



Traffic in Brussels;
Delayed start. We Start at
10:00

DIGITAL TWIN METHODS AND LIFETIME ASSESSMENT USING DATA-DRIVEN METHODS

FIRMEST WORKSHOP 15/10/2025 @ U-Residence VUB



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#stronggrowth



A glowing lightbulb is the central focus of the image, set against a dark background. A thought bubble is positioned above the bulb's base, and a speech bubble is to its right. The lightbulb's glow creates a soft, warm light that illuminates the surrounding area.

Ugh... another
Workshop about **digital**
twins...

SO WHAT IS A DIGITAL TWIN?

OWI-LAB'S DEFINITION

YOU DO WHAT YOU WANT WITH IT 😊

A DIGITAL TWIN IS ANY TOOL THAT
ALLOWS FOR DECISSION SUPPORT
REGARDING AN ASSET BEYOND A
DIRECT MEASUREMENT



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VLAIO



BLUE
CLUSTER



VRIJE
UNIVERSITEIT
BRUSSEL

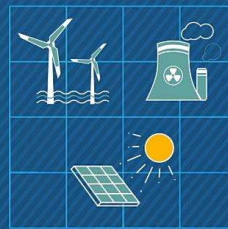
What decisions we need to support at **OPERATORS AND DEVELOPERS ?**

Can we **Extend or Optimise the lifetime** of our foundations?

Will my farm cope with the **changed loads** coming from unforeseen external factors?

Are my **foundations still stable**? Do I plan remedial actions?

GRID INTEGRATION



CORROSION & ADDITIONAL LOAD



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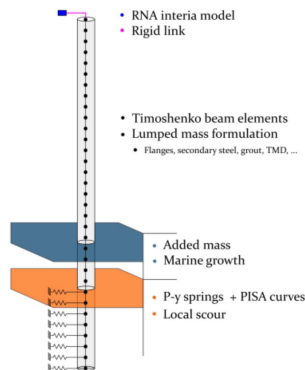


WHAT IS A DIGITAL TWIN?

Many flavours, all relevant

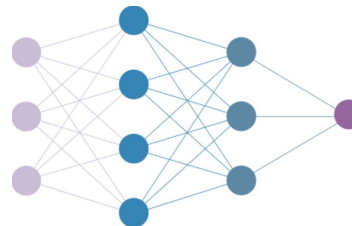
- **Physics based digital twins**
- **FE MODELS**

- Model created using analytical equations/FEM + SSI
- Model can be updated based on short term and/or longterm measurements (unique model per structure)



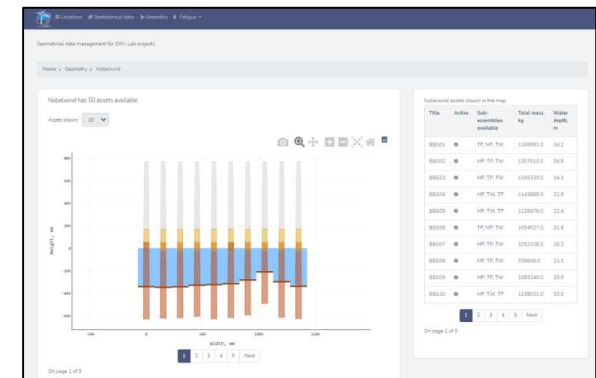
- **Data-Driven digital twins**
- **Machine learning**

- Model trained using machine learning tools (NN, RFC, SV, PCA,...)
- Model trained based on sufficient longterm term measurements (model transferred to other structures)



- **Descriptive Digital twins**
- **Data management**

- A unified way to collect and relevant metadata pivotal to decision support
- Populated from design information, or updated to most recent best practices (e.g. material resistance, defects, ...)



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AGENDA

Traffic in Brussels;
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- 09h30 – Welcome
- 09h45 – Introduction to **Firmest**
- 10h00 – OWI metadatabase : organizing design data (VUB)
- 10h30 – Digital twins for structural dynamics of offshore wind turbines (VUB)
- 11h00 – Different angles to Data driven lifetime assessment (VUB)
- 11h30 – Rethinking fatigue resistance (UGent)
- 12h00 – Networking lunch
- 13h00 - FIRMEST IAB members, hands-on workshop



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15/10/2025

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DEPARTMENT OF ELECTROMECHANICAL, SYSTEMS AND METAL ENGINEERING

SOETE LABORATORY

Firmest Workshop: Introdu

Digital twin methods and lifetime assessment
using data-driven methods

Prof. Kris Hectors, prof. Wout Weijtjens, Prof. Wim De Waele,
prof. Christof Devriendt, dr. Karen Hemelsoet

15/10/2025



Agenda

09:30 Welcome

09:45 Introduction Firmest research project

10:00 OWI-Metadatabase: organizing design data

10:30 Digital twins for structural dynamics of offshore wind turbines (VUB)

11:00 Different ways to look at data-driven fatigue life analysis (VUB)

11:30 Rethinking fatigue resistance (UGENT)

12:00 Networking lunch

UGent research team



Prof. Wim De Waele

- Supervision, coordination



Prof. Kris Hectors

- Supervision, coordination, supporting research



Dr. Karen Hemelsoet

- Valorisation activities



Ir. Jiacheng Qi

- PhD student, fundamental research

VUB research team



Prof. Christof Devriendt
• Supervision



(Dr.) ir. Negin Sadeghi
• Supporting research



Prof. Wout Weijtjens
• Coordination, supporting research



Dominik Fallais
• PhD Candidate, Virtual sensing

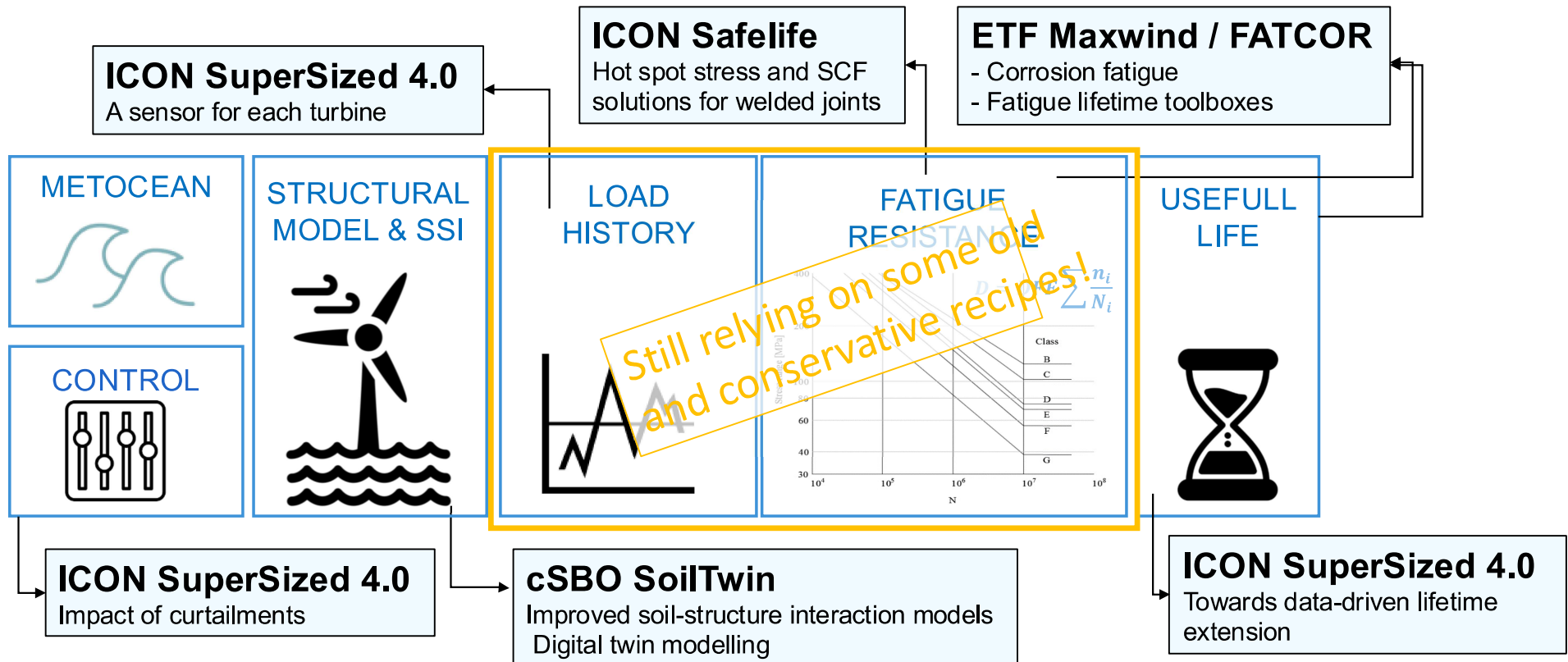


Dr. Ir. Pietro D'Antuono
• Supporting research



Ahmed Mujtaba
• Phd Candidate, Fatigue assessment

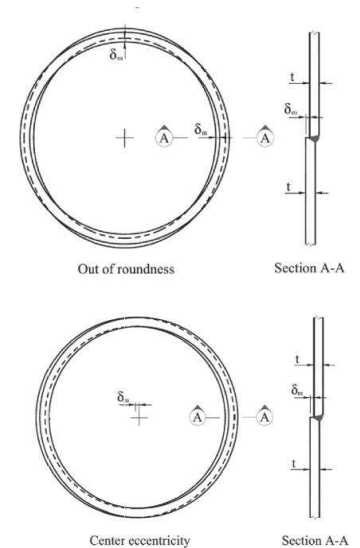
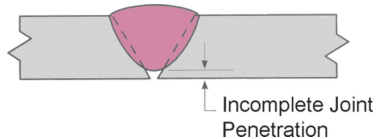
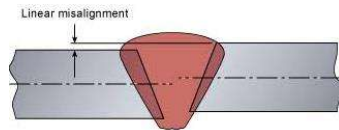
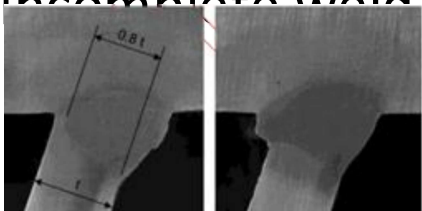
Fatigue is a key design driving factor for OWT's



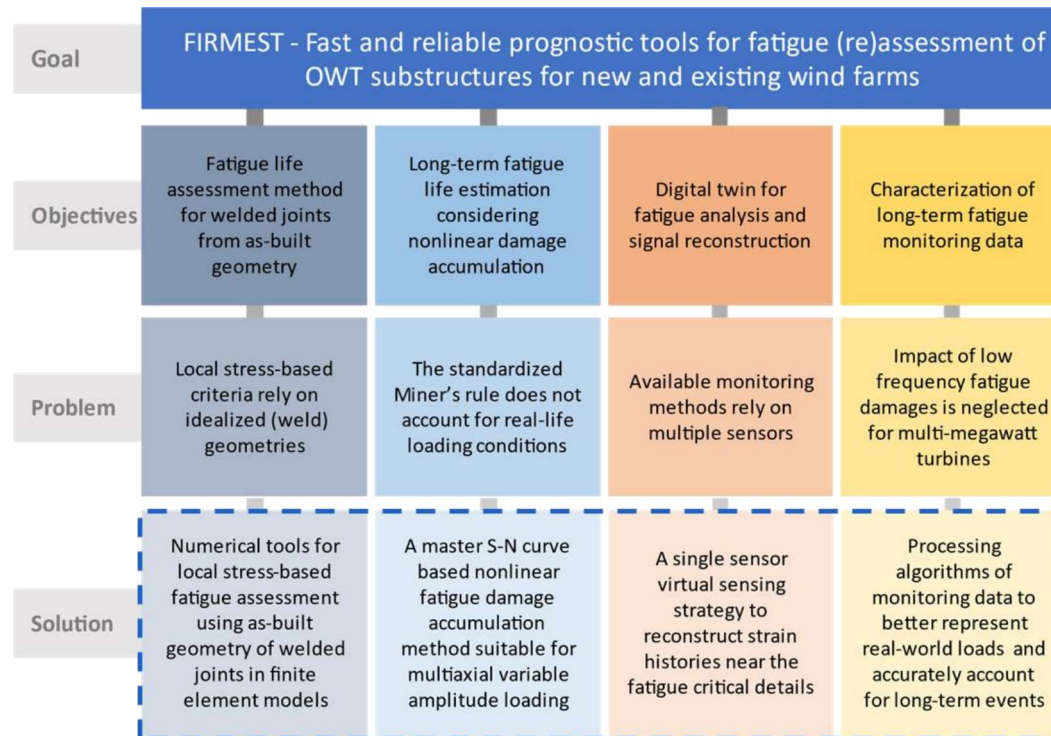
The challenge of fatigue in critical structures

Design models are idealized, but reality is not. How do we bridge this gap?

As-built structures differ from the as-designed (ovality, misalignment, weld profile, incomplete weld);



Firmest goes beyond the state-of-the-art



➡ *General objectives directly translated into work plan*

Firmest goes beyond the state-of-the-art

	2024				2025				2026			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
WP1 High-fidelity models of non-idealized welds and local approach for fatigue driving stress												
1.1 (Semi-)automated welded joint reconstruction based on as-built data												
1.2 Structural stress method for multi-axial stresses and weld root failure												
1.3 Implicit gradient model for as-built joints												
WP2 Fatigue damage accumulation and lifetime for variable amplitude load scenarios												
2.1 Fatigue life calculation based on local stress approaches												
2.2 Non-linear damage accumulation and load sequence/interaction effects												
2.3 Experimental work												
WP3 Development of a Digital Twin for fatigue analysis and signal reconstruction												
3.1 Data architecture for detailed fatigue information of as-built structures												
3.2 Digital twin development and uncertainty quantification												
3.3 Single sensor strain reconstruction using a virtual sensing concept												
WP4 Advanced characterization and processing of long-term fatigue monitoring data												
4.1 Advanced characterization of long term fatigue data in offshore wind												
4.2 Update fatigue toolbox for advanced processing of long term fatigue data												
WP5 Valorization and dissemination												
5.1 Case study 1 – Sensitivity analysis of the influence of weld imperfections on fatigue life												
5.2 Case study 2 – Sensitivity analysis for a 3MW and a 9MW machine for different EOC scenarios												
5.3 Dissemination												
5.4 Valorisation strategy												
WP6 Management												
6.1 Project Management, Organisation and Coordination												
6.2 Data management												
6.3 IP management												

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