Bi-axial fatigue test developments

Knowledge Centre
Wind turbine Materials and Constructions

Sandia blade workshops 2012

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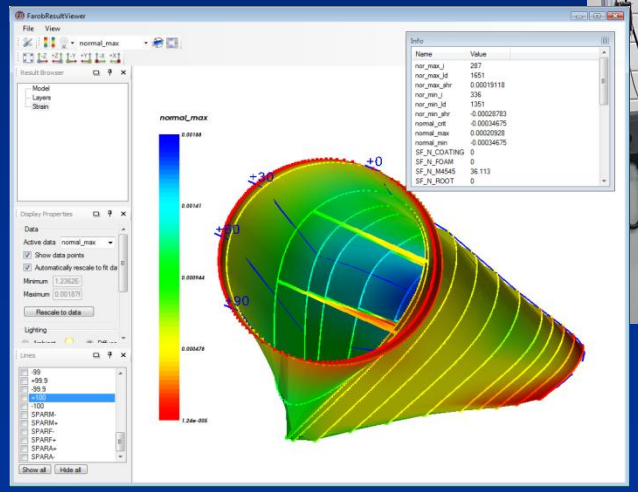
Overview

- Introduction
- Blade testing at WMC
- Full scale fatigue tests
- Advances in bi-axial fatigue testing
- Concluding remarks

Wind turbine Materials & Constructions

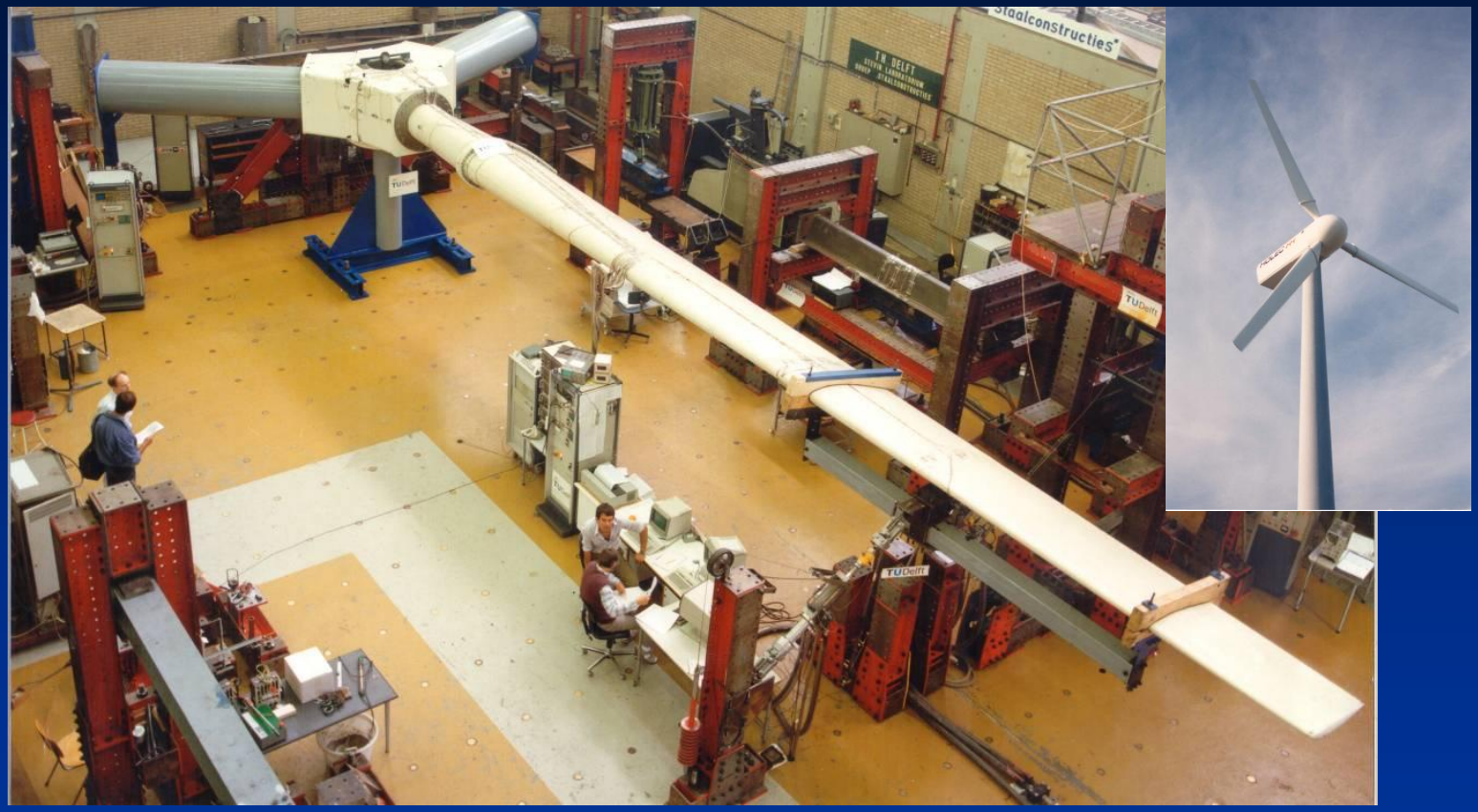
- Full-scale structural testing
- Material research
- Software development



WMC History

Blade design and testing (1984)

WMC did a re-design of the all steel WPS30 blade and developed the full scale testing procedure for rotor blades.



Blades became larger

WMC Wieringerwerf

Knowledge Centre **WMC**

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Full Scale Test Lab

- High flexibility
- Strong floor 66 x 28 m
- Three blade test stands
- Blades up to 60 m (75 m planned)
- In house workshop

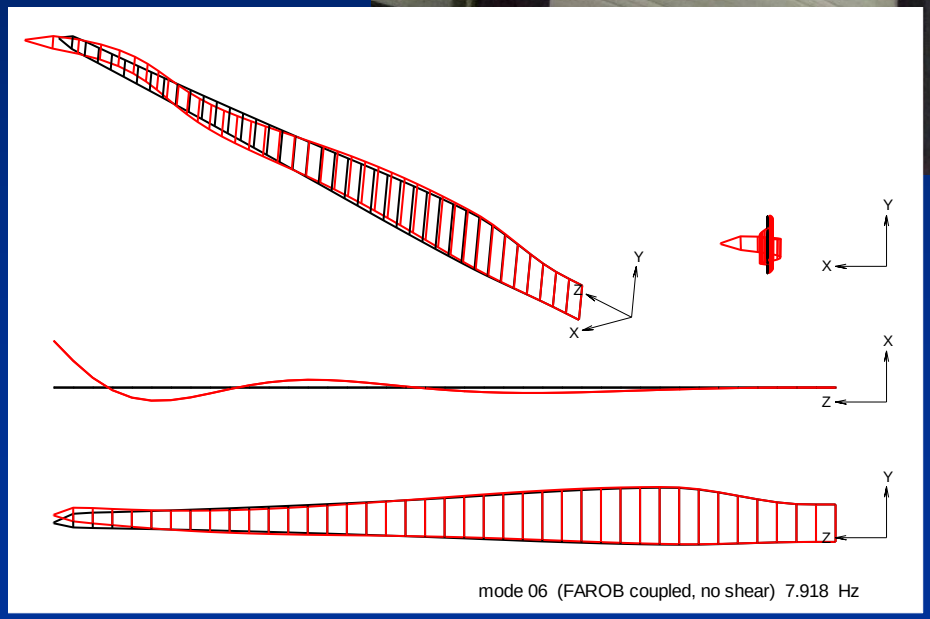
Blade testing

Proposed minimum test programme

acc. IEC 61400-23

- Mass, COG
- Natural frequency test
- Static tests
- Fatigue test(s)
- Post fatigue static tests

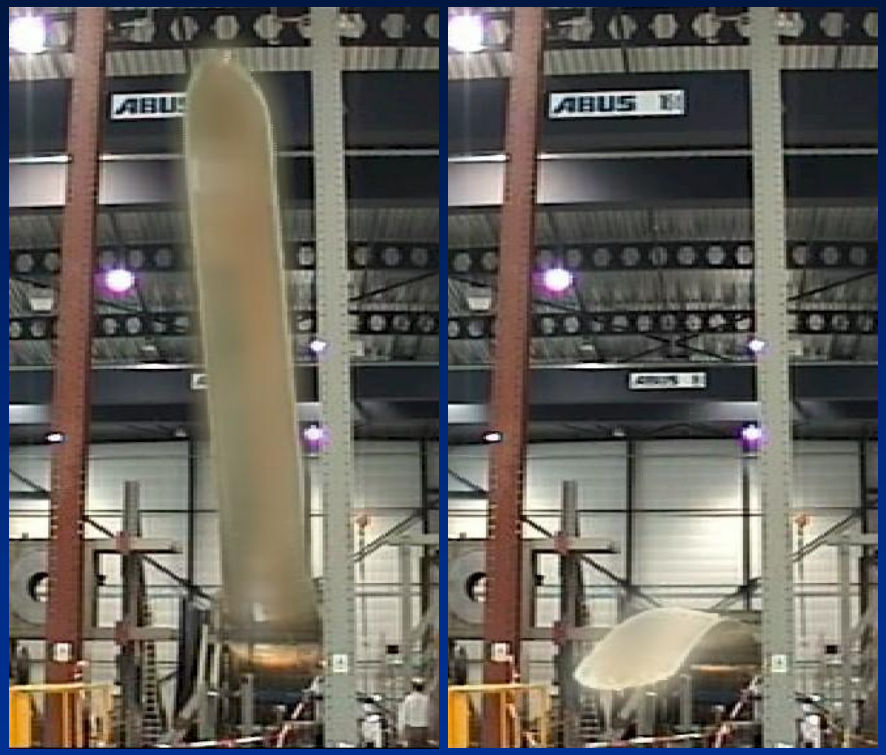
Frequency modal analysis



Blade Testing
Multiple-point Single-axis Static Test

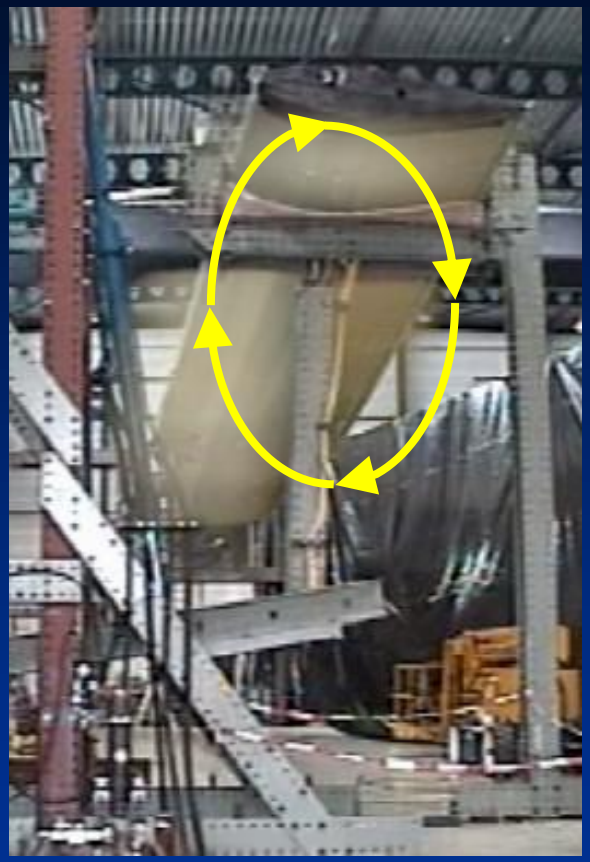
Single Axial Fatigue

- **Advantages**
  - Simple hardware
  - Simple tuning of bending moment distribution
  - High frequency
  - Low energy consumption
  - Distributed loading
- **Disadvantages**
  - Separate flap and edge test
  - Not testing total circumference
  - Mass on blade for R≠-1



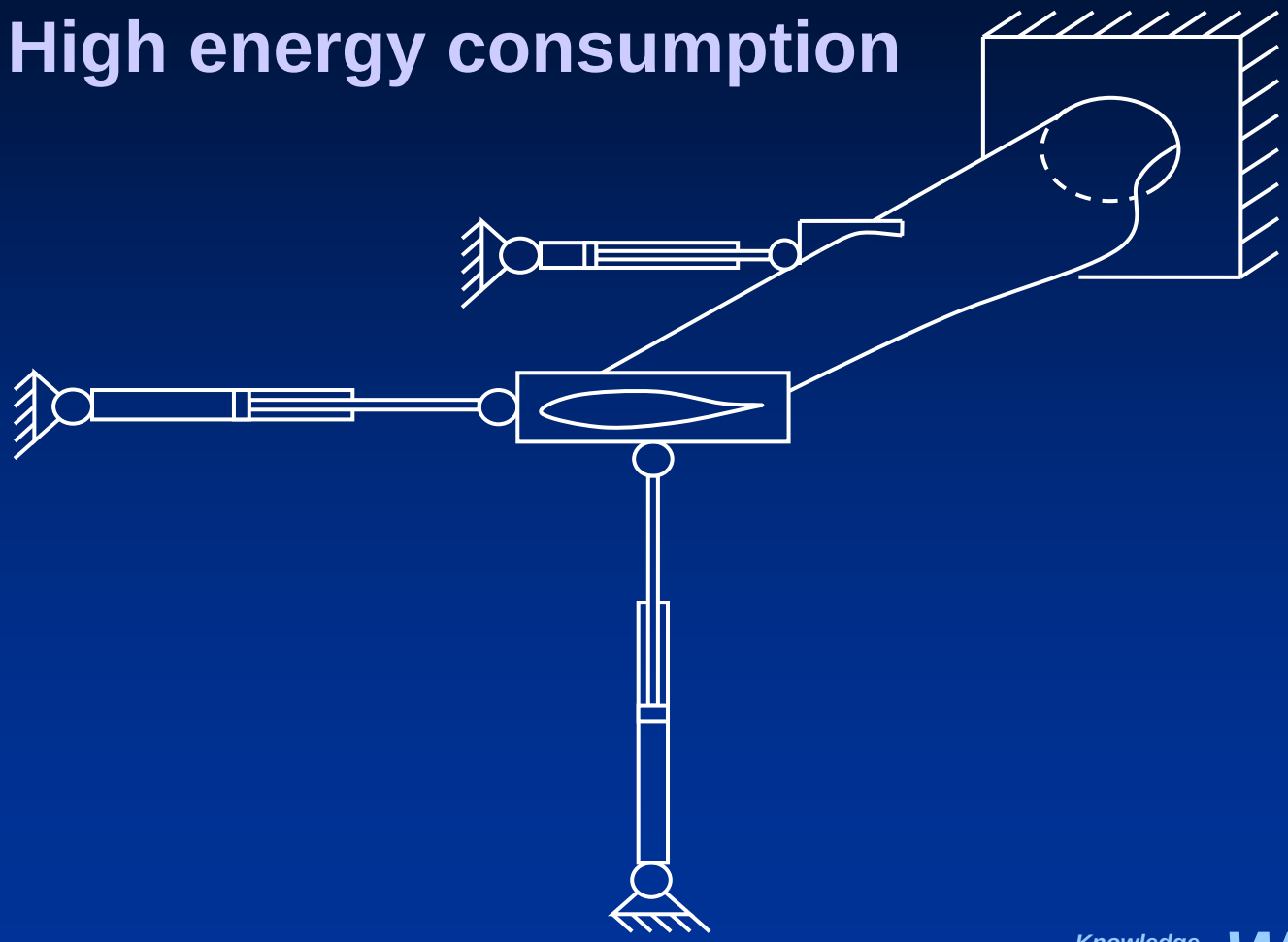
Bi-axial Fatigue Testing

- **Advantages**
  - Accurate coordination of flat & edge loading combinations
  - Torsion loading
  - Short test time
  - All R-values, weight compensation possible
  - Automated stiffness measurements
  - Moderate energy consumption
- **Disadvantages**
  - More complicated hardware and controlling
  - Tuning of moment curve requires additional hardware



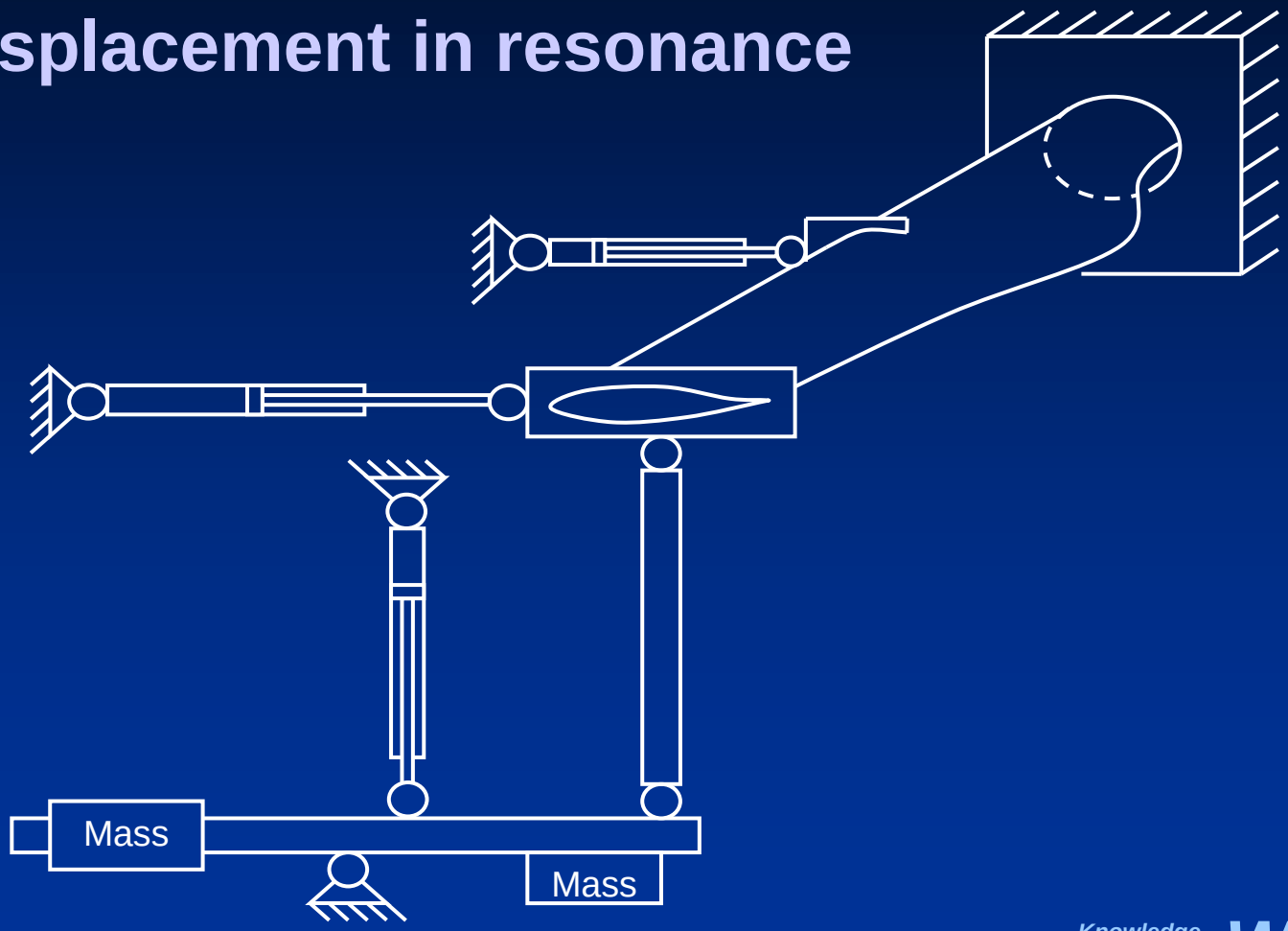
Bi-axial test setup development

Forced displacement
→ High energy consumption



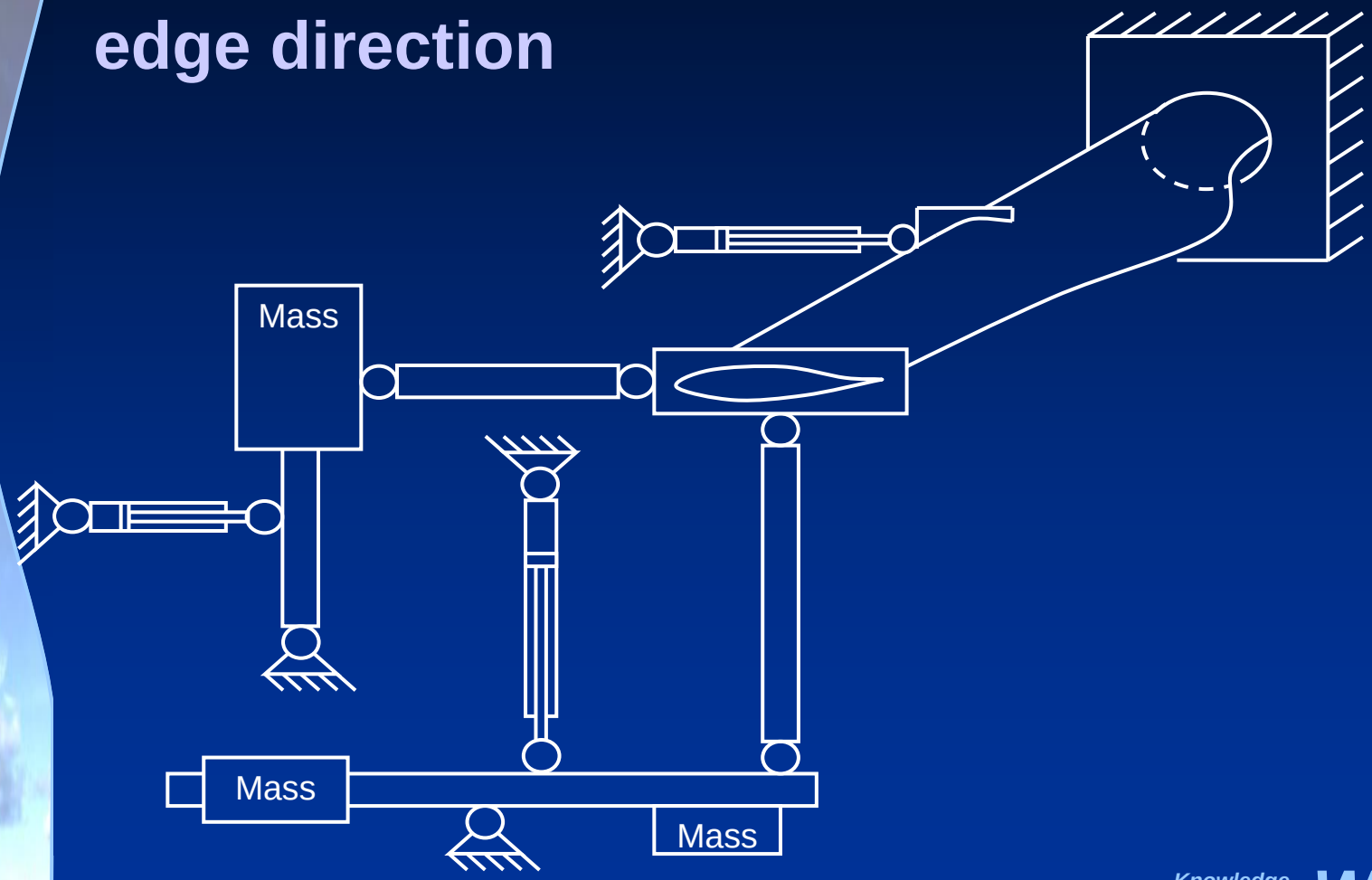
Bi-axial test setup development

Crank rod mechanism to drive flap displacement in resonance



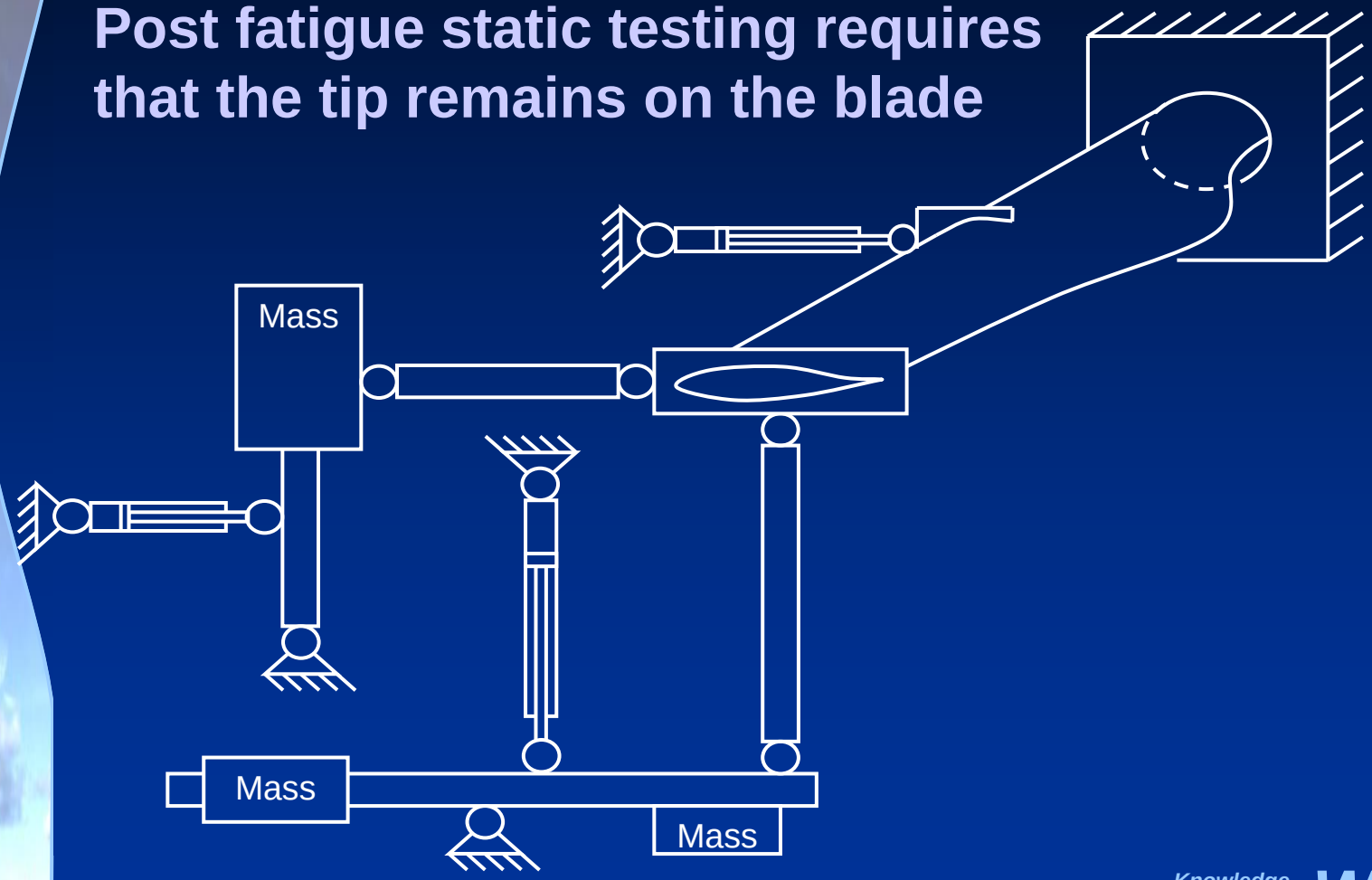
Bi-axial test setup development

Add crack rod mechanism in edge direction



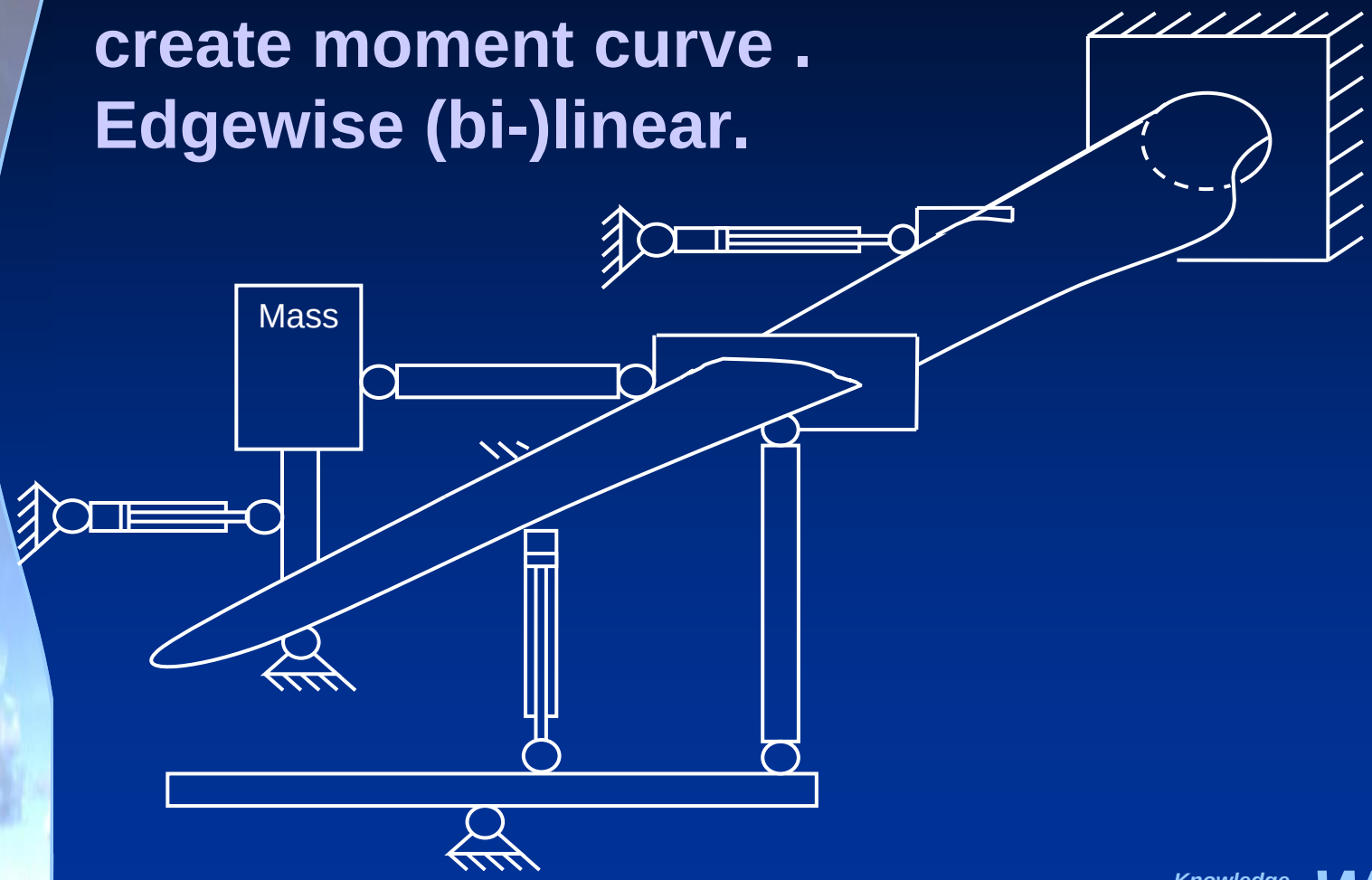
Bi-axial test setup development

However……
Post fatigue static testing requires that the tip remains on the blade

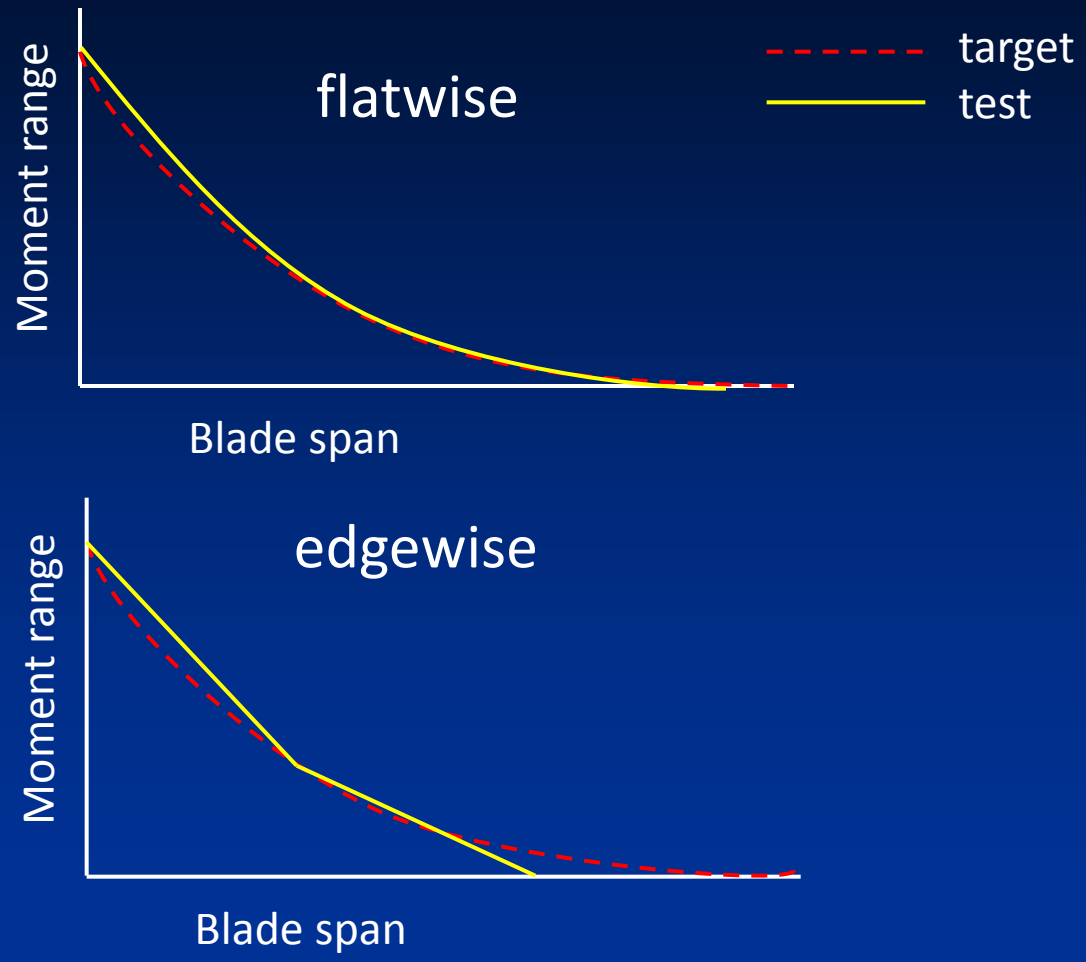


Bi-axial test setup development

Test is driven at flatwise frequency to create moment curve .
Edgewise (bi-)linear.



Bi-axial test setup development



Bia-axial fatigue test

- Flatwise moment distribution as single axis (near) resonance: larger portion of the blade tested.
- Edgewise moment distribution (bi-) linear.
- Blade tip not removed: blade ready for post fatigue static test.

Concluding remarks

- The type of blade fatigue test should be based upon the critical areas of the blade
- Single axial tests focus on spar and leading and trailing edge. Easy to test a large blade span
- Bi-axial tests give a better distribution of fatigue damage over the circumference of the blade.
- Demand for post fatigue static testing is important requirement for test selection