CONSTRUCT

U.PORTO

FEUP FACULDADE DE ENGENHARIA UNIVERSIDADE DO PORTO

Vibration-based Structural Health Monitoring of Wind Turbines

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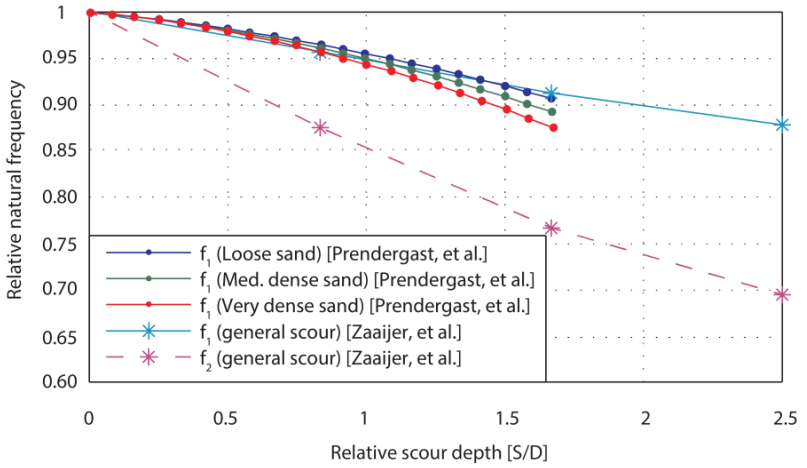
2011

Motivation

- Why monitoring?
  - Remote and harsh sites
  - Increasingly larger dimensions
  - Prone to rapid wear
  - Maintenance strategies

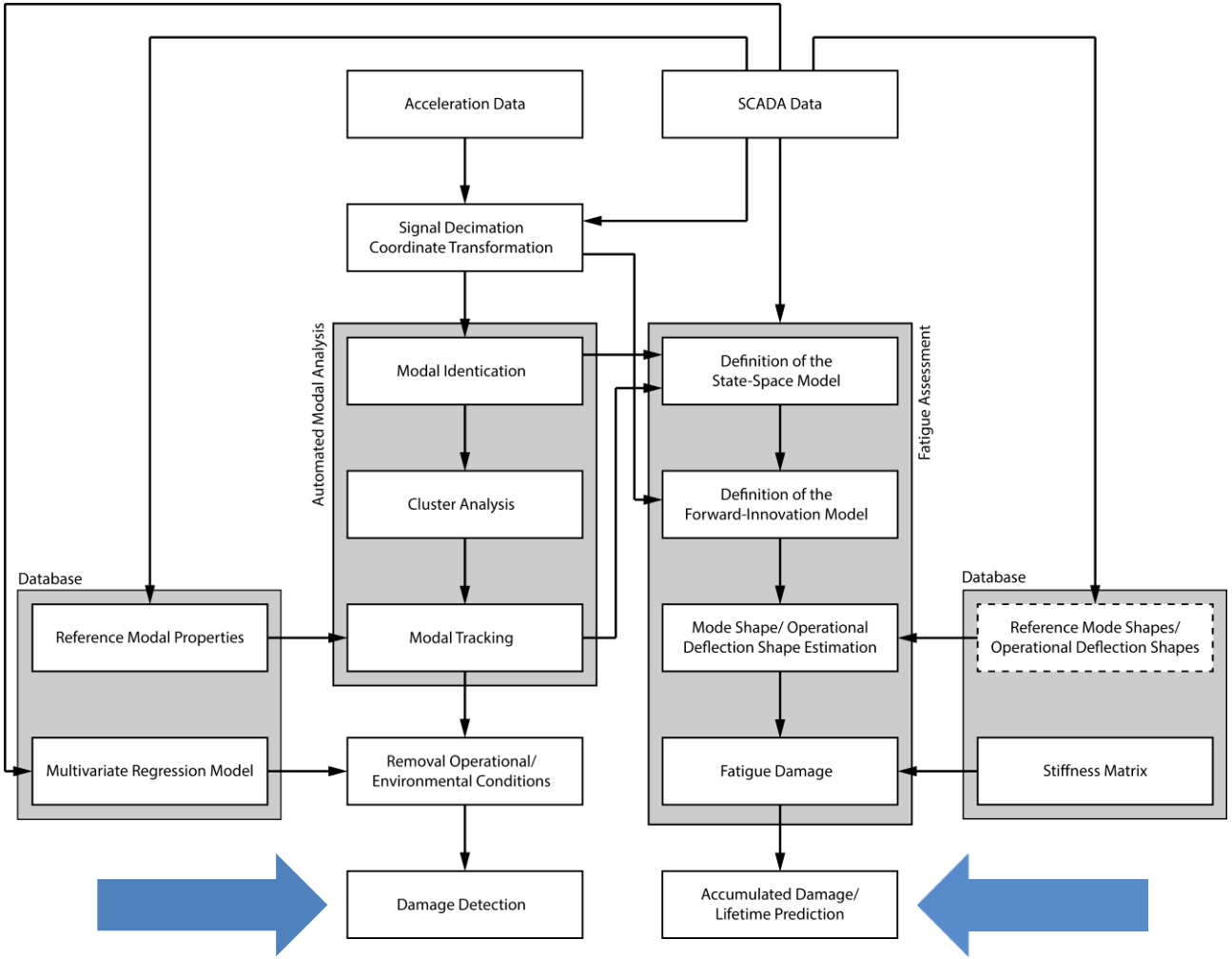


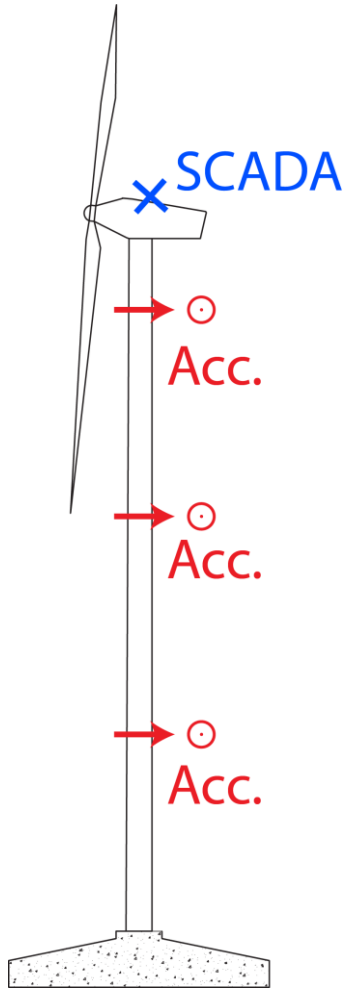
- Why Vibration-based OMA?
  - Highly dynamic structure
  - Vibration modes sensitive to damage



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Monitoring System



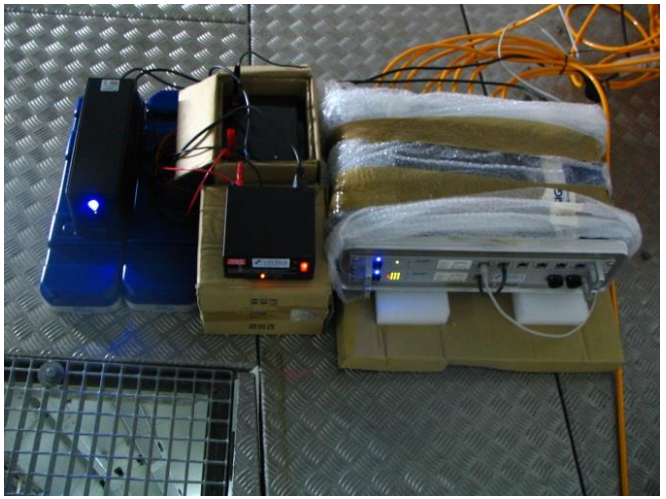


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3 Case studies

- Senvion MM82 (2.0 MW)
  - Torrão Wind Farm
    - Hub height: 80 m
    - Rotor diameter: 80 m
    - Steel tower





- Izar Bonus 1.3MW/62
  - Penedo Ruivo Wind Farm

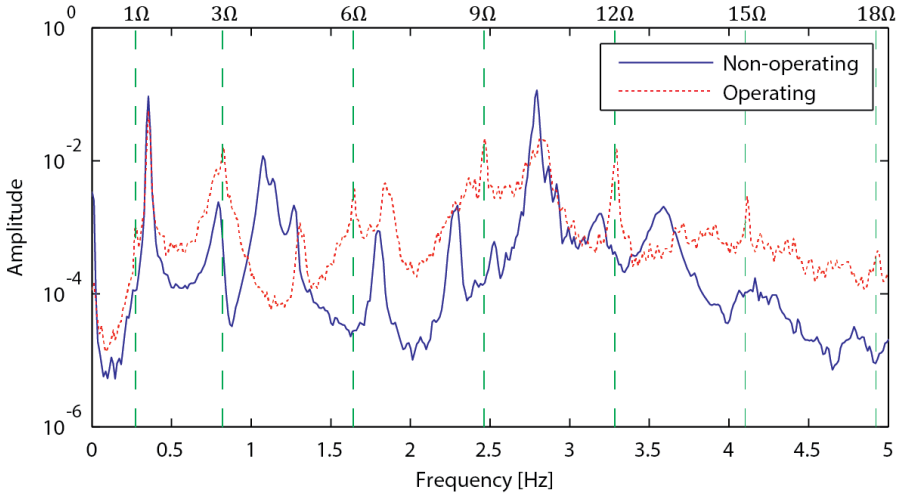


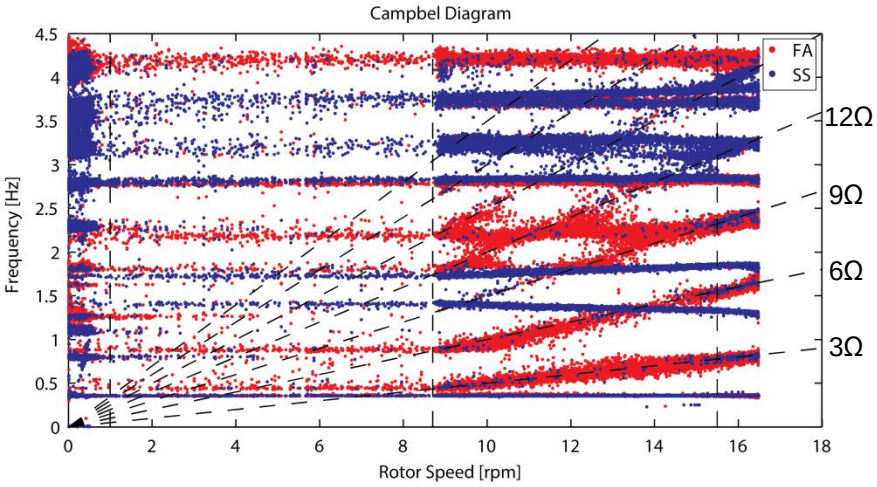
- Vestas V90-3.0MW
  - Offshore Belwind Wind Farm

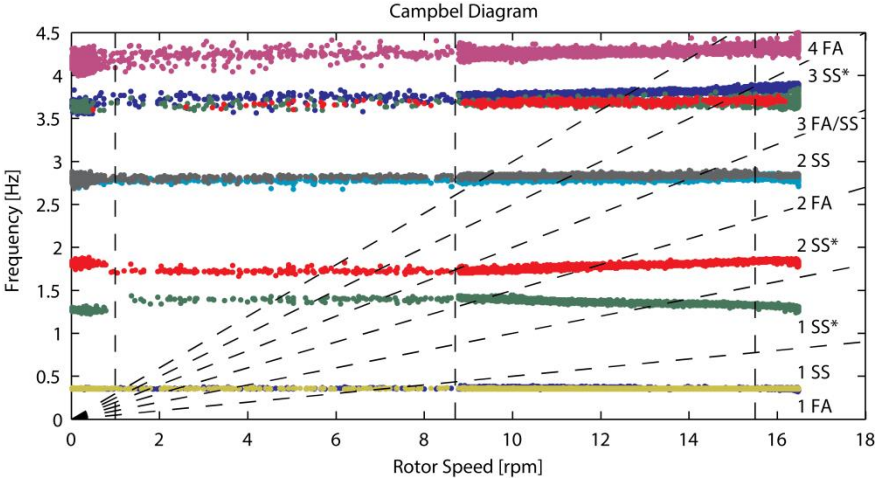


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Senvion MM82 – Modal Identification

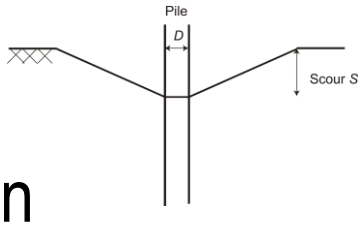




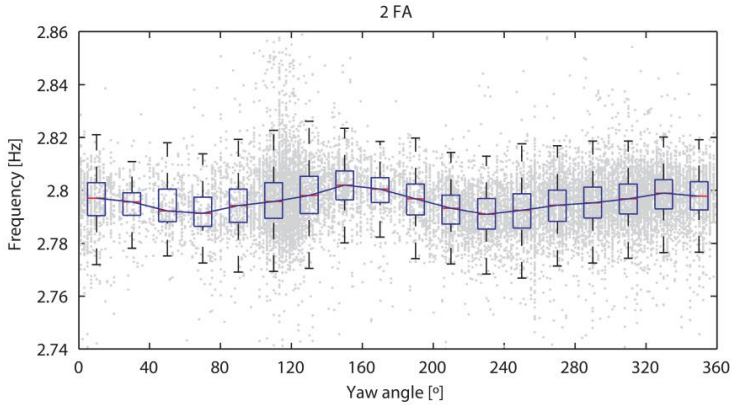


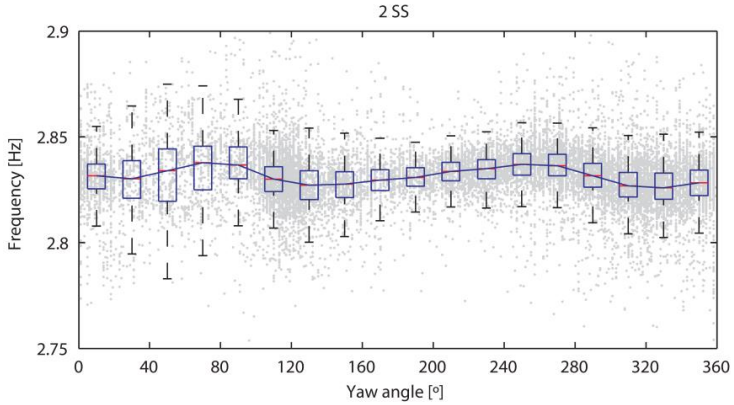
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Senvion MM82 – Damage Detection

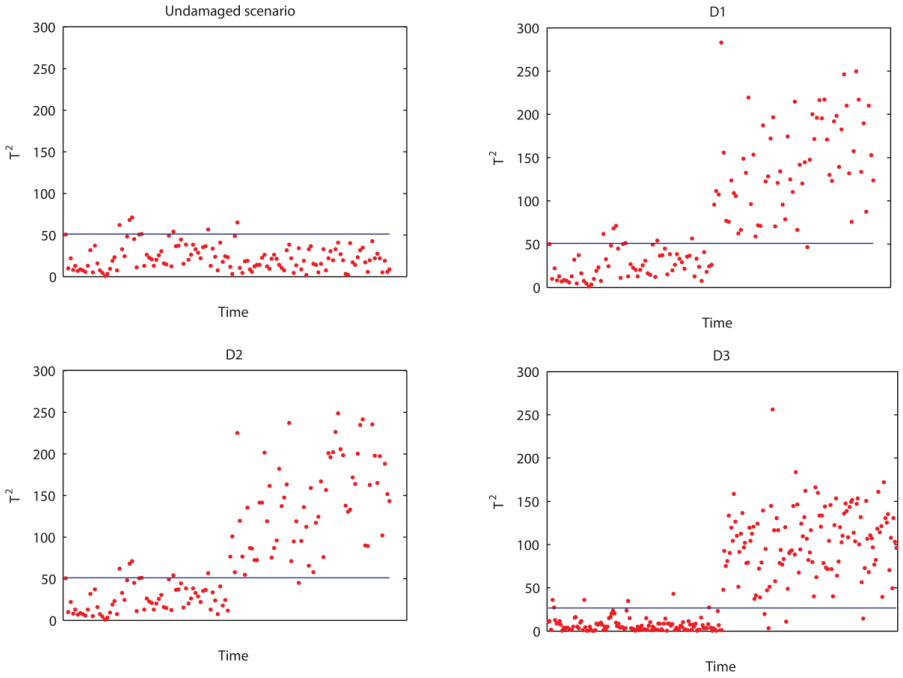


- Foundation analysis
  - Asymmetry detection





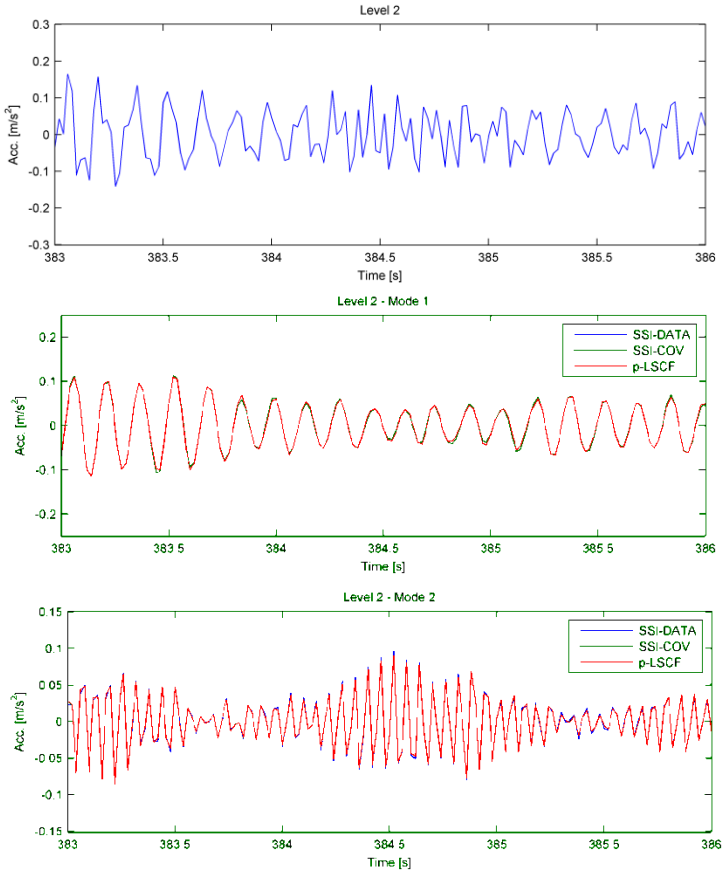
- Damage simulation
  - D1: Scour ⟶ 7.5% *D* (<< 130%)
  - D2: Foundation ⟶ < 5 times
  - D3: Blade damage ⟶ 85% *K*

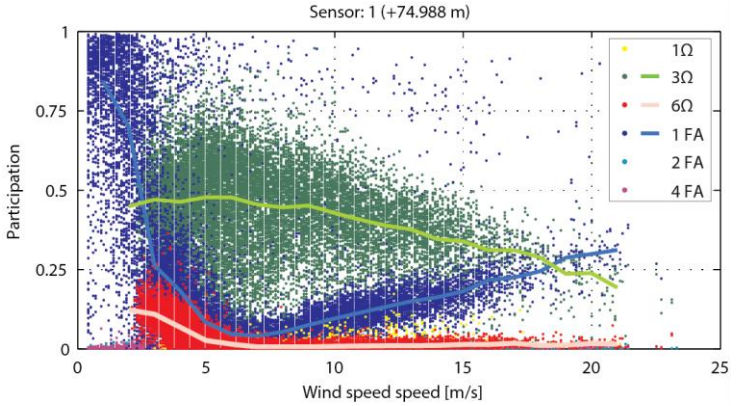


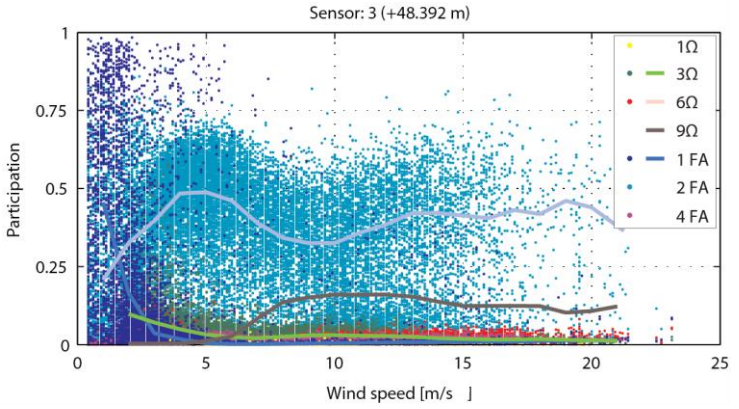
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Senvion MM82 – Modal Acceleration Response

- Post-processing tool
  - Split acceleration into modal/ harmonics acceleration response
  - Level of participation of each mode in the response

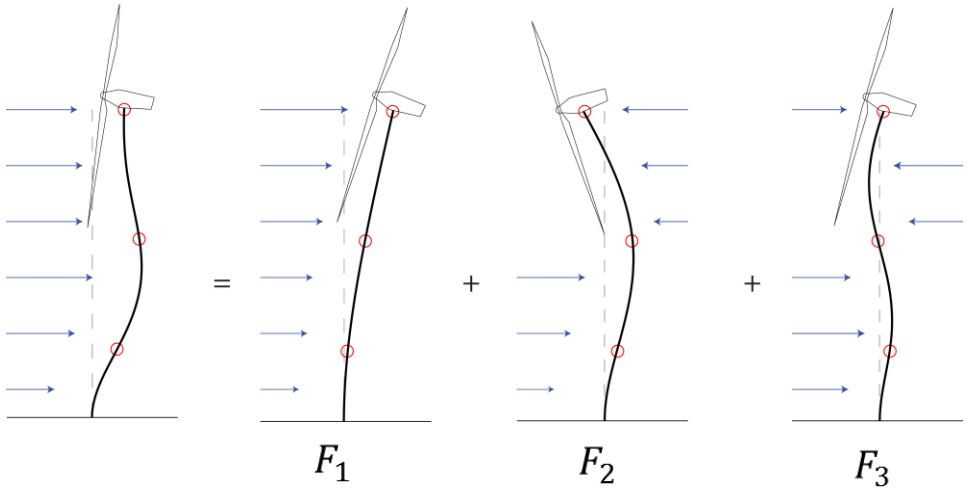




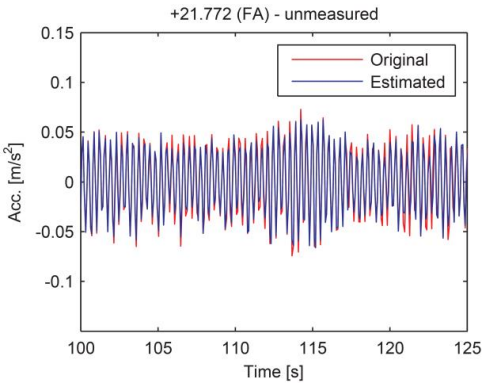


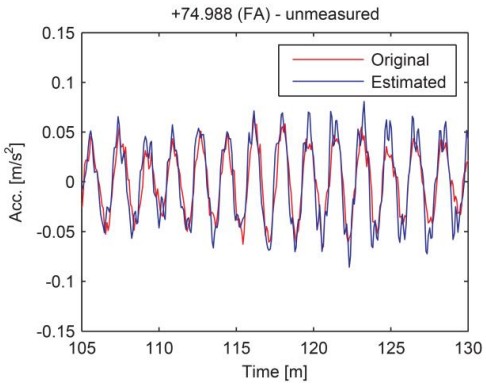
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Senvion MM82 – Fatigue Assessment

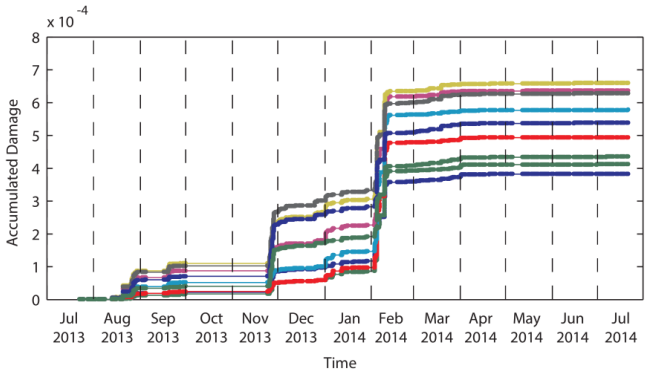


- Vibration estimation at unmeasured sections



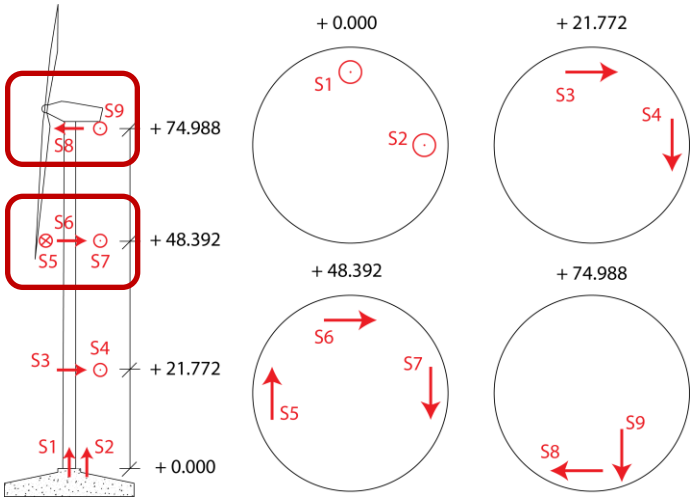


- ("Dynamic") fatigue damage evolution



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Senvion MM82 – Optimization



- Layout 1 – Top sensors
  - Damage identification
    - D1: Scour → 16.2% *D* (<< 130%)
    - D2: Ok
    - D3: Ok
  - Fatigue
    - Error ≈ -42 %

- Layout 2 – Sensors at 2/3 tower height
  - Damage identification
    - D1: Ok
    - D2: Ok
    - D3: Ok
  - Fatigue
    - Error ≈ -14 %

- Layout 3 – Top Sensors + 2/3 tower height
  - Damage identification
    - D1: Ok
    - D2: Ok
    - D3: Ok
  - Fatigue
    - Error ≈ + 5%

Conclusions

- Modal identification
  - Ability of OMA algorithms to identify modal properties throughout different operating conditions
  - The results obtained show a high accuracy in detecting structural changes (damage) at the foundation / tower level (onshore and offshore wind turbines)
- Fatigue assessment
  - The methodology for fatigue assessment showed promising results to estimate the fatigue damage condition at any position of the support structure
- Optimization
  - There is an important potential to reduce costs of installation