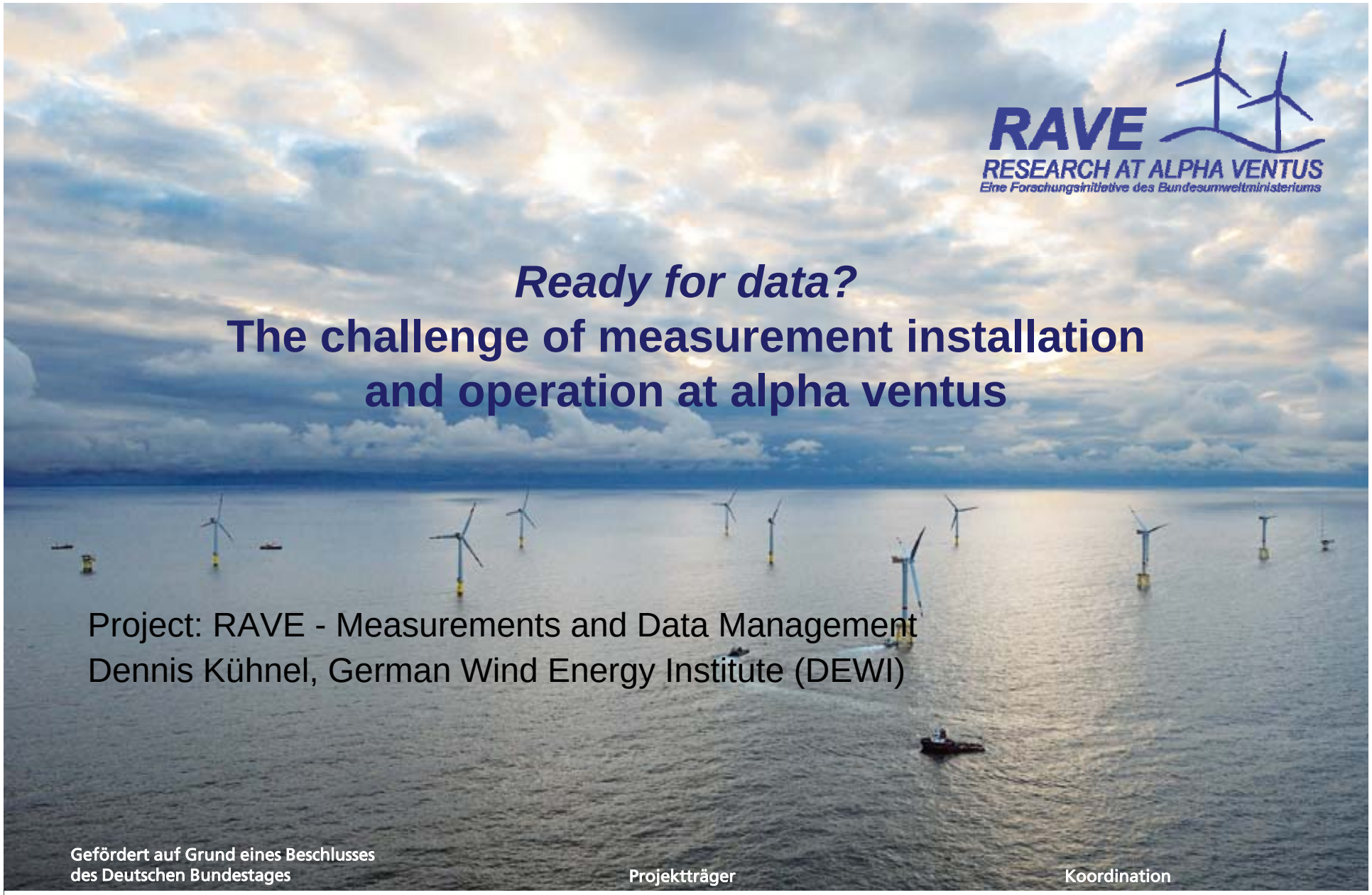


RAVE
RESEARCH AT ALPHA VENTUS
Eine Forschungsinitiative des Bundesumweltministeriums

Ready for data?
The challenge of measurement installation and operation at alpha ventus

Project: RAVE - Measurements and Data Management

Dennis Kühnel, German Wind Energy Institute (DEWI)

Gefördert auf Grund eines Beschlusses des Deutschen Bundestages

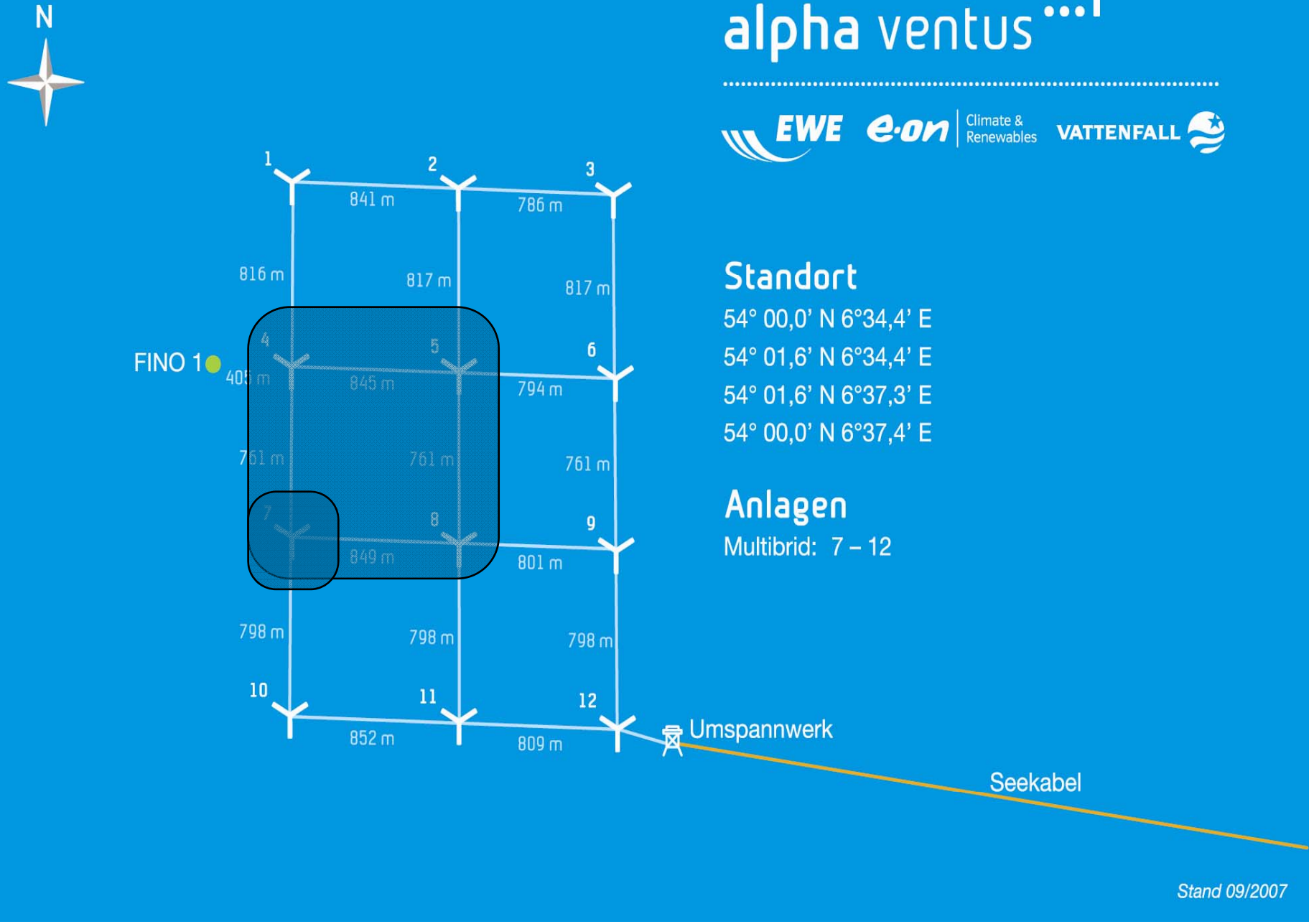
Projektträger

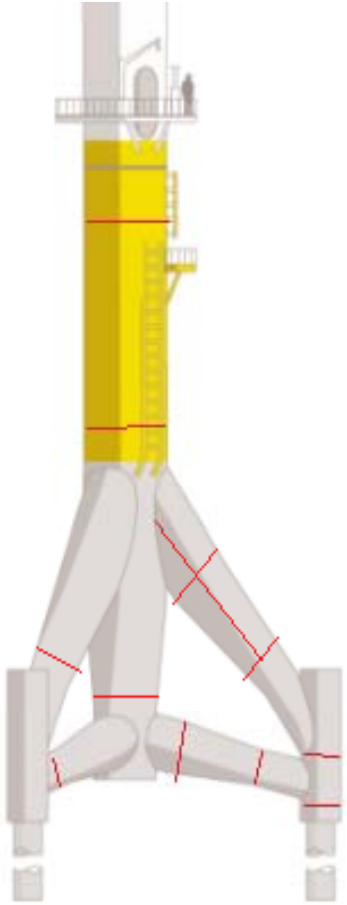
Koordination

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit

ptj Projektträger Jülich Forschungszentrum Jülich

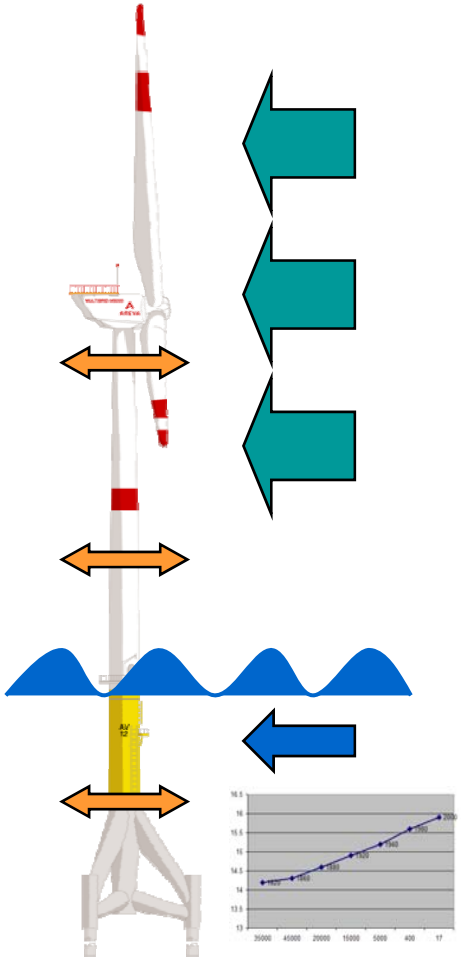
Fraunhofer IWES


N
alpha ventus
EWE
e·on
Climate & Renewables
VATTENFALL
1
2
3
841 m
786 m
816 m
817 m
817 m
FINO 1
4
5
6
845 m
794 m
761 m
761 m
761 m
7
8
9
849 m
801 m
798 m
798 m
798 m
10
11
12
852 m
809 m
Umspannwerk
Seekabel
Standort
54° 00,0' N 6°34,4' E
54° 01,6' N 6°34,4' E
54° 01,6' N 6°37,3' E
54° 00,0' N 6°37,4' E
Anlagen
Multibrid: 7 – 12
Stand 09/2007



Planning

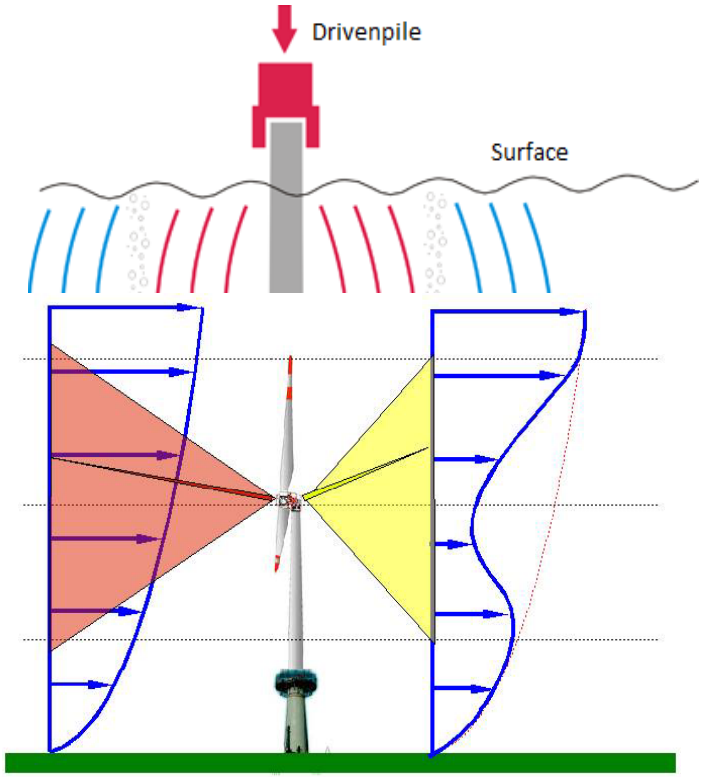
Installation

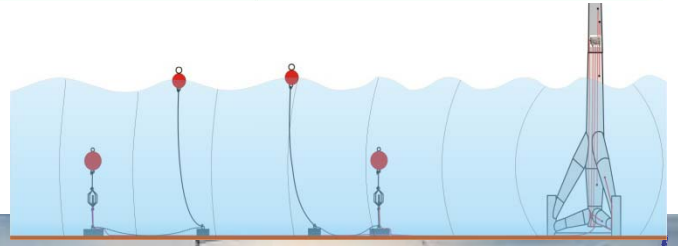


Measurement

Planning - *What to measure?*

- *Structural Loads and Dynamics*
- *Acoustics and Operational Noise*
- *Meteorology and Wind Measuring*





Planning - *What to measure?*

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- *Acoustics and Operational Noise*
- *Meteorology and Wind Measuring*
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Planning - *What to measure?*

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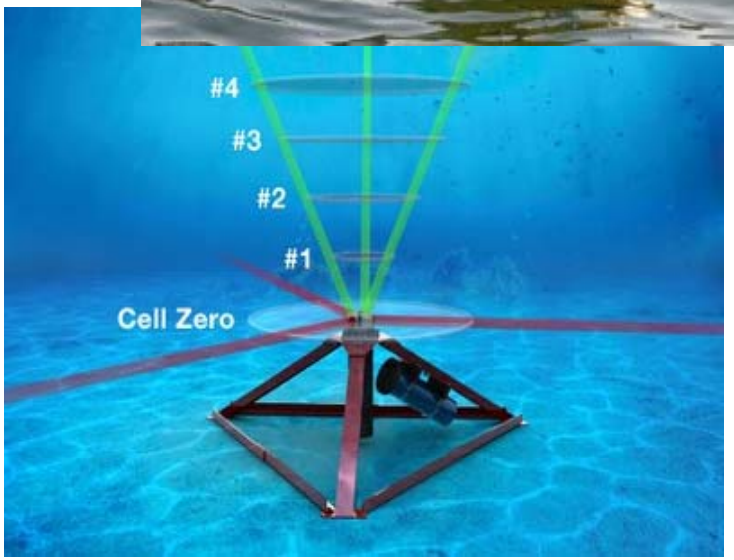

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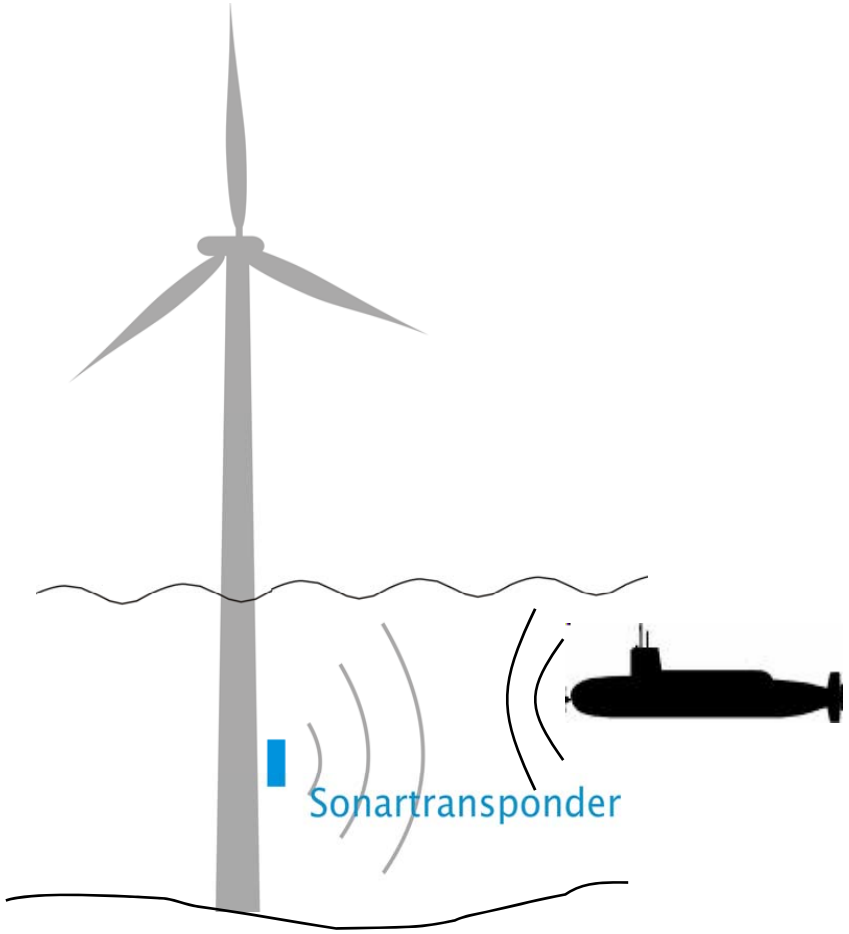
- *Grid Integration*
- *Sonar Transponder*



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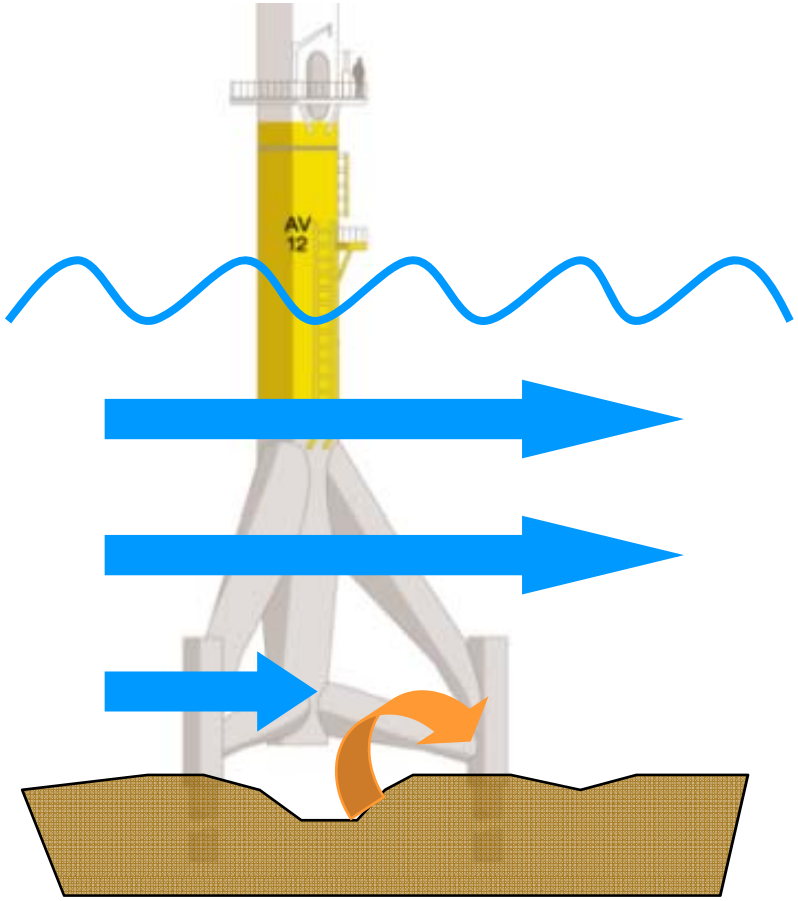
- *Grid Integration*
- *Sonar Transponder*
- *Ground Erosion*



Planning - *What to measure?*

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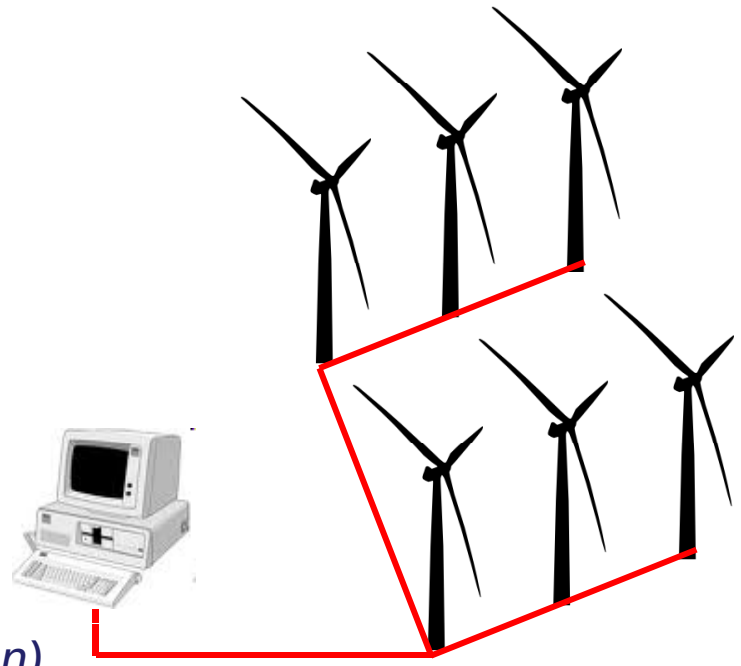
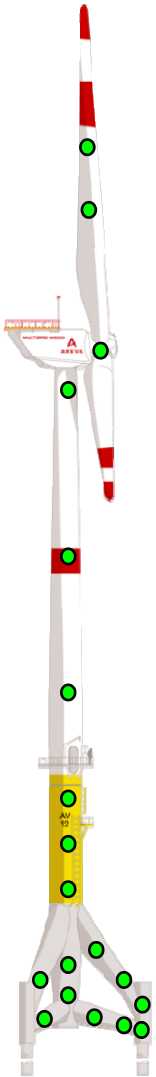
- *Sonar Transponder*
- *Ground Erosion*
- *Turbine Operation Data (High Resolution)*





Planning - *Sensors & Measurement Equipment*

- Strain Gauges (>160) from Blade Tip to Driven Pile (electrical & optical)
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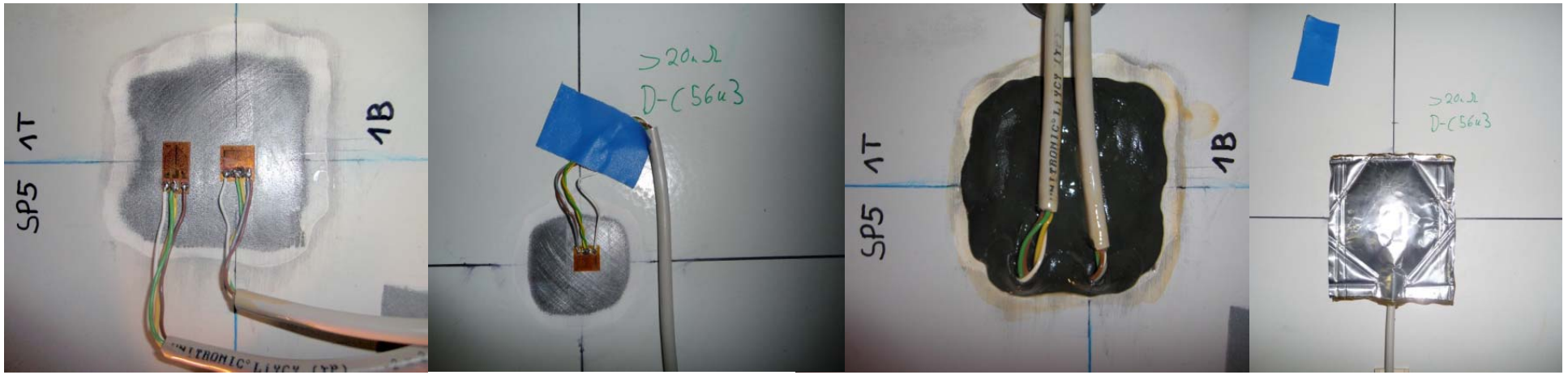
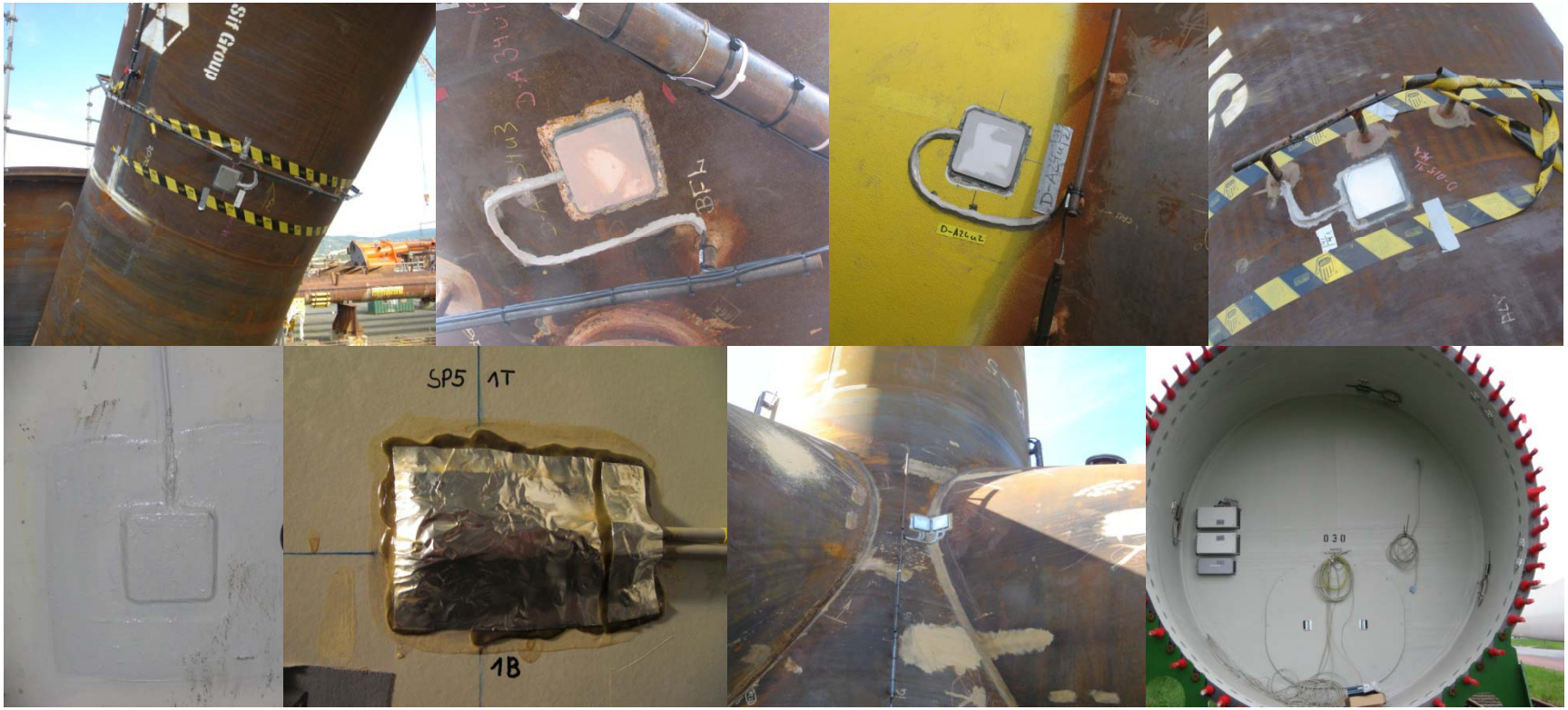
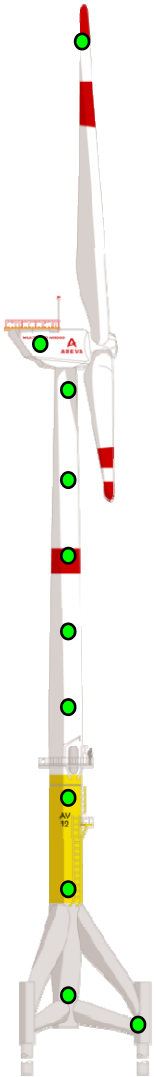
Sensor Installation - *Example: Electrical Strain Gauge*



Sensor Installation - *Strain Gauges Placement*





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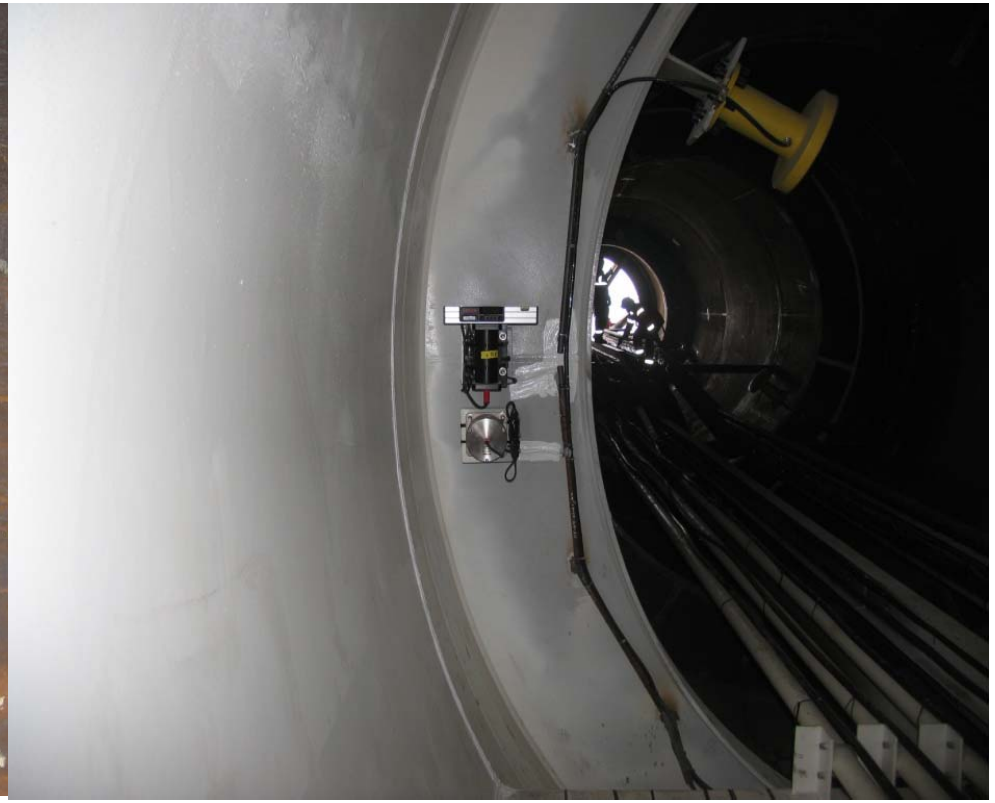
Sensor Installation - *Acceleration Sensor Placement*



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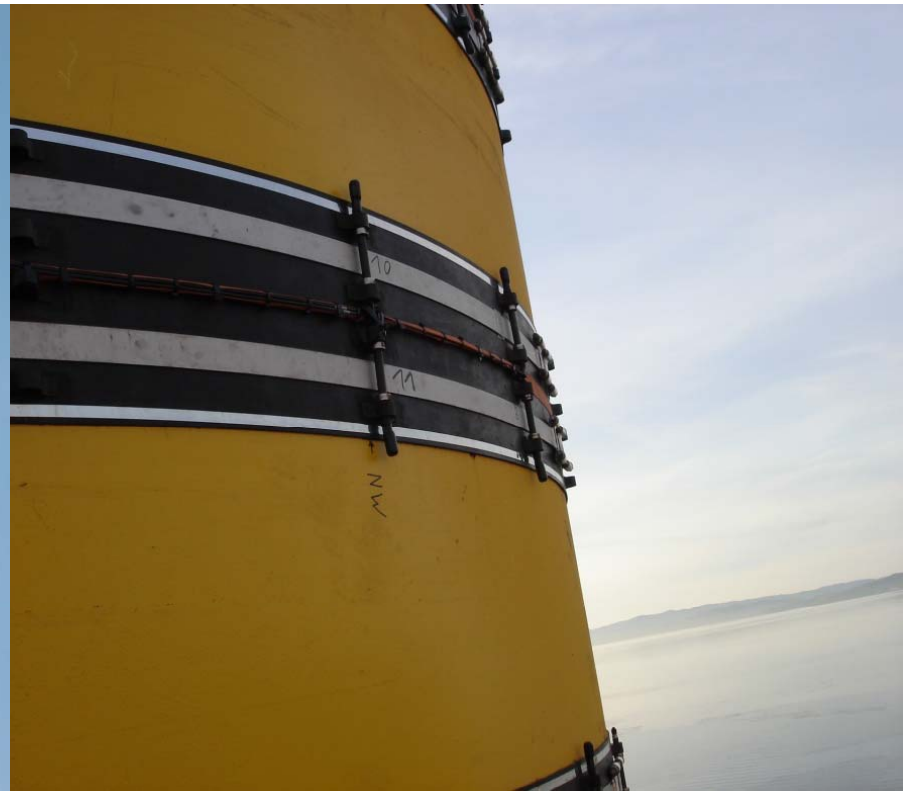
Sensor Installation - *Water Pressure Rings*



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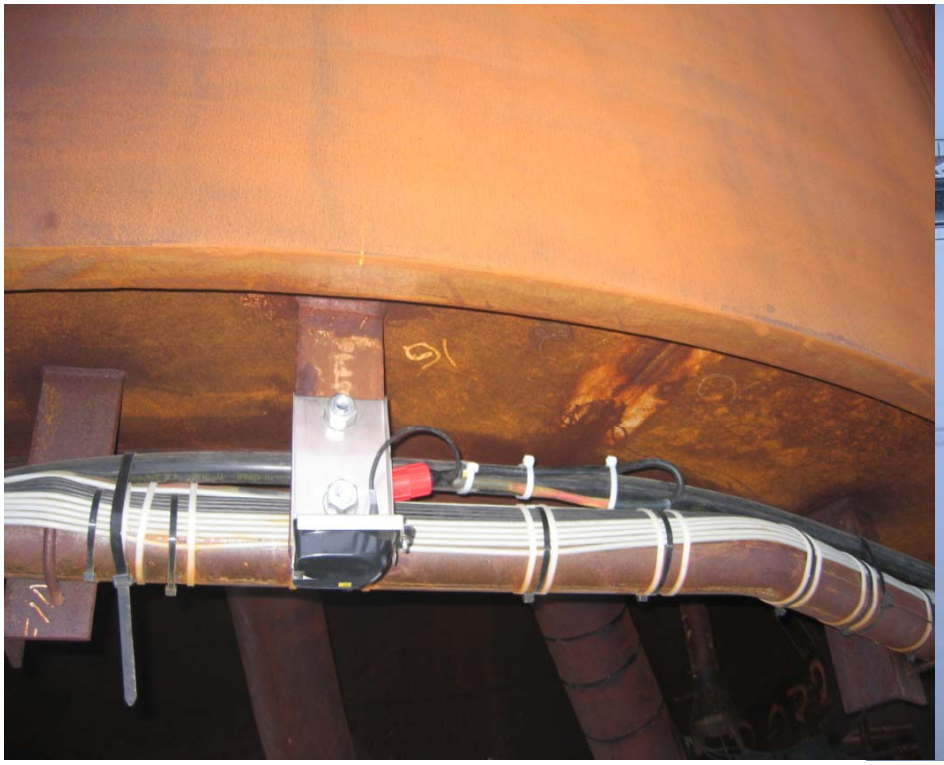
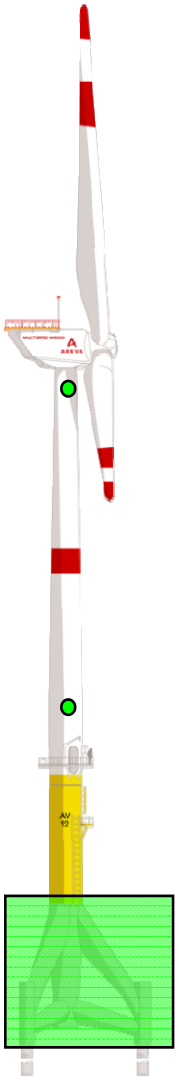
Sensor Installation - *Echo Sounders at Bottom of Tripod*





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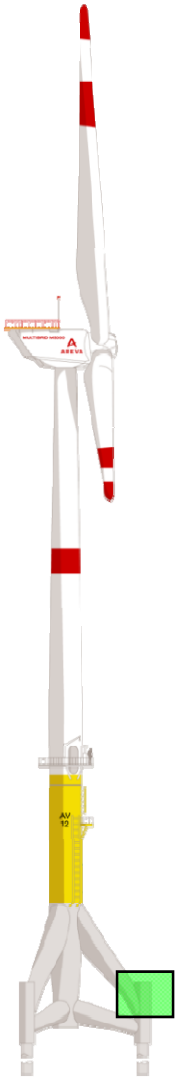

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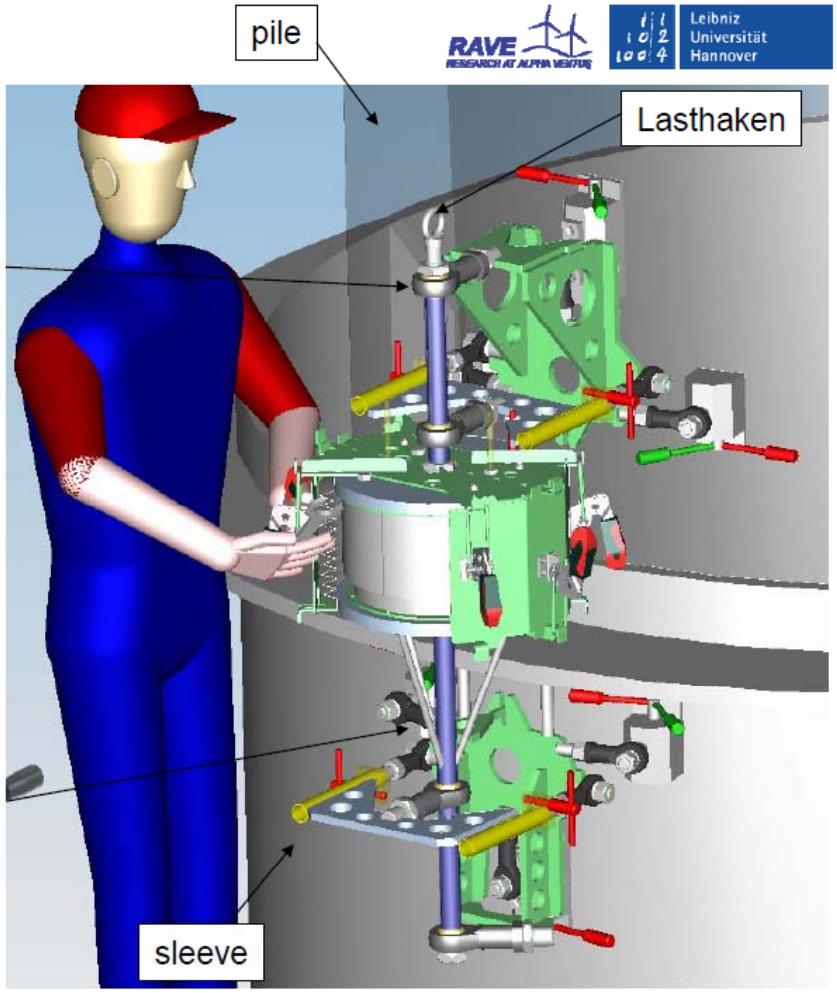
Sensor Installation - *Preparing the Relative Movement Sensor*



Planning - *Sensors & Measurement Equipment*

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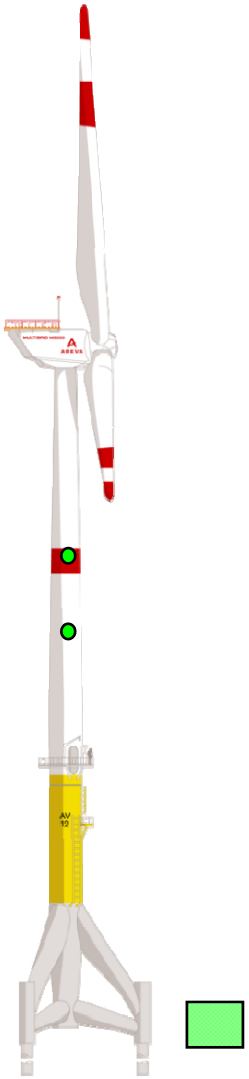
Sensor Installation - *Wave Height Radar and Wave Camera*



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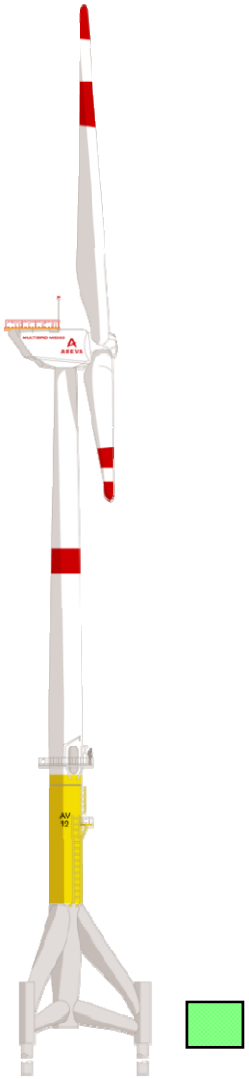
Sensor Installation - *Acoustic Sensors outside Tripod*



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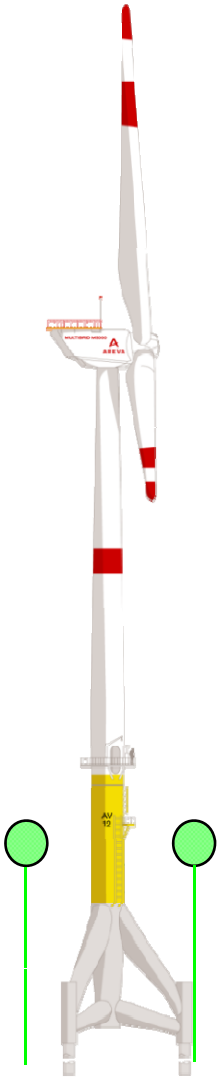
Measurement - *Ground Stationed Acoustic Doppler Current Profiler (ADCP)*



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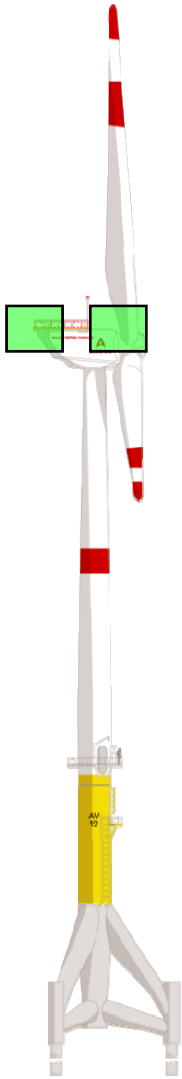
Measurement - *Wave Buoys*



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Measurement - *LiDAR Placement for incoming Winds and Wake*

Planning - *Sensors & Measurement Equipment*

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Measurement - *Corrosion Steel and Concrete Test Samples*

Planning - *Sensors & Measurement Equipment*

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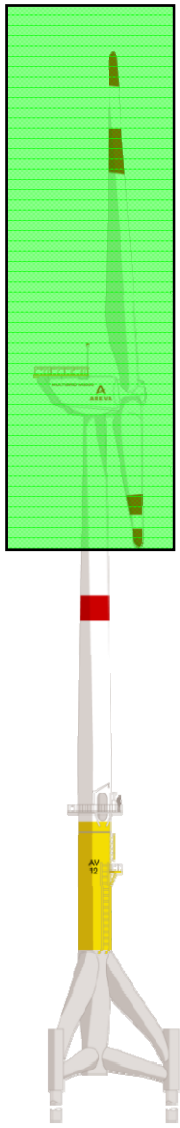

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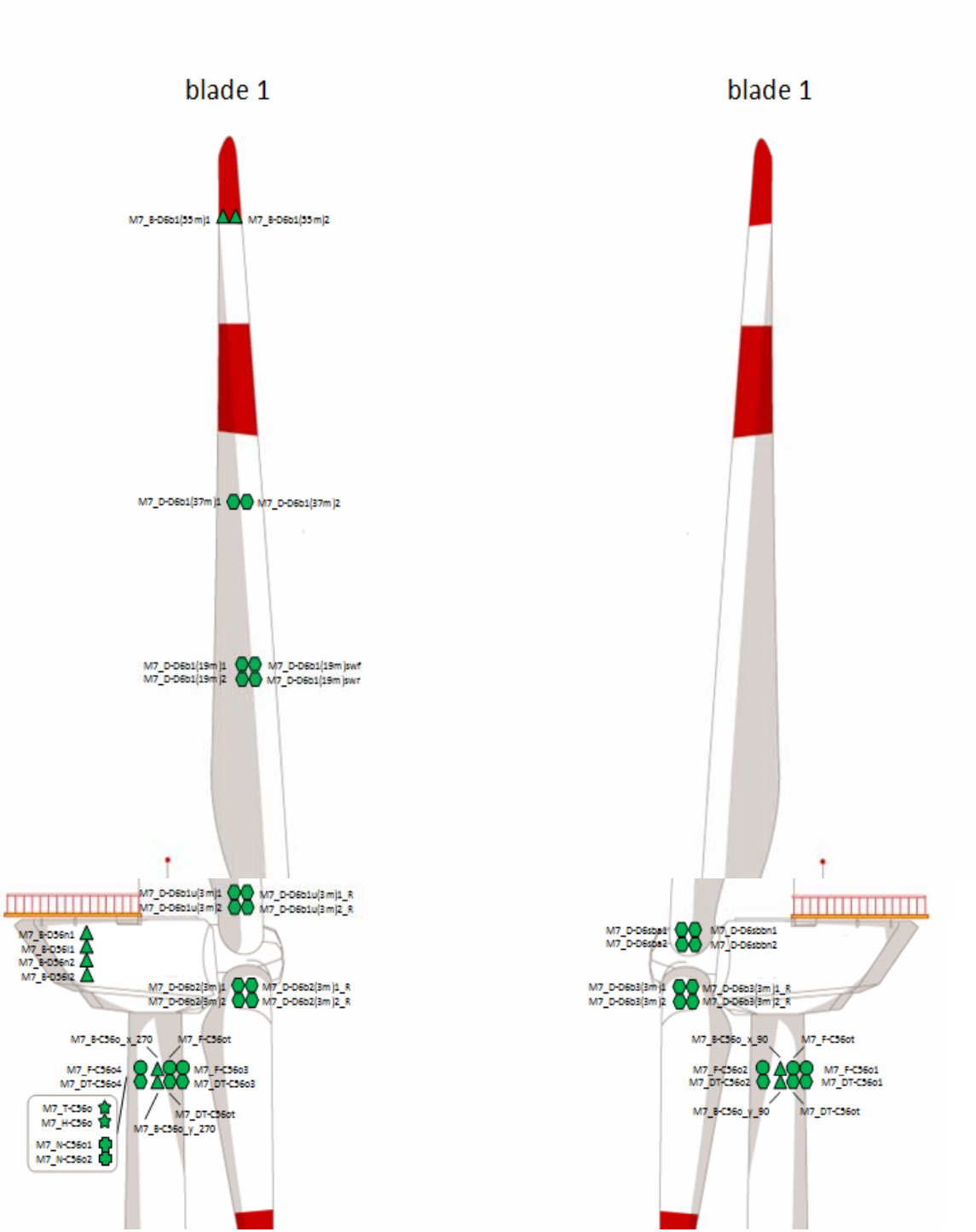
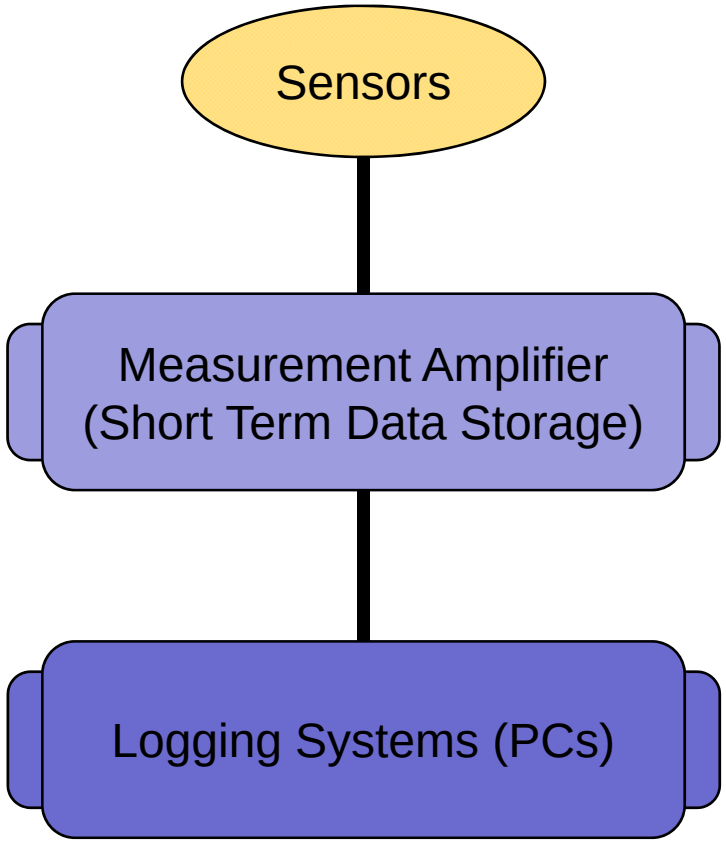

blade 1
M7_B-D6b1(55m)1
M7_B-D6b1(55m)2
M7_D-D6b1(37m)1
M7_D-D6b1(37m)2
M7_D-D6b1(19m)1
M7_D-D6b1(19m)2
M7_D-D6b1(19m)swf
M7_D-D6b1(19m)swr
M7_D-D6b1u(3m)1
M7_D-D6b1u(3m)2
M7_D-D6b1u(3m)1_R
M7_D-D6b1u(3m)2_R
M7_B-D56n1
M7_B-D56l1
M7_B-D56n2
M7_B-D56l2
M7_D-D6b2(3m)1
M7_D-D6b2(3m)2
M7_D-D6b2(3m)1_R
M7_D-D6b2(3m)2_R
M7_B-C56o_x_270
M7_F-C56ot
M7_F-C56o4
M7_DT-C56o4
M7_F-C56o3
M7_DT-C56o3
M7_T-C56o
M7_H-C56o
M7_DT-C56ot
M7_B-C56o_y_270
M7_N-C56o1
M7_N-C56o2
blade 1
M7_D-D6sbpa1
M7_D-D6sbpa2
M7_D-D6sbbn1
M7_D-D6sbbn2
M7_D-D6b3(3m)1
M7_D-D6b3(3m)2
M7_D-D6b3(3m)1_R
M7_D-D6b3(3m)2_R
M7_B-C56o_x_90
M7_F-C56ot
M7_F-C56o2
M7_DT-C56o2
M7_F-C56o1
M7_DT-C56o1
M7_B-C56o_y_90
M7_DT-C56ot

Sensor Installation - *Schematic Measurement*



Sensors

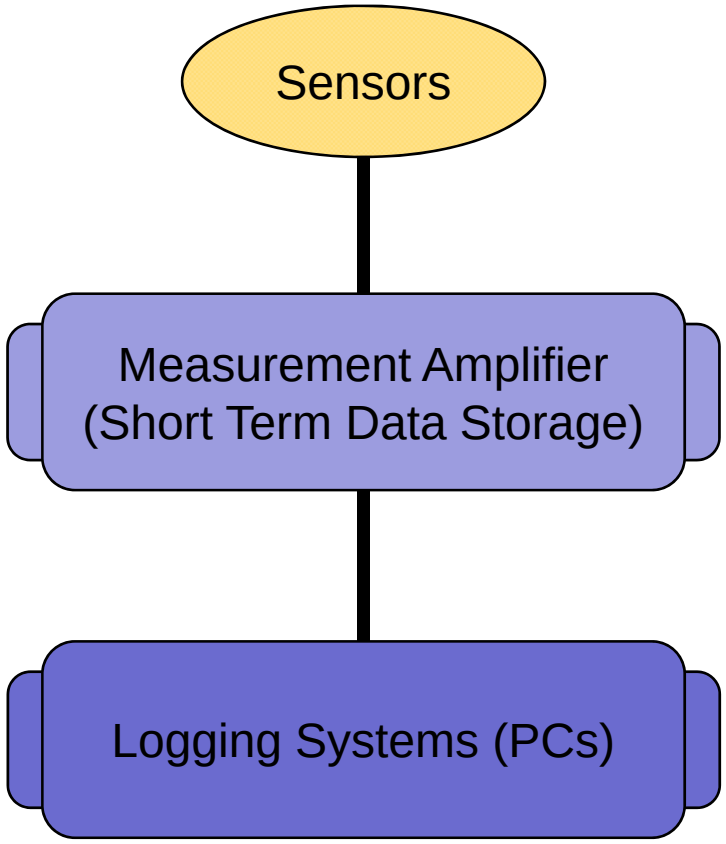
- *Over 300 distinct Sensors*

Sensor Installation - *At the Installation Site (Verdal, Norway)*

Sensor Installation - *Inside Main Column Sensors & Cables*

Sensor Installation - *Cables…*

Sensor Installation - *Schematic Measurement*



Sensors

- *Over 300 distinct Sensors*

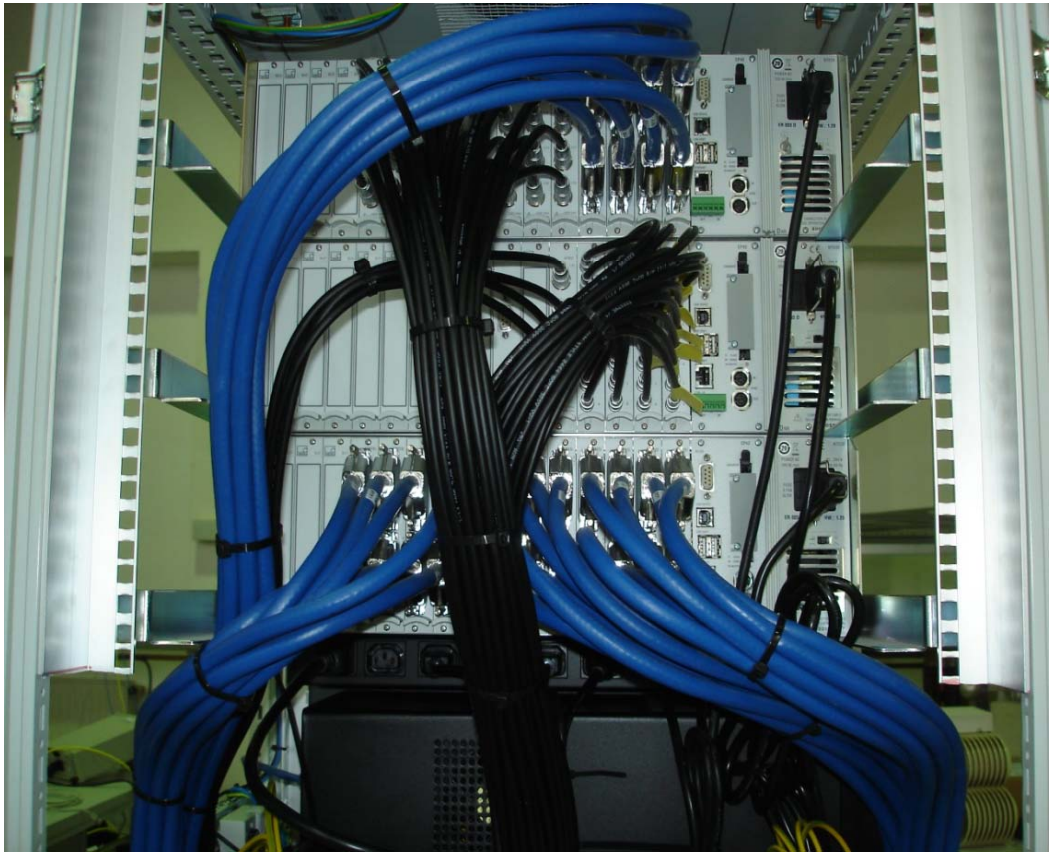
Amplifier

- *6 Amplifiers on AV07, 2 on AV08*
- *Main Column, Nacelle (Hub via Bluetooth)*

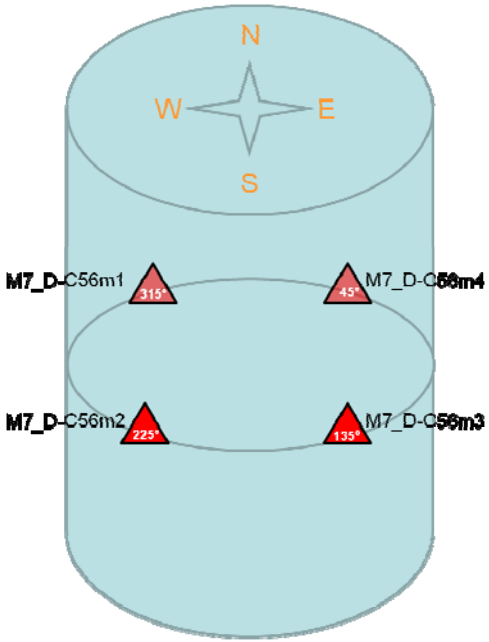
Logging Systems

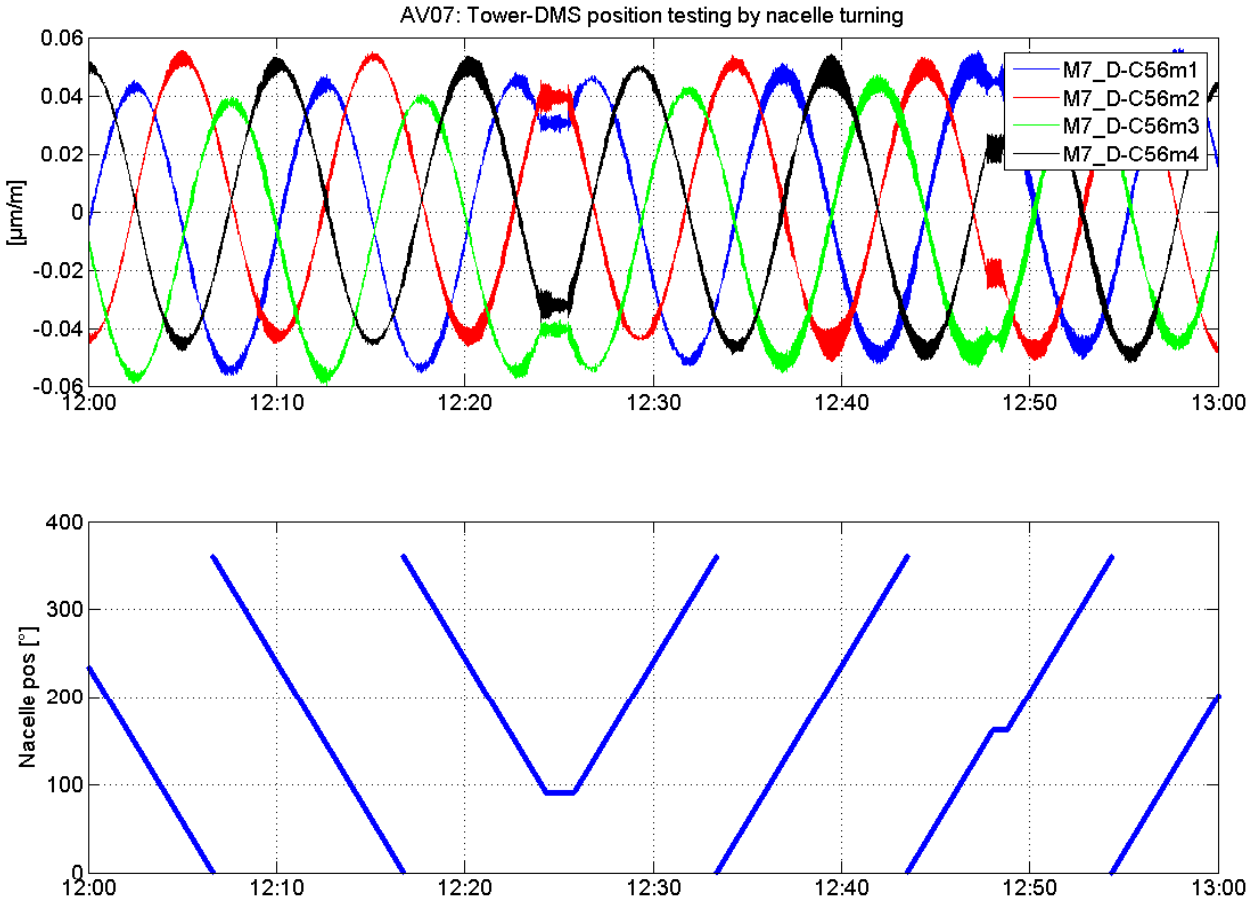
- *2 Control Cabinets*
- *2 PCs offshore, 2 onshore (Oldb.)*
- *Auxiliary Power Supply*
- *Network Switches for Remote Control*
- *Network Power Sockets*

Sensor Installation - *Amplifiers and Control Cabinet*



Measurement - *Validation of Data – DMS Load reaction test*





RAVE
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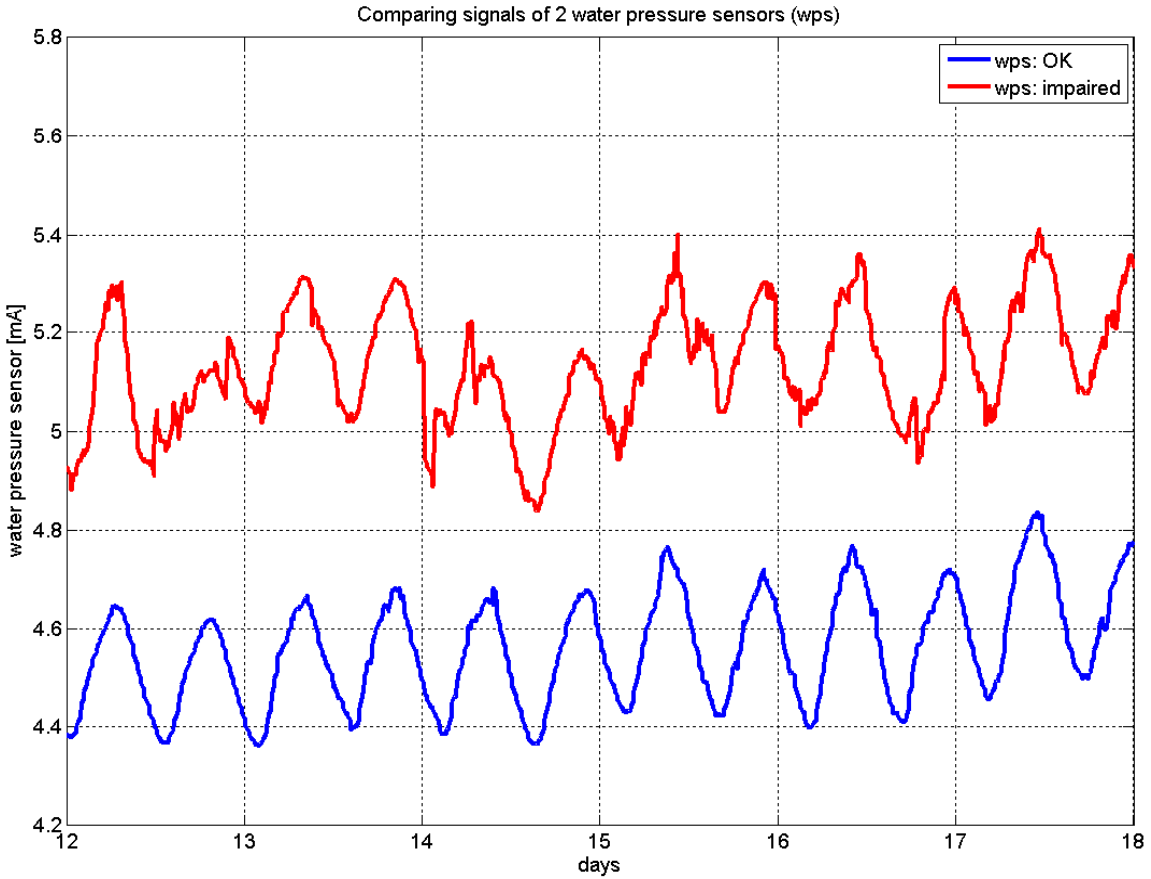
Measurement - *Validation of Data*



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Measurement - *Validation of Data*

Validation of Data

- *Direct Resistance Measurement on Sensors*
- *Signal Range*
- *Linear Calibration with Sensor Data Sheet*
- *Physical Value Thresholds*
- *Sensor similarity?*
- *Load Reaction*
- *Spektral Analysis*

Measurement - *Validation of Data & Data Summary*

Validation of Data

- *Direct Resistance Measurement on Sensors*
- *Signal Range*
- *Linear Calibration with Sensor Data Sheet*
- *Physical Value Thresholds*
- *Sensor similarity?*
- *Load Reaction*
- *Spektral Analysis*

Data Summary AV07-AV12

- *>400 Channels*
- *50Hz (mostly)*
- *>18.000 Values per Second*
- *10min save Intervalls*
- *~120MB / 10min*
  ~17GB / Day
  ~6.3TB / Year

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und Reaktorsicherheit

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