



Issues involved (Annex I)

OPTIMAT BLADES

Background:

- Large investments in Wind Energy
- Increase of Turbine Size
- Accessibility of Offshore turbines limited
- Increase of economical risk in case of

Blades:

- Blades are subjected to severe and complex loading
- Blade mass becomes more domination for larger blades
- Accurate and Reliable Design Recommendations are required to design large blades
- Life of existing blades uncertain
- Avoiding unnecessary waste of damaged blades by repair



State of the Art (Annex I)

OPTIMAT BLADES

Available results of research programmes and knowledge can be characterized by:

- Uni-axial stress state (no complex stress state)
- Mainly constant amplitude
- Variable amplitude prediction appears to be not accurate
- Thin coupons (no thick laminates)
- Limited data on effect of external conditions
- Different research programmes used different material and specimens
- Results of research programmes not consistent
- No recommendations on repair
- Data on conditions assessment and residual strength is limited

As a consequence the current design recommendations have their limitations



Measurable Objectives (Annex I)

OPTIMAT BLADES

To obtain improved and profound knowledge of:

- **Blade material behaviour under Variable Amplitude loading**
- **Blade material behaviour under Complex Stress States**
- **Blade material behaviour under External (Extreme) Conditions**
- **The stress state and behaviour of Thick Laminates**

To obtain improved knowledge of:

- **Interaction Effects of the conditions mentioned above**

To develop methodologies for:

- **Repair**
- **Condition Assessment, Residual Strength and life Prediction**

To implement the obtained knowledge into:

- **A Consistent Set of Accurate and Reliable Design Recommendations**



Innovation (Annex I)

OPTIMAT BLADES

- The FRP material behaviour is investigated extensively
 - All important topics are investigated in one integrated project in a consistent way
 - The partnership ensures the required knowledge, experience and commitment of:
 - The Research institutes
 - Certification Bodies
 - The industry
- The results are implemented directly in accepted design recommendations
- The level of enhancement is expected to be substantial



Contribution to the EU programme (Annex I)

OPTIMAT BLADES

- **The results of the project will lead to:**
 - Reliable optimal designed Blades
 - Reduced use of material and environmental impact
 - Life extension of blades
 - Extension of availability of wind turbines (especially offshore)
 - Extension of the possible size of wind turbines
- **These results will lead to:**
 - The reduction of costs for Wind Energy
 - The increased reliability of Wind Energy
- **As a consequence the results will contribute to:**
 - Less waste of material
 - Increase of economical application of wind energy
 - Decrease of CO₂



Project Workplan (Annex I)

OPTIMAT BLADES

Task Group 6:

Implementation of the obtained knowledge of the Task Groups 1-5 into a consistent set of design recommendations

(TUDT → *WMC*)

WP15 Design Recommendations



Current Design Codes

OPTIMAT BLADES

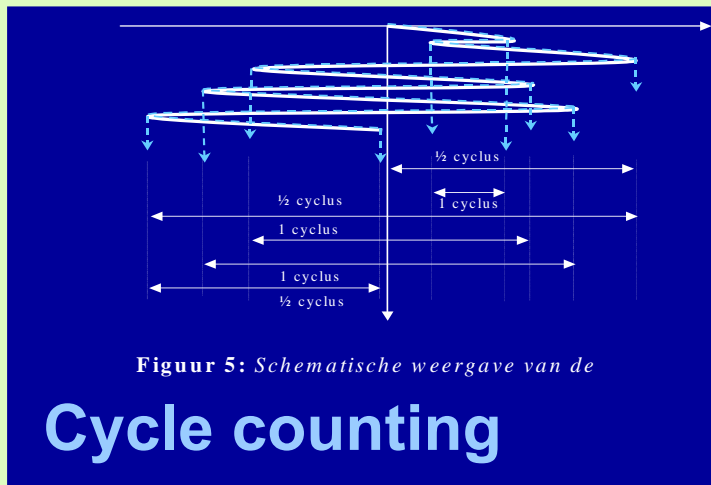
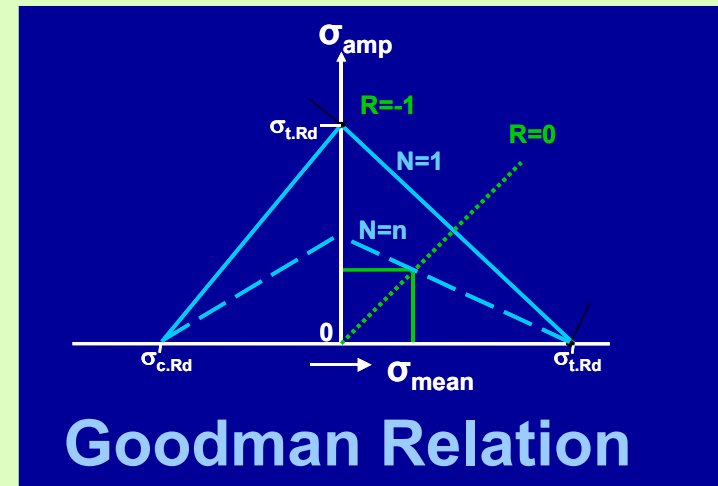
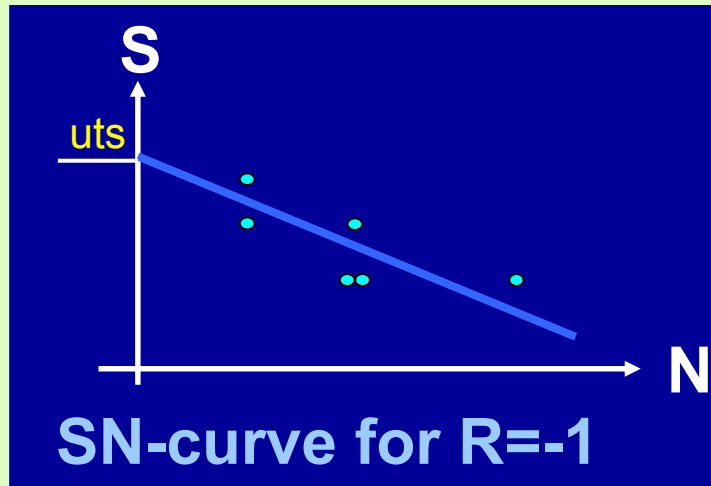
With respect to static strength, the current design codes are not clear how to deal with:

- **Bi-axial stress state (which failure criteria)**
- **Static residual strength affected by fatigue damage**
- **Extreme conditions**
- **Repair**



Current Design Codes

Based on the static strength (UTS), fatigue is evaluated by a structure with the following aspects::



Figuur 5: Schematische weergave van de

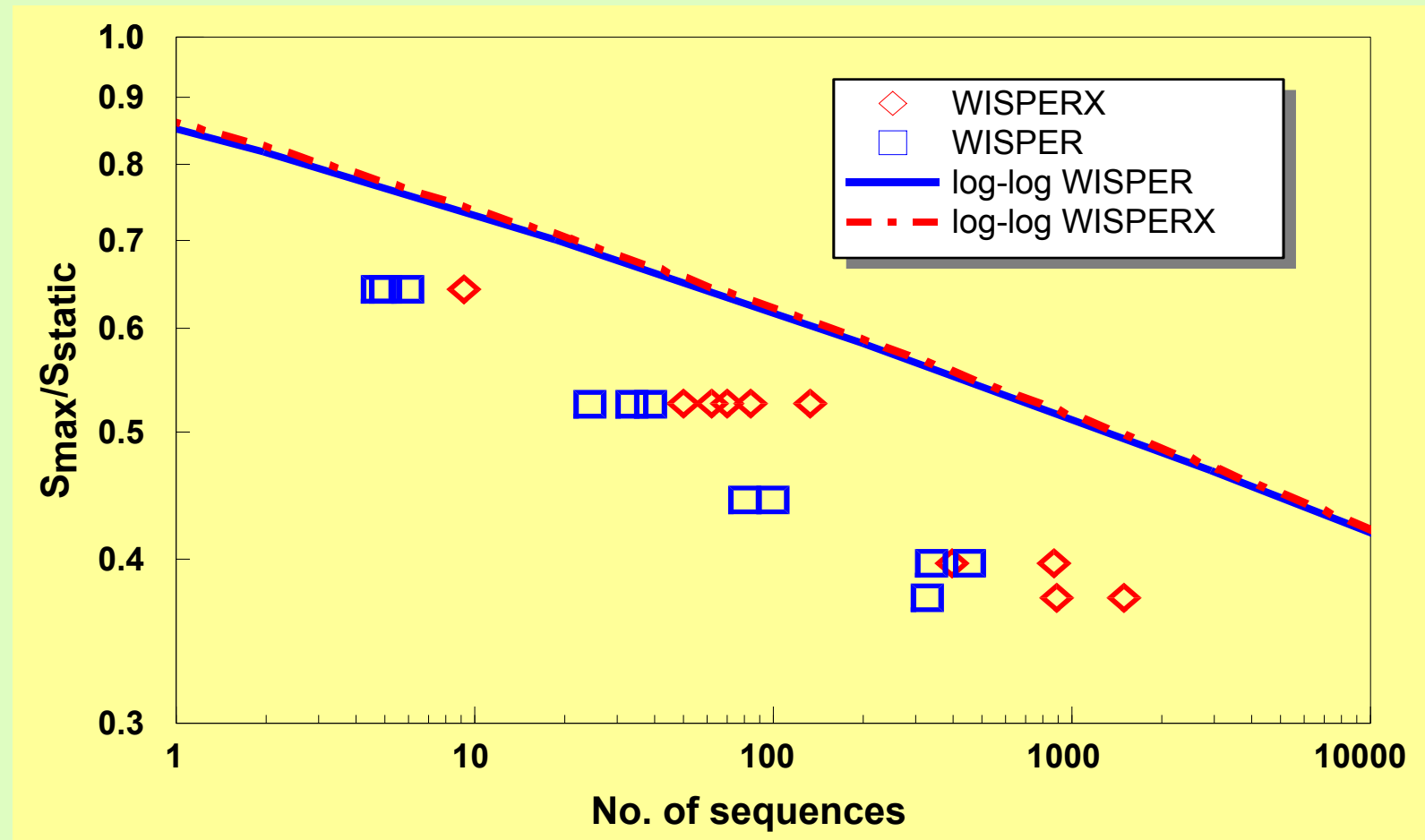
$$D = \sum_{i=1}^M \frac{n_i}{N_i} = \frac{n_1}{N_1} + \frac{n_2}{N_2} + \dots \leq 1$$

Miner's Sum



Prediction of VA fatigue life

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The Making of New Design Recommendations

OPTIMAT BLADES

Can we take the existing Structure as a basis?

If yes, what need to be done?

- Just changing some parameters?
- Modifications of the different aspects?
- Extensions?
- Other?



The Making of New Design Recommendations

OPTIMAT BLADES

If we can use the current (but to be modified structure) the following (but may-be more) have to be checked:

- What is the relation between the static properties?
- What is the relation between static properties and the Fatigue behaviour?
- What properties must be tested for “new” materials



The Requirements for New Design Recommendations

OPTIMAT BLADES

- **Accurate and with a known level of confidence.**
- **Not too conservative (researchers feel safe but it does not help the implementation of wind energy).**
- **Clear to interpret (Clear Statements must be made by the TGs).**
- **Possible to implement (No new research project should be necessary for every “new” material)**
- **Giving the scope and limitations for “new” materials (When is extra testing/research required)**



The Making of New Design Recommendations

OPTIMAT BLADES

- **How do implement the effects of**
 - Variable amplitude loading
 - Complex loading
 - Extreme conditions
 - Thick laminates and repair
 - Residual strength?
- **For the**
 - Static strength
 - Fatigue behaviour



The Making of New Design Recommendations

For instance: The S-N curve

- Can it be linked to the static strength?
- Is there a fixed slope (R-1)?
- How do implement the effects of Complex loading?
- Does the slope change for different extreme conditions?
- Etc.

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The Making of the New Design Recommendations (Actions)

OPTIMAT BLADES

- The TLs will have to identify where the current design principles are inadequate, based on the results of the research of there TG.
- The TLs should propose improvements, modifications, extensions making the design recommendations more accurate.
- On the basis of this TG6 will come up with the more accurate design recommendations.
- To enforce the commitment, all the industrial partners are also added as member of TG6 (Part of the Manmonth effort will also be shifted from SC to TG6)