TIGER TIDAL STREAM INDUSTRY ENERGISER

SEA TECH WEEK BREST-FRANCE

Morbihan Hydro Energies

EUROPEAN UNION

Interreg France (Channel Manche) England

European Regional Development Fund

GROWING THE SUPPLY CHAIN FOR COST EFFECTIVE RELIABLE COMPOSITE BLADES, TOOLING AND SENSOR DESIGN FOR TIDAL TURBINES

13/10/2020 – SEA TECH WEEK, BREST FRANCE

UPDATING BV NI603: VALIDATION AND CERTIFICATION OF EMERGING COMPOSITE TECHNOLOGIES – EXPERIENCES FROM BLADE TESTING IN REALTIDE & MEVEF

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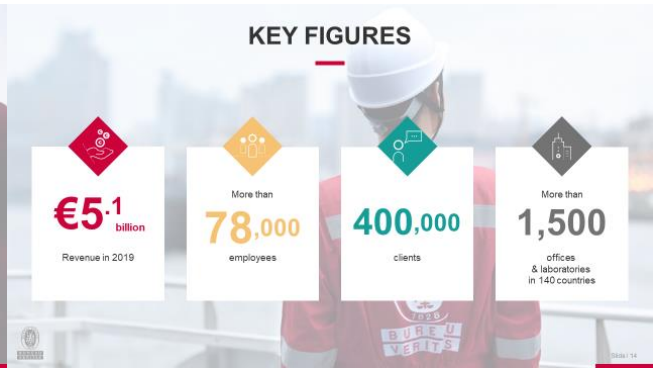
Bureau Veritas

Bureau Veritas



MARINE & OFFSHORE

MISSION

Bureau Veritas protects its clients' people and assets, passengers and the marine environment

EXPERTISE

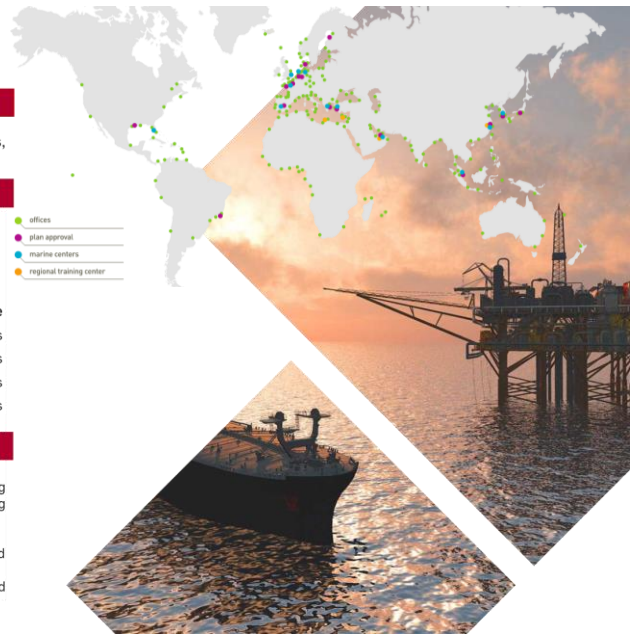
Verifying the conformity of ships (under construction and in service) to classification rules and standards that mainly concern structural soundness & reliability of the machinery on-board

FOR

Service type	Asset type
Design review	Passenger ships
Periodical inspections	Cargo ships
Subsea certification	Floating & fixed units
	Marine Renewable units

KEY ASSETS

- Almost 200 years of classification expertise protecting lives and assets in challenging marine operating environments
- Leading expertise in the complex marine LNG sector
- Strong expertise in smart ship technology and advanced services for cyber security and resilience
- Committed to minimizing impact on oceans and atmosphere



COMPOSITE MATERIALS SECTION

RealTide

RealTide: Advanced monitoring, simulation and control of tidal devices in unsteady, highly turbulent realistic tide environments

REALTIDE

2018-2021

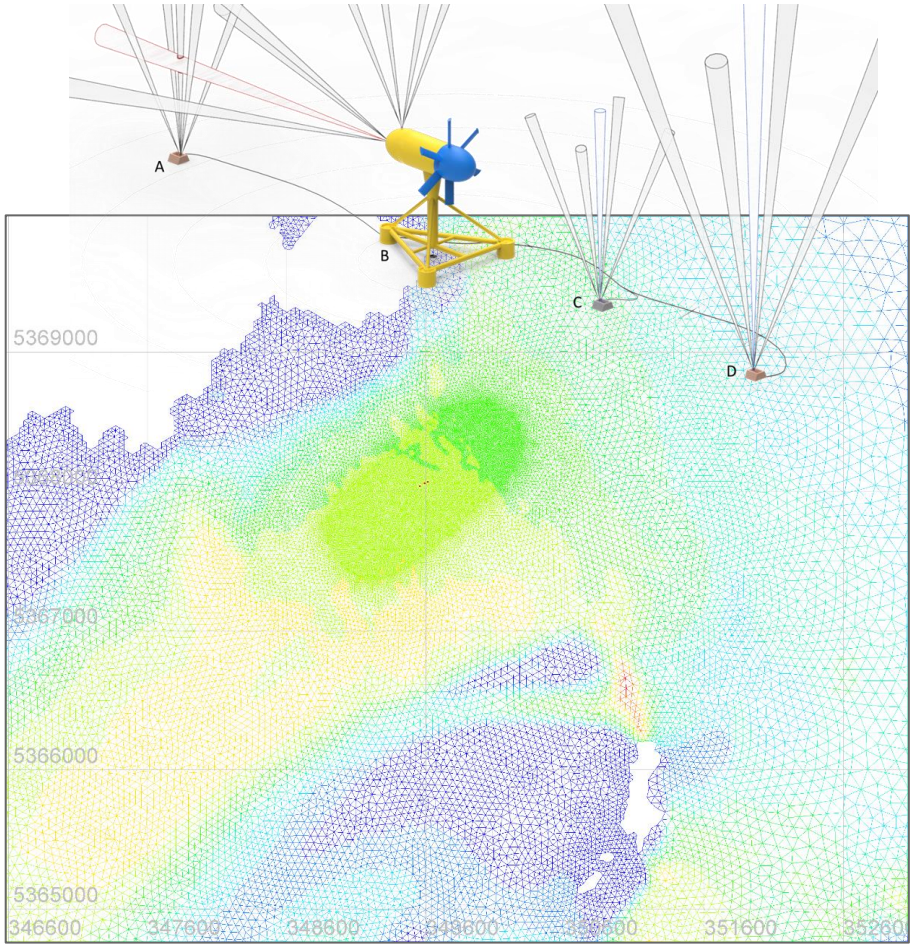
5 M€

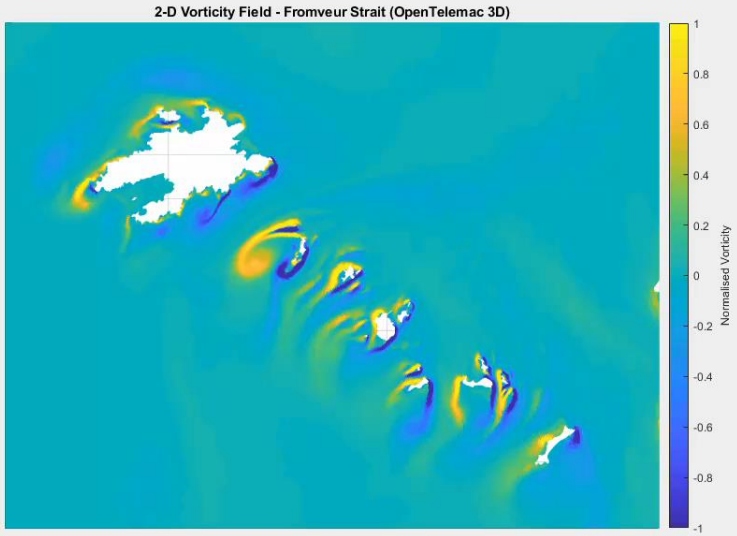
Horizon 2020 research and innovation programme under Grant Agreement n°727689

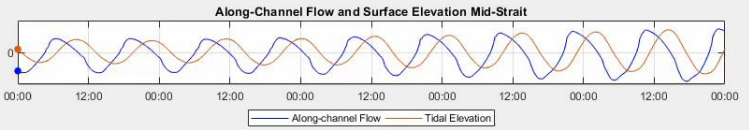
Objective: to identify **main failure causes** of tidal turbines at sea and to provide **a step change** in the design of key components, namely the **blades** and **power take-off systems**, adapting them more accurately to the **complex environmental tidal conditions**.

RealTide

- Field measurements and models



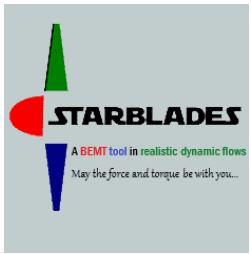


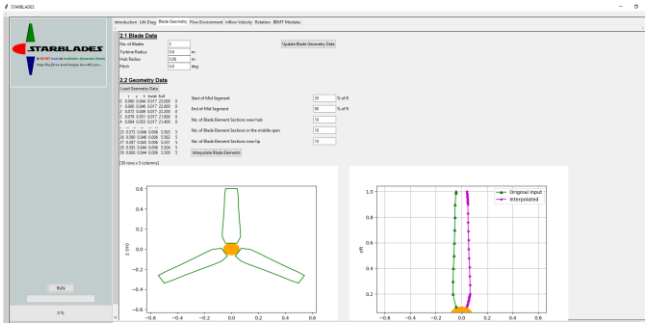


c.old@ed.ac.uk, The University of Edinburgh. 2020. www.realtide.eu

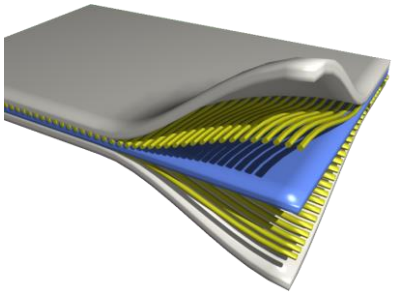
RealTide

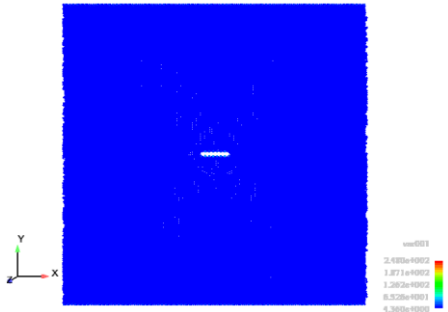
- **STARBLADES** – an in-house developed tool for the computation of forces on a tidal turbine blade
- Based on **Blade Element Momentum Theory** (BEMT)
- Classical BEMT embedded with improvements to account for **realistic and dynamic flows**
- Enables **faster computations** as compared to CFD solvers





- **Fatigue methodology**





LOADS

- Dynamic flow environment
- Flow modification by rotating turbine

MATERIAL

- Multiple layers
- Anisotropic
- Non-homogeneous

FATIGUE

- Complex mechanism
- Non-linear phenomenon

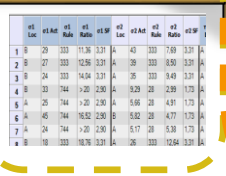
- **Fatigue methodology**

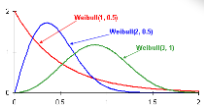
LOADS

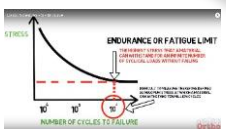
MATERIAL

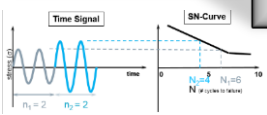
FATIGUE PHENOMENON

Loading conditions	Forces on blade section	Ply-by-ply stresses	Probability distribution of stresses	S-N curves for UD ply	% of damage on each ply	Total Fatigue damage
Based on NI603	StarBlades	ComposeIT	Weibull Law	IFREMER tests	Miner Sum	Most critical ply damage
Operating condition of the turbine Tides Current Waves	Corresponding to each loading condition Shear Force and Bending Moment distribution	Laminate loads from BEMT code Laminate properties based on tensile test results	Characterize the probability distribution of loading, as a probability distribution of stresses For each ply For both directions (L & T)	L direction (parallel to fibres) T direction (perp. to fibres)	Cumulative damage based on probabilistic approach Obtain damage ratio for each ply, in both directions d_{L1}, d_{T1}, d_{L2}, d_{T2}, d_{L3}, d_{T3}, ...	Maximum of damages on each ply d = max (d_{L1}, d_{T1}, d_{L2}, d_{T2}, ...)



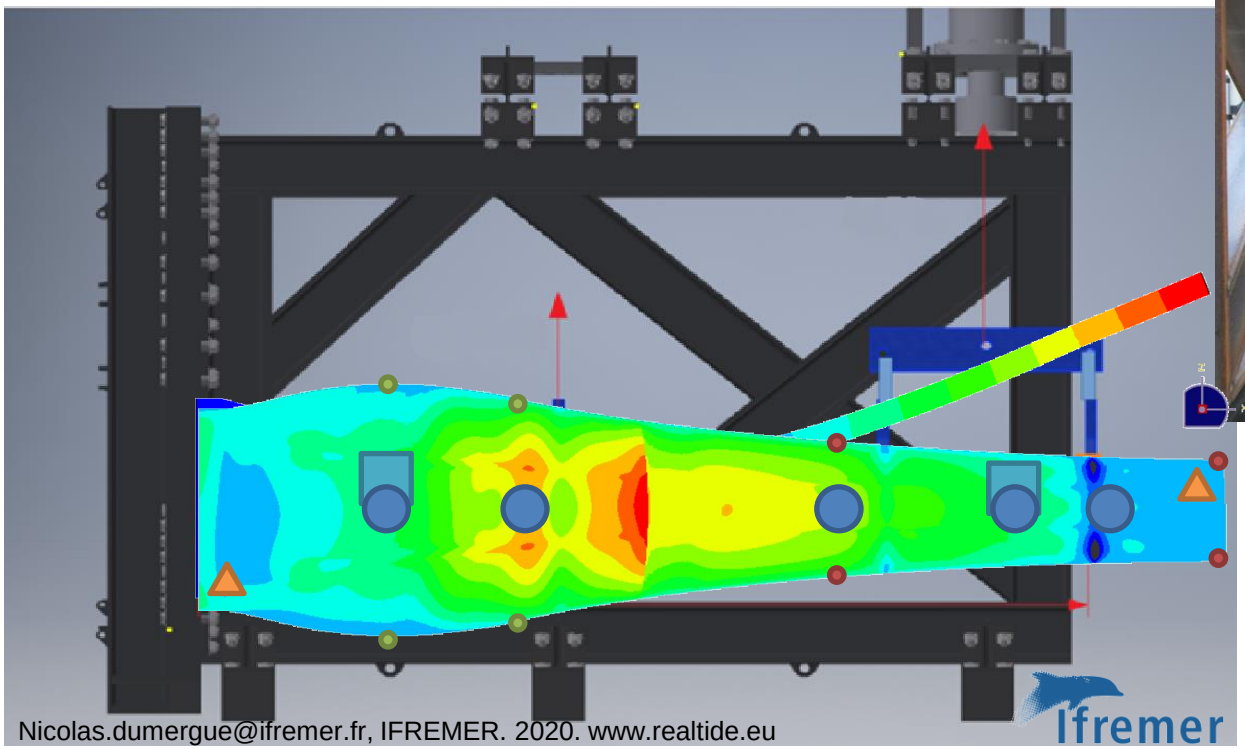






RealTide

- Testing



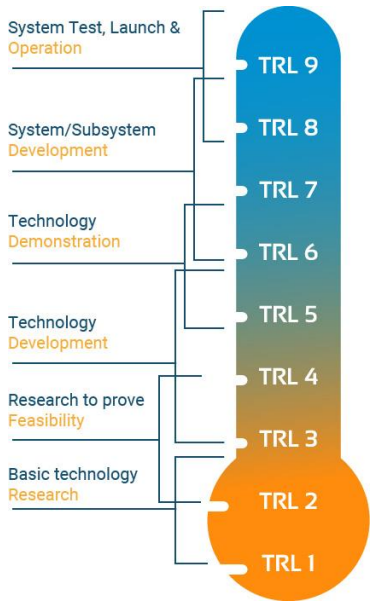
MEVEF

- **M**aîtrise des **E**ffets du **V**ieillissement sur l'**E**ndommagement en **F**atigue des matériaux composites stratifiés pour les EMR immergés.

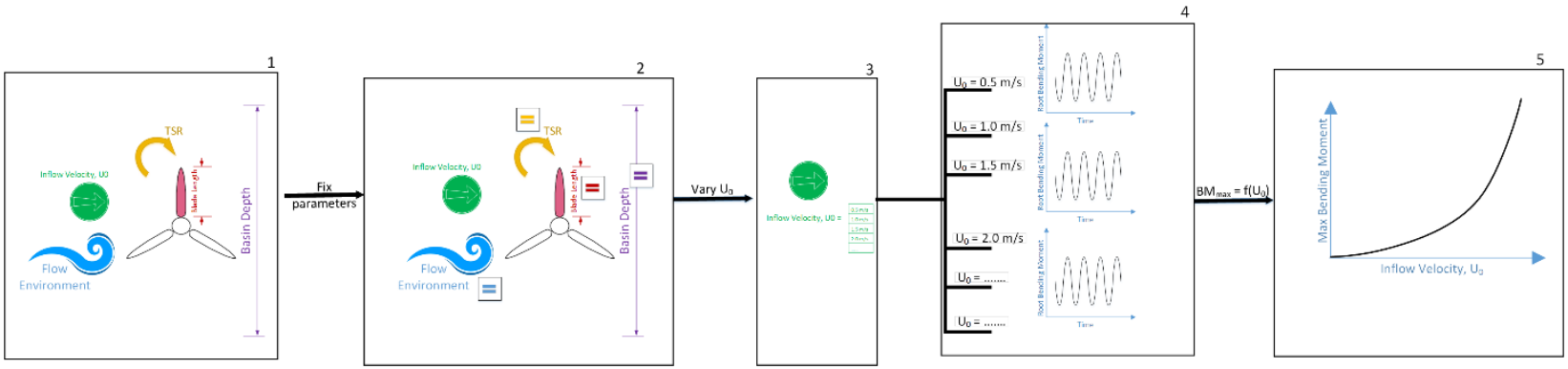
- The objective of the MEVEF project is to **treat the behaviour** of composite structures or components in **fatigue** and their **ageing** in a coupled manner, by proposing **predictive models** and elements for the **development of future regulatory notes**.

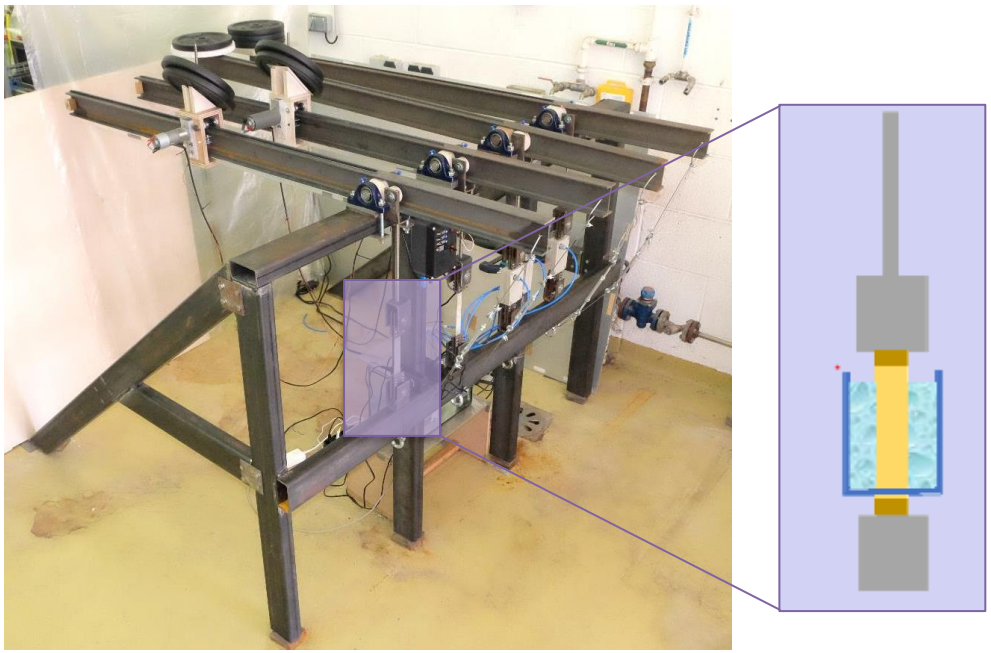
2018-2021

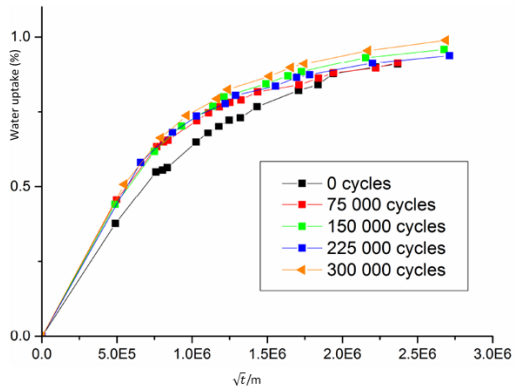
0.6 M€

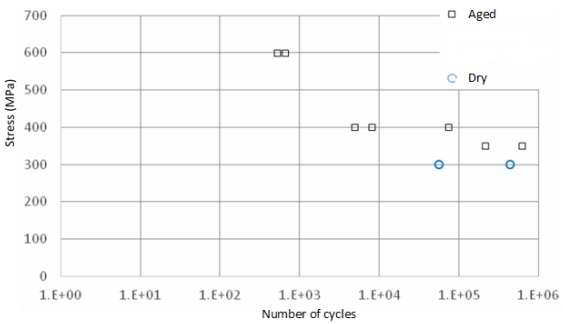


MEVEF

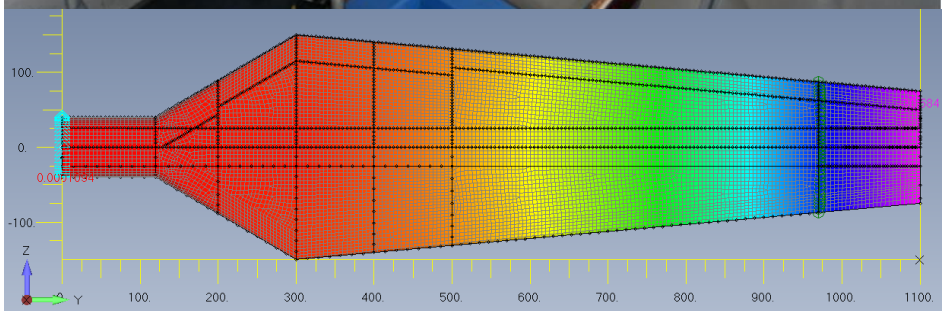

1
TSR
Inflow Velocity, U0
Flow Environment
Basin Depth
Fix parameters
2
TSR
Inflow Velocity, U0
Flow Environment
Basin Depth
Vary U0
3
Inflow Velocity, U0 =
4
U0 = 0.5 m/s
U0 = 1.0 m/s
U0 = 1.5 m/s
U0 = 2.0 m/s
U0 = ...
U0 = ...
Root Bending Moment
Time
BMmax = f(U0)
5
Max Bending Moment
Inflow Velocity, U0

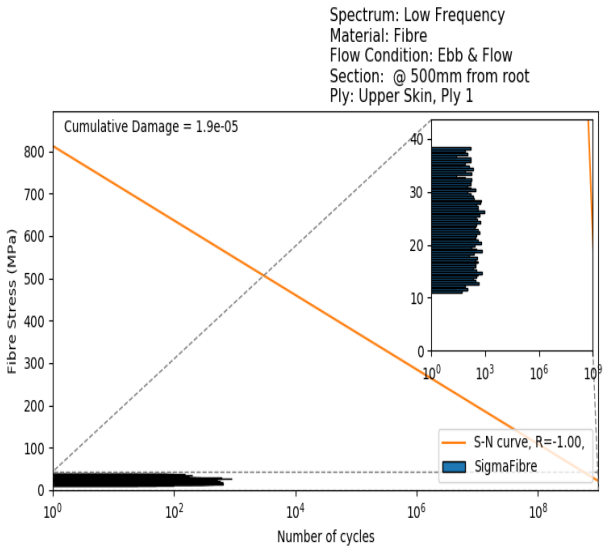



Water uptake (%)
1.0
0.5
0.0
0.0
5.0E5
1.0E6
1.5E6
2.0E6
2.5E6
3.0E6
√t/m
0 cycles
75 000 cycles
150 000 cycles
225 000 cycles
300 000 cycles


Stress (MPa)
700
600
500
400
300
200
100
0
1.E+00
1.E+01
1.E+02
1.E+03
1.E+04
1.E+05
1.E+06
Number of cycles
Aged
Dry

- Model scale vs Full scale





- Miner Sum approach

$$D = \sum d_i = \sum \frac{n_i}{N_i}$$

➔ Fatigue life assessment

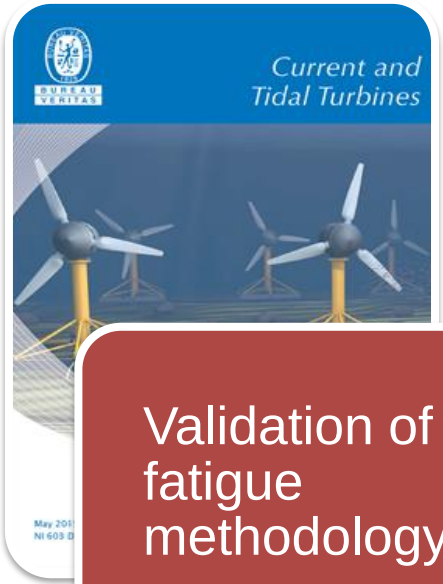
Conclusion

RealTide

- Coupons tests
  - *Dry & Aged*
- Full scale test
  - *Static*
- Simulations

MEVEF

- Coupons tests
  - *Dry & aged*
- Model scale test
  - *Static and dynamic*
- Simulations



Validation of fatigue methodology

Improvement of existing rules