

# Modelling and Analysis of Vibration - Turbines & Supporting Structures

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Design Engineer

## Who Are We?

- Established in 2001
- Science-based company with roots in the [University of Edinburgh – Centre for Materials Science & Engineering](#)
- Strong multidisciplinary engineering team:
  - Mechanical
  - Software
  - Electronic
  - Structural
  - Numerical Modelling



- Expert in the Science of Vibration:
- Survey
- Analysis & Diagnosis
- Design Validation
- System Modelling
- Solution Implementation
- Commission & Test
- Operational Service & Monitor

Our Client concerns:

- Performance degradation
- Structural diagnostics
- Energy efficiency
- Condition monitoring
- Predictive Maintenance
- Environmental concerns
- Legislation



## Operational Process

<b>Introduction</b>	Initial customer contact	<ul style="list-style-type: none"> <li>• Research</li> <li>• Referral</li> </ul>
<b>Scoping</b>	Preliminary Study	
<b>Requirements Analysis</b>	Collaborative Brief Development	<ul style="list-style-type: none"> <li>• Validate problem</li> <li>• Establish project goals</li> <li>• Confirm expected outcome</li> </ul>
<b>Solution Implementation</b>	Production of Deliverables	<ul style="list-style-type: none"> <li>• Reflect value added</li> <li>• OEM sublicensing potential</li> <li>• React</li> </ul>

## Industry Sectors

- Academic
- Audio
- Automotive
- Condition Monitoring
- Civil & Construction
- HVAC
- Marine
- Medical
- Semi-Conductor
- Transport



## Product Development HAVmeter

- Personal Vibration dosimeter
- Alerts the user in real time
- Provides understanding of exposure
- Small and robust
- Stores data from each day

**HAVMETER**

*The complete solution to HAV.*



## Renewable - Marine

- Tidal Power



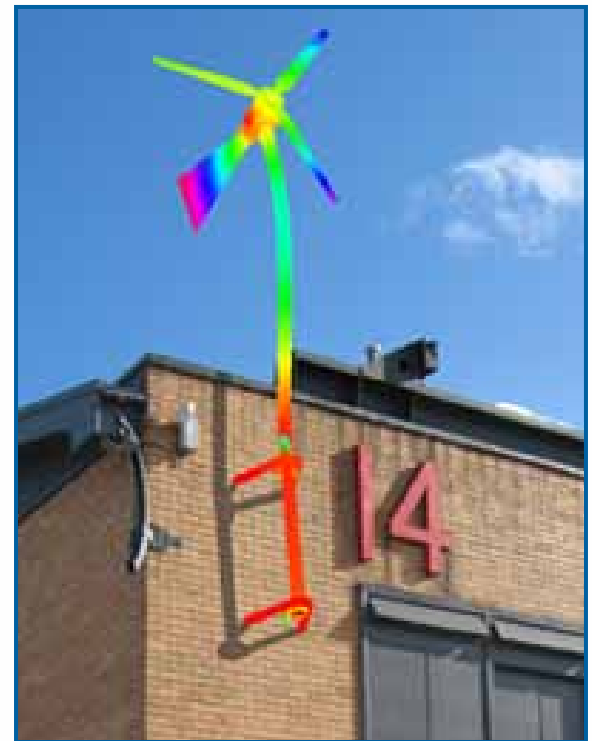
## Renewable - Wind

- SQT: Seismically Quiet Tower



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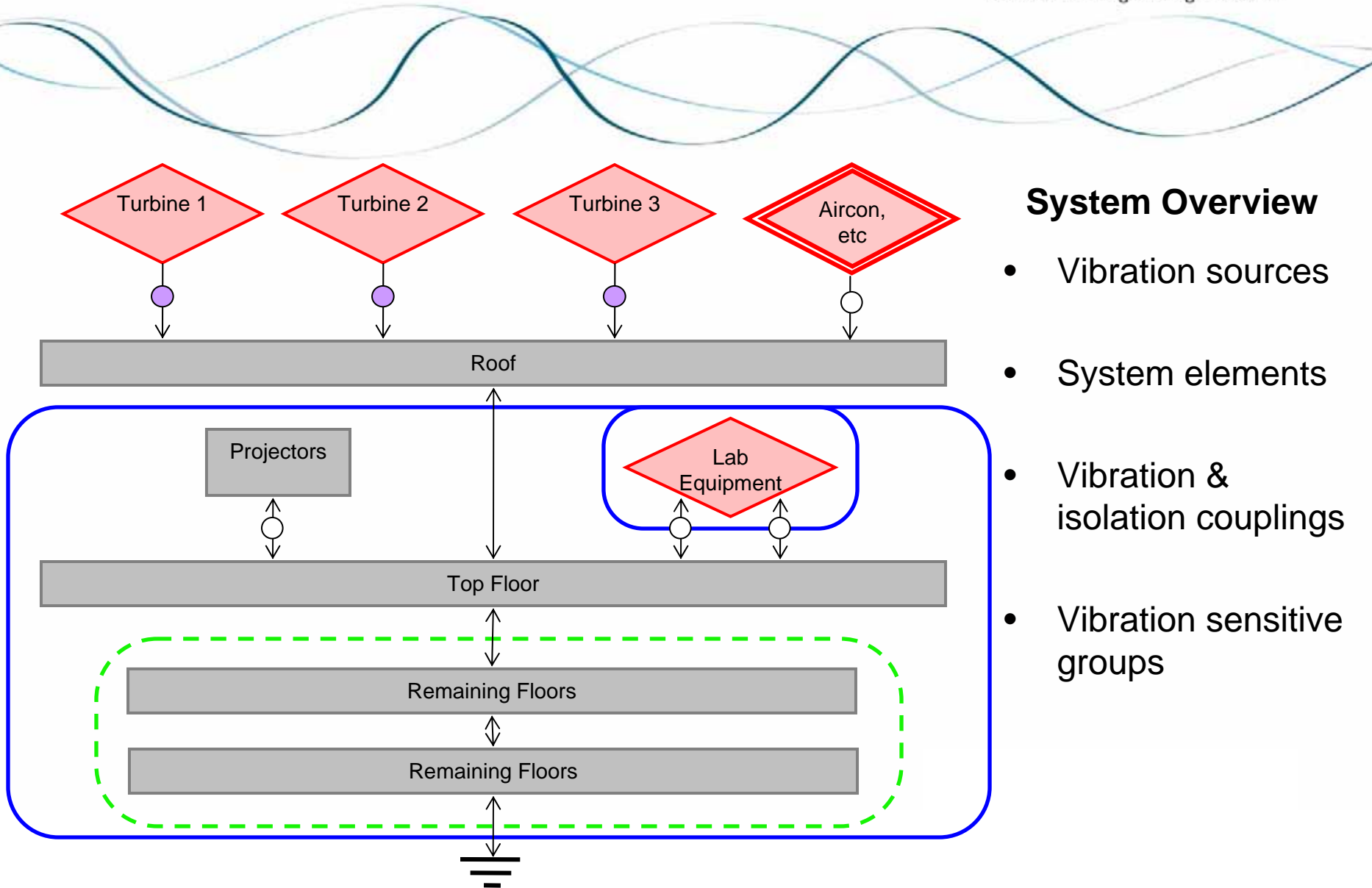
- Significant market
- Sustainability targets
- Noise propagation
- Vibration levels
- Sensitive equipment criteria
- British Standards and legislation



## Case Study

- University Campus
- New Building
- 3x 6kW turbines
- Sensitive equipment inside the building
- Lecture, laboratory and office spaces





## System Overview

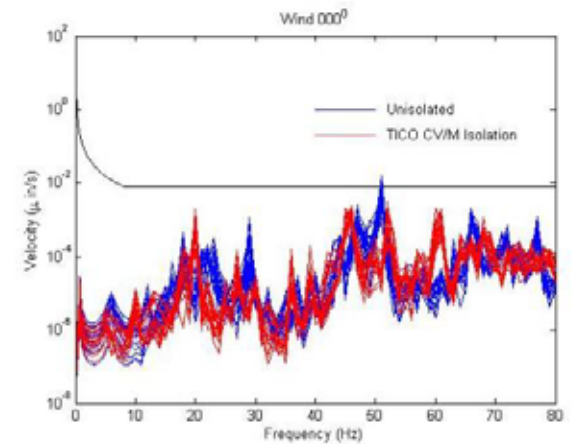
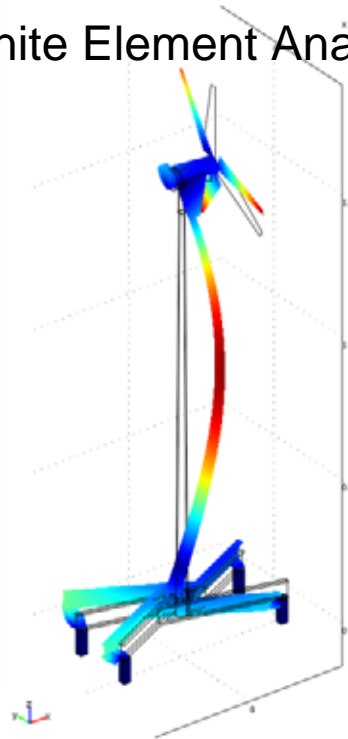
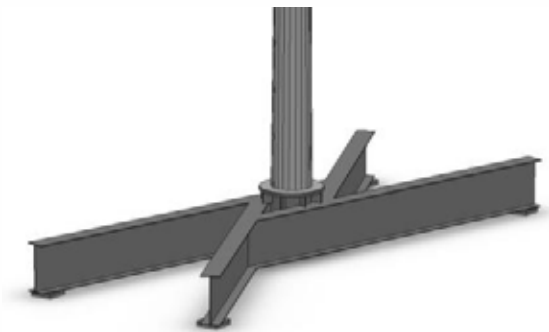
- Vibration sources
- System elements
- Vibration & isolation couplings
- Vibration sensitive groups

## Calculation Method

Iterative procedure of:  
CAD Design

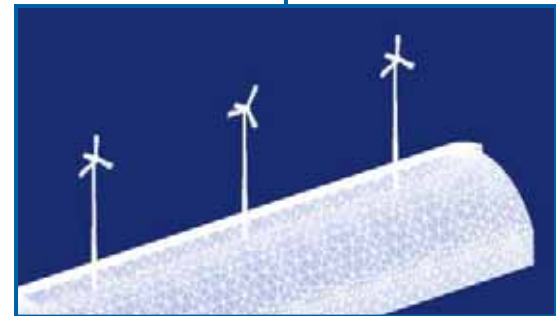
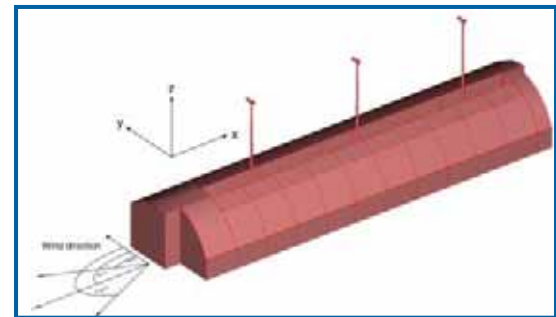
Finite Element Analysis

Processing



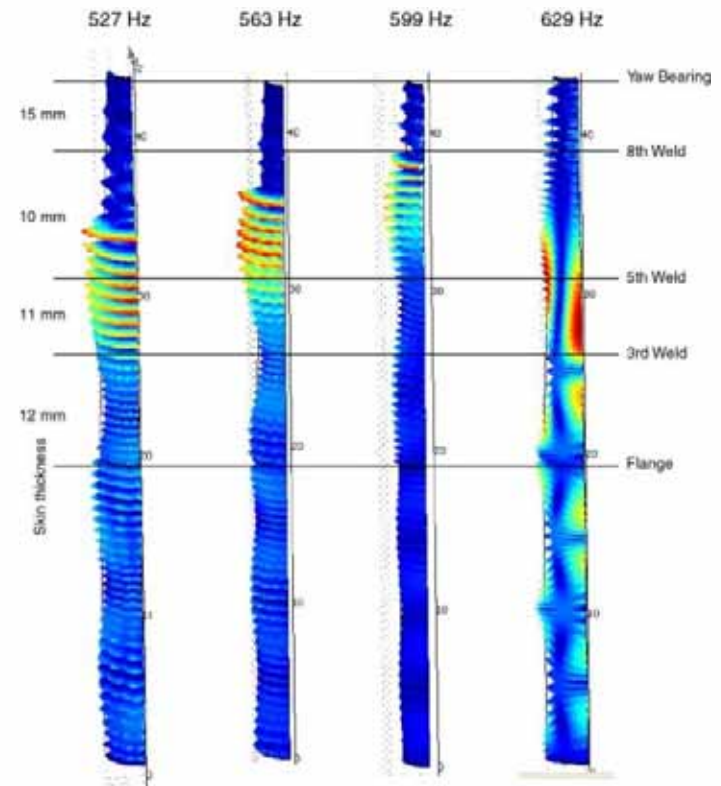
## Constructing the Model

- Building and Structure
- Isolation Properties
  - Important to choose materials that are tuned correctly for the system
- Turbine Elements
  - Nacelle & Blades
  - Tower
  - Mounting system



## Turbine tower

- Natural Frequencies
- Mode shapes
- Tower skin modes
- Model the way the steel in the tower ripples
- Indication of the tonal noise expected
- Model applied damping for required tonal reduction



## Excitations and vibration data

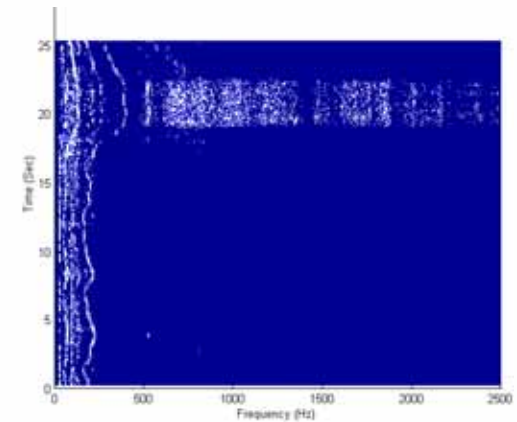
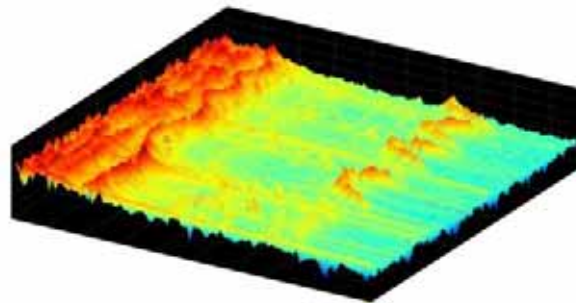
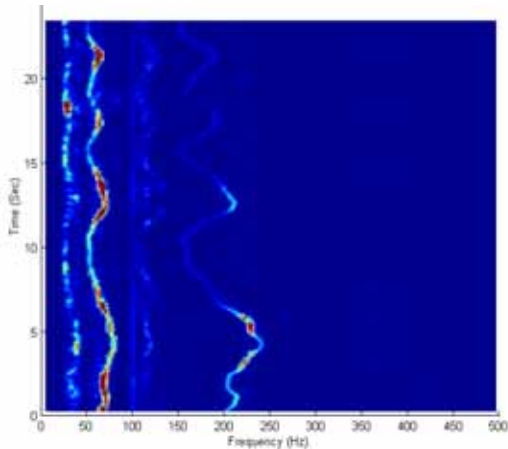
- For a strong simulation, high-quality, sensible data is required:
  1. Data from experimental data
  2. Manufacturers data
  3. Theoretical / simulated data
- Additional consideration to potential phase matching of the 3 turbines





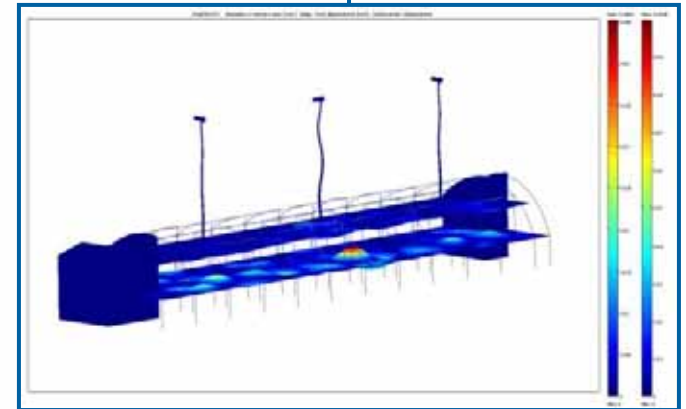
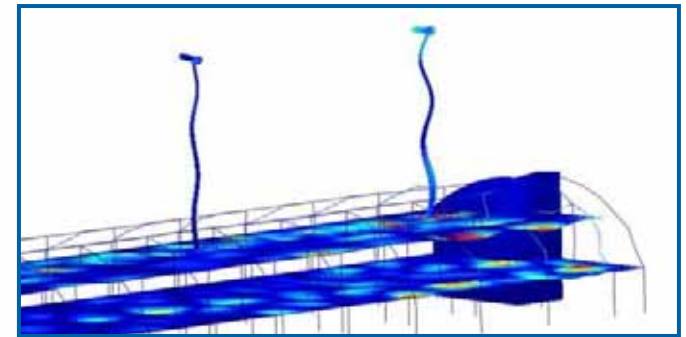
## Vibration Measurement

- Identifies running frequencies
- Shows interaction between forced and resonant vibrations
- System's vibration signature
- Can be used for condition monitoring



## System Results

- Check performance with and with out isolation
- Establish any vibration hotspots
- Find problem operation frequencies
- Quantify levels in relation to standards and design specifications
- Revise design if required
- Introduce vibration specifications for installations in the building



## Verification

- Measurement
- Often the only vibration consideration in the spec is the turbines
- Sources from roads, air-conditioning, etc, are often omitted which can complicate signoff
- Important to consider how client interprets data
- Highlights a need to establish a vibration specification for the installations in the building



## Experts in the Science of Vibration



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