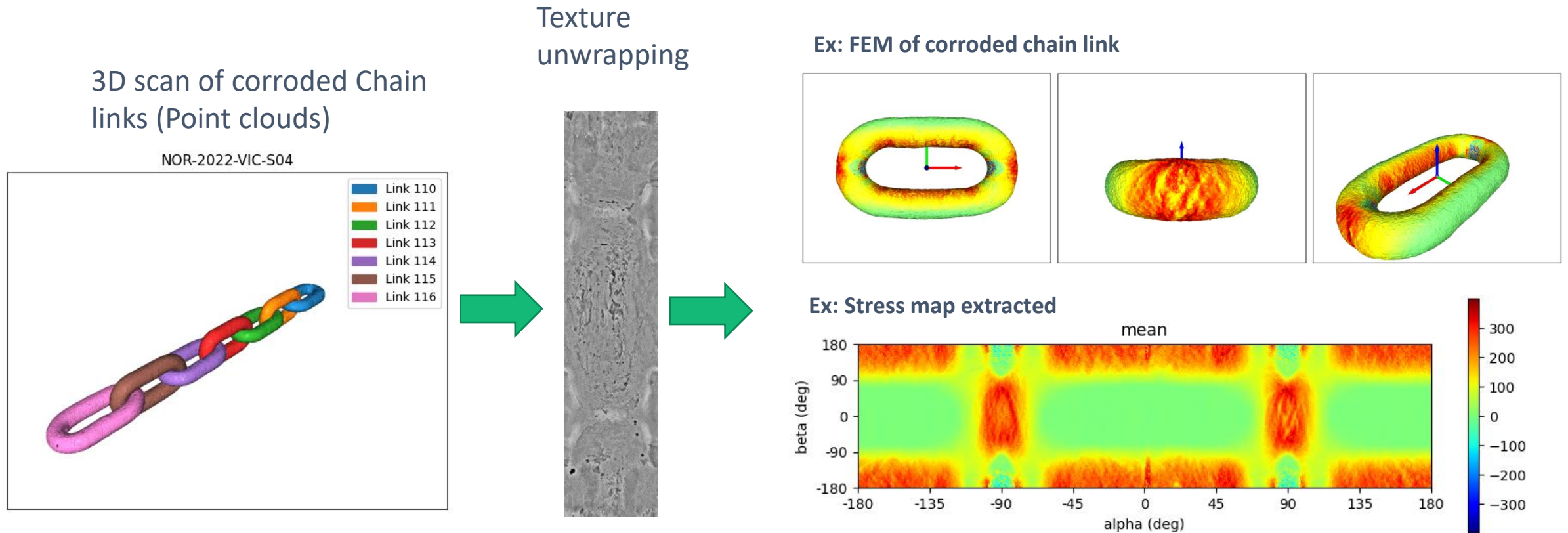
Corrosion severity signature (radar representation)

136mm, 16 years service



WP1 Objective corrosion grading of chain links: Task 1.1 New corrosion grades

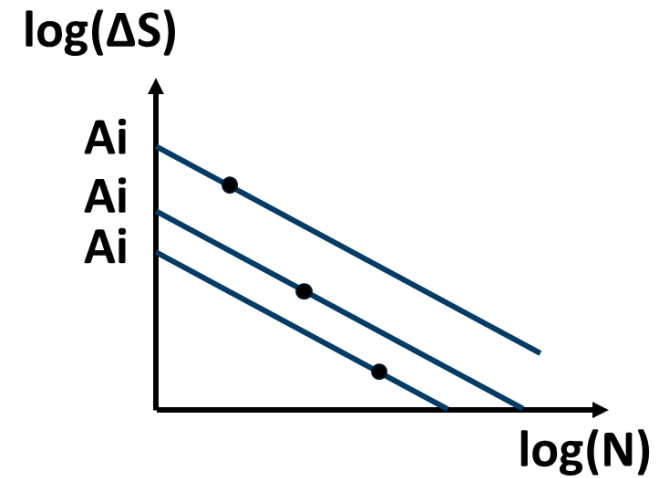
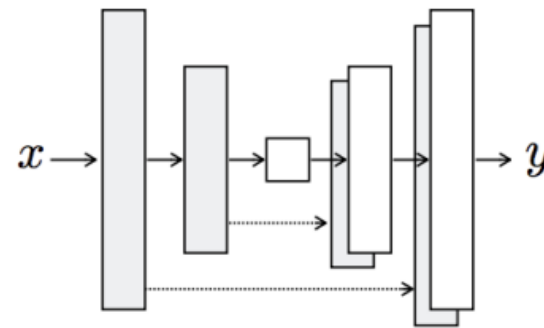
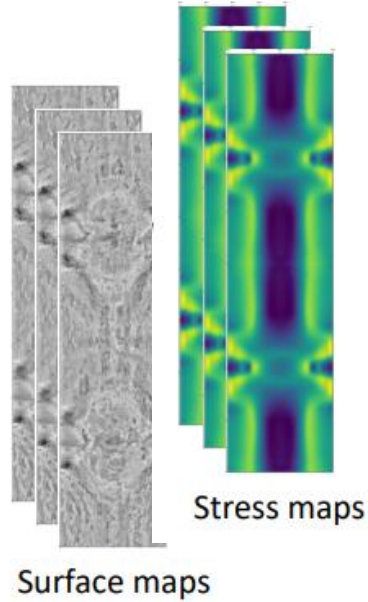
- New corrosion grades considering pits, material loss and position on the chain link: Hybrid (FEM) based corrosion criteria



WP1 Objective corrosion grading of chain links: Task 1.1 New corrosion grades

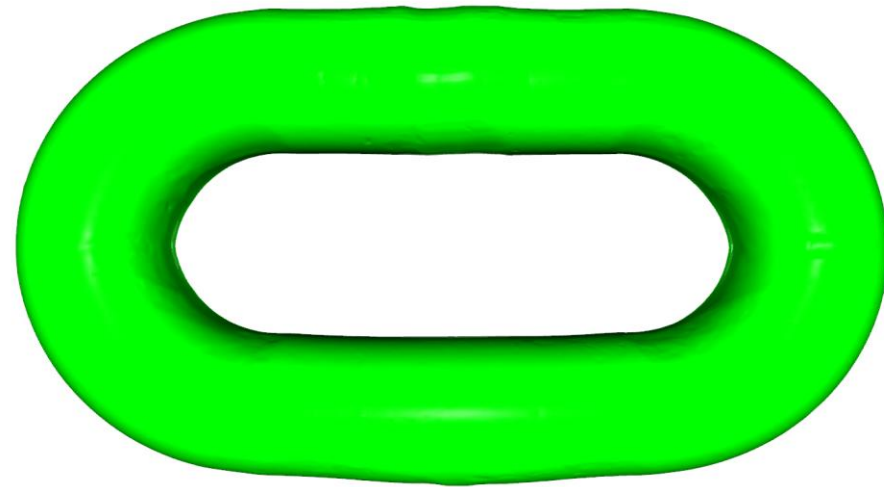
- Pipeline for automatic stress map prediction with FEM and AI-accelerated FEM.

➤ Hybrid corrosion assessment tool for design & digital twin



WP1 Objective corrosion grading of chain links: Task 1.2 Model corrosion evolution from 3D scans

- Use 3D scan data to enable interpolation of corrosion patterns between chain links with varying years of corrosion.

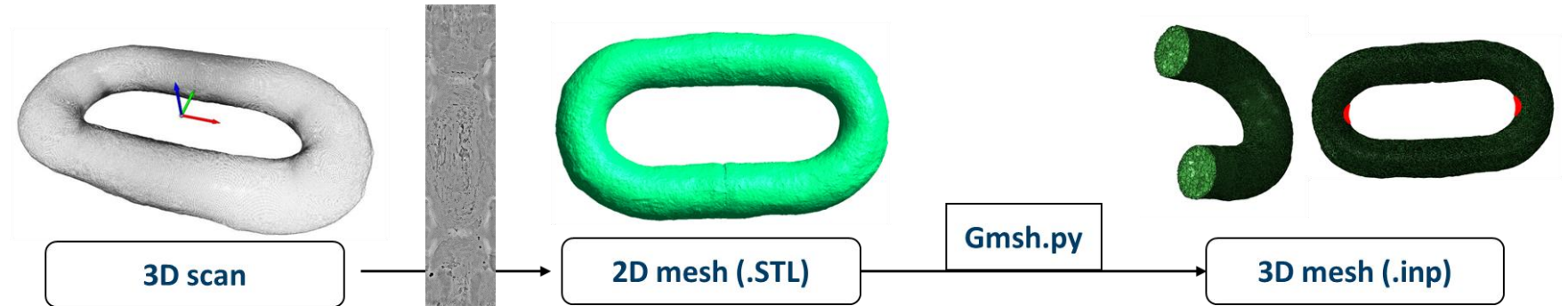
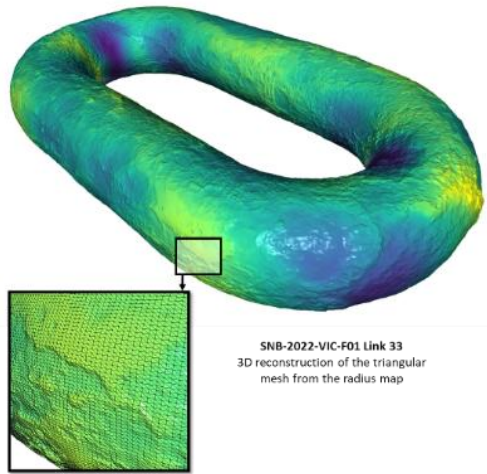


0 years

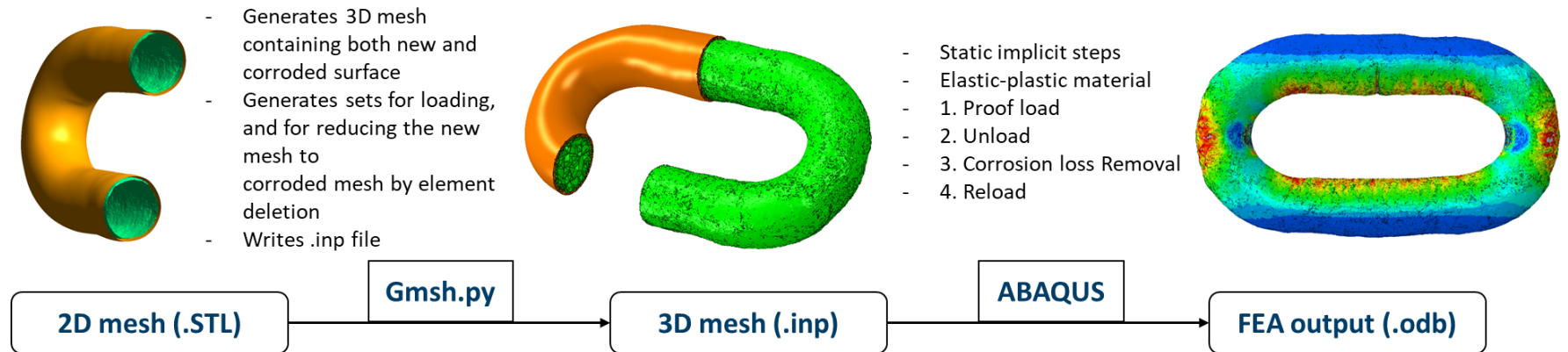
Ex: Corrosion evolution deduced from post-processing of 3D scans of chain links

WP2 FEA Stresses concentration, Fatigue crack initiation and crack growth at hot spots:

Task 2.2 Seamless Integration of Finite Element analyses



Pipeline for FE simulations (with actual corroded geometry and actual RS)

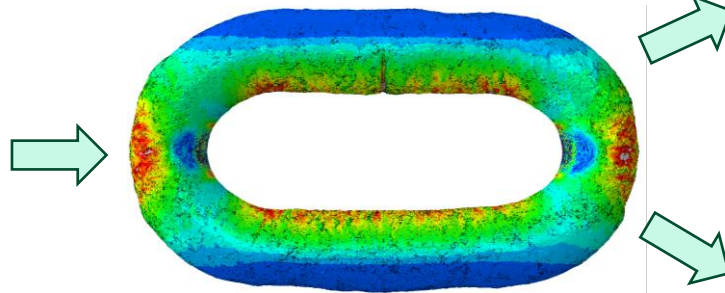


WP2 Fatigue crack initiation and crack growth at hot spots:

Task 2.4 Study the impact of local stresses on fatigue capacity at hot spots.

➤ Parametric FEA studies

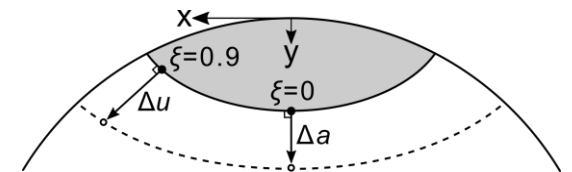
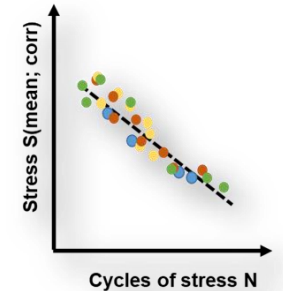
FEM with actual chain links geometry and actual RS



SCF investigation, input to Wp1 for corrosion grade in S-N model

$$N_f = N_i + N_p$$

3D local stress distribution and defect geometry as input to crack initiation and crack growth models.



$$N_p = \frac{da}{dN} = C(\Delta K_{th})^m$$

WP3: New insights for enhanced SN-based model

- ❖ **Improve corrosion-grade S-N fatigue models by quantifying:**
 - Impact of general corrosion loss
 - Effects of localized corrosion (e.g., PWC, pitting, mega pits)
 - RS influence on S-N curve slope ($m > 3$ for corroded links)
- ❖ **Quantify crack initiation vs. crack growth contributions**

Cases studies are also defined based on partners new input data to expand the assessment:

- ❖ **Case study 1 : heavy corrosion & Crowns and PWC failures**
- ❖ **Case study 2 : PWC & very heavy corrosion**
- ❖ **Case study 3 : interlink wear & low corrosion**
- ❖ **Case study 4 : very heavy corrosion incl. mega pits**
- ❖ **..**



SINTEF

— 75 år —

For more information, please contact

Email: alexandre.kane@sintef.no