

# OPTIMAT BLADES

## TG4 Overview



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*Knowledge  
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**WMC**



**ECN**

**TU Delft**

Delft University of Technology



## WP 10: objectives

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- **Objective (old)**
  - To establish the accuracy of thin-walled theory by comparison to finite element calculations and test results for thin and thick flat plates.
- **Objective (new)**
  - To establish the influence of thick laminates by comparing properties between thin and thick laminates.
  - To try to assess residual stains due to the curing process



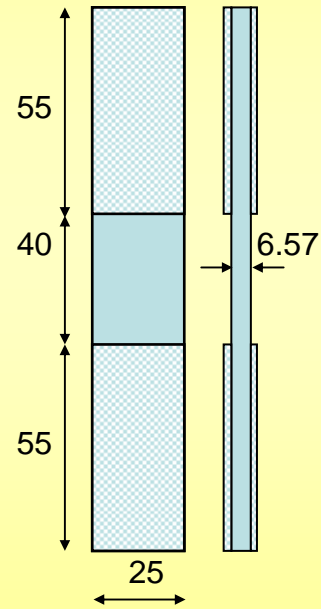
# WP 10: Assessment

- **The theoretical assessment was started and work on stress patterns was carried out by ECN and UP.**
- **However, due to change of insight:**
  - Lack of experimental material properties in thickness direction
    - Could have been established if needed
  - Lack of FE analysis tools in thickness
    - Was to be carried out by LMG but was cancelled in lieu of the production of extra test specimens by LMG
  - A lack of curing data (temperature vs. time vs. Young's modulus)
  - A general disinterest by industry to investigate 3D analyses at a time when beam analyses are still the main design tools and shell (2D) elements just starting to get general use.
- **Work in this task was suspended**
  - Also due to WMC giving priority to other tasks with more interaction with partners

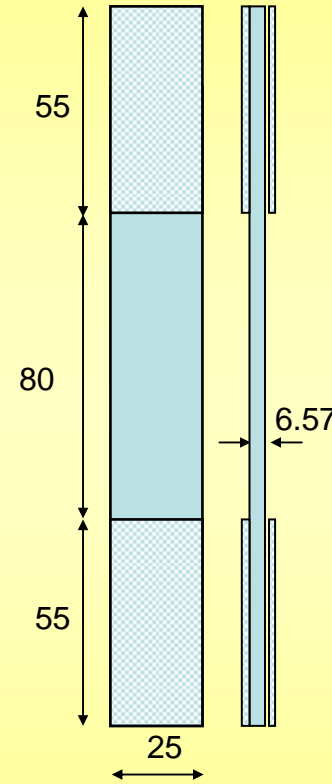


# Test Geometry for WP10

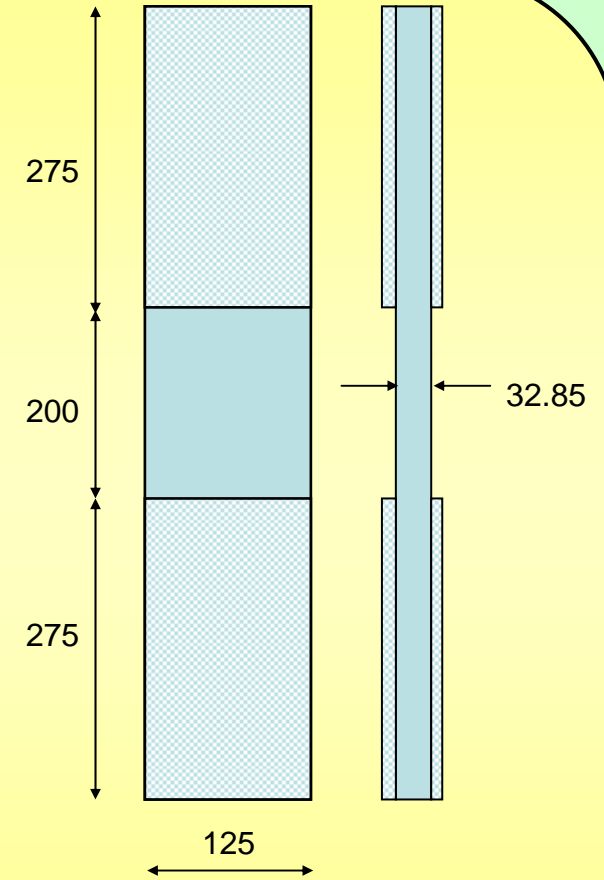
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Standard OPTIMAT Geometry MD



WP11 thin MD laminate  
Static tension / R=0.1 only



WP11 thick MD laminate  
Static tension / R=0.1 only

NB: pictures not to scale



## ***10.1 Laminate definition and test plan***

- **Assessment**
- **This task was carried out.**
- **Planning and expected results**
  - However, due to major set backs and changed insights, a fully new work plan for WP10 is being defined, concentrating on comparisons between thin and thick laminates, rather than theoretical modelling.
- **The revised planning should lead to a successful WP within the project, giving useful information on the differences between thin and thick laminates.**



## ***10.2 Production and test of thin and thick laminates***

- **Assessment**
- **Due to change of plans, no specialized thin and thick laminates have been produced, nor tested.**
- **This task will not concentrate on establishing material properties and FE analyses in thickness direction.**
- **Instead a direct comparison between thin and thick laminates is planned**
- **Planning and expected results**
- **Successful production and testing within the project are foreseen.**
  - A possible problem can be the successful production of thick laminates with embedded optical fibres
  - Also, the testing of optical fibres at WMC could be problematic as WMC has experienced problems with its new and slightly experimental optical fibres measurement system.



## 10.3 Theoretical assessment

- Assessment
- The theoretical assessment was started and work on stress patterns was carried out by ECN and UP.
- However, due to lack of experimental material properties in thickness direction, lack of FE analysis tools in thickness, which was to be carried out by LMG but was cancelled in lieu of the production of extra test specimens by LMG, further work in this task was stopped.
- Planning and expected results
- The task is no longer considered relevant within the objectives of this task, and hence will be dropped.
  - The 1.5 PMs of L can help alleviate problems of LMG within WP16



## ***10.4 Intermediate evaluation***

- **Assessment**
- **Some work was done comparing laminate theory with 2D FE analyses.**
- **Planning and expected results**
- **A new, direct approach should aid in reaching the overall objective of WP10**





# WP10: Deliverables and Milestones

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4	10	Definition report of typical thick laminate.	Report	5	PU	OB_TG4_R001	100%
23	10	Evaluation report which compares the analytical methods with experimental data. <b>NB will change to:</b> Evaluation on the effect of thick laminate	Report	26	PU	To be done: TG4	0%

6	10	DPA on thick laminates and laminate definition		5	Yes	
14	10	Evaluated thickness influence		26	No	



## WP 11: objectives

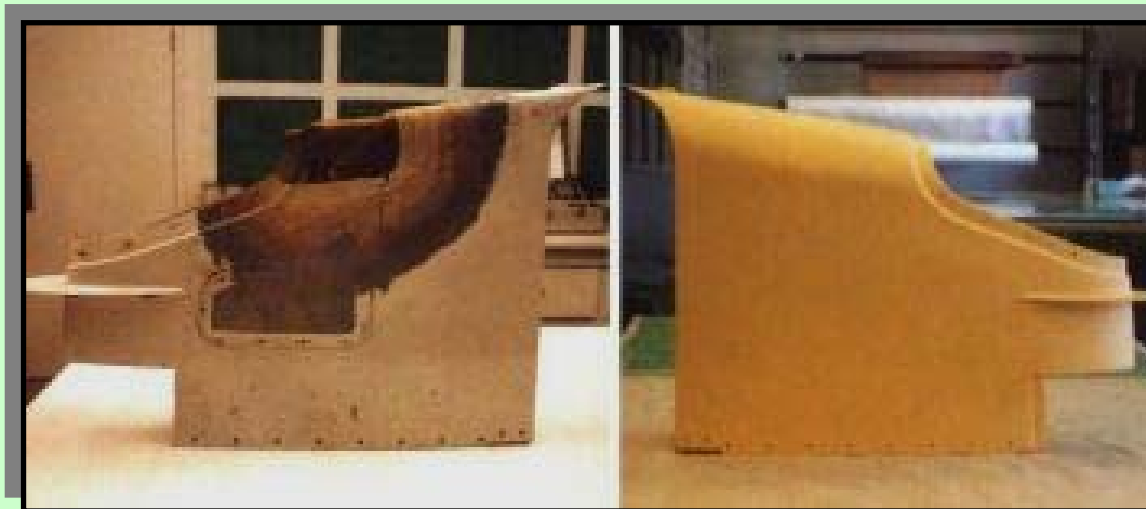
- **To implement suitable repair methods that will bring back functionality and strength to the blades by benchmarking and verification on small components.**



## 1-INDUSTRIAL OBJETIVES

### *EVALUATION OF THE REPAIR TECHNIQUES*

1. Compare Different Repair Procedures
2. Obtain Experimental Data and Analytical Models to support Repair Task
3. Define Repair Test Procedures for Thin and Thick Laminates



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## ***Task 11.1 Identification of repair zones and techniques***

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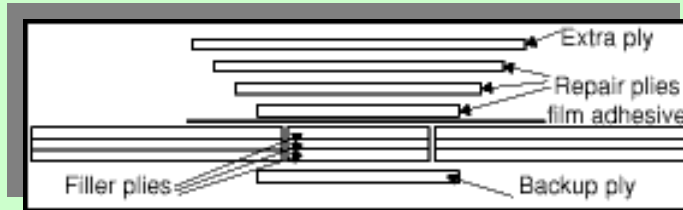
- **Assessment**
- This task has been finished successfully
- CRES has also distributed a questionnaire on repair to the industrial partners from which GAMESA and LMG have responded.
  - From the answers on the questionnaire, it becomes clear that both industries are interested in scarf repair of similar defects.
  - GAMESA is also interested in the plug/patch repair system.
  - A number of scarf repairs have been selected for testing.
    - Slopes 1:25 1:50 1:75 1:100
    - Repair thickness 1/3 and 2/3
- **At the meeting before MTA, GAMESA expressed in interest in plug/patch repair**
  - Due to demise of Polymar, these test can be added to Wp11.
- **Planning and expected results**
- **The identification has been successfully completed**



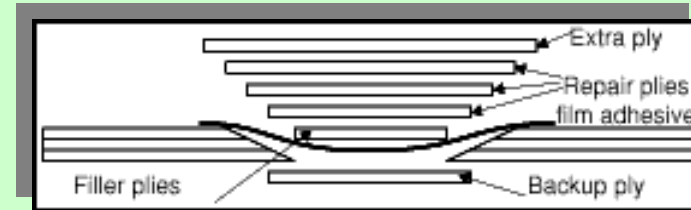
## 3.1 TASK 11.1 REPAIR ZONES AND TECHNIQUES

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### 1. SOLID COMPOSITE LAMINATES REPAIR:

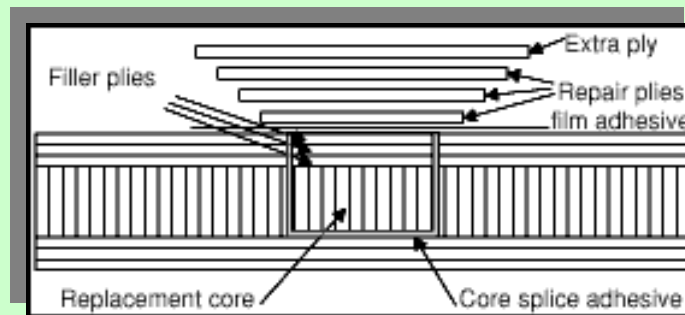


PATCH REPAIR

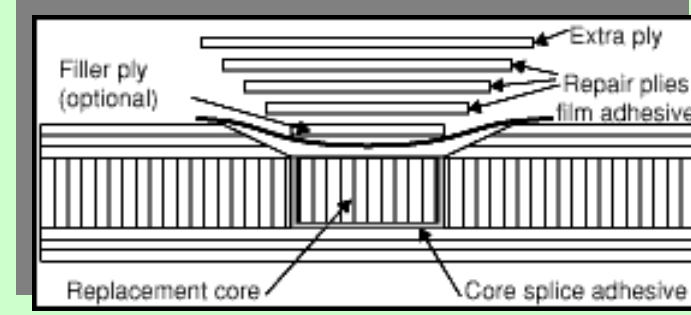


SCARF REPAIR

### 2. SANDWICH STRUCTURES REPAIR:



PATCH REPAIR



SCARF REPAIR

### 3. ADHESIVE BONDINGS REPAIR

### 4. COATING - SURFACE PROFILE DEFECTS REPAIR



## ***11.2 Production and test of flawed small specimens***

- **Assessment**
- Production and testing are progressing well, with both CRES and WMC testing specimens from LMG).
- CRES is also testing specimens made by GAMESA.
- The work on testing Polymarin specimens was partly carried out by WMC.
  - As Polymarin left the project due to bankruptcy, this work will be dropped.
- The work of CCLRC on NDT of specimens is delayed and may be dropped altogether, due to technical problems.
  - However, a new technique by CCLRC may be employed for determining the residual strains
- **Planning and expected results**
- A large number of results is in and an evaluation as described in task 11.3 should be possible



## ***11.3 Evaluation of the repair techniques***

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- **Assessment**
- No work on evaluation has been done yet; preliminary results indicate that several repair techniques may be less effective than was hoped.
- **Planning and expected results**
- The tests should result in useful insight on the effectiveness of the repair methods, some tentative recommendations on repair techniques will likely result.



# WP11: Deliverables and Milestones

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5	11	Suitable repair techniques for small specimens	Report	5	CO	OB_TG4_R002	75%
13	11	Evaluation of repair techniques as used for small specimens (report)	Report	26	PU	To be done: TG4	20%

7	11	DPA on repair locations and techniques	5	Yes	
15	11	Go/no-go decision repair of curved components	26	Yes	No-Go





## WP 12: objectives

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- To validate the predicted properties for thick, curved laminates as used in large blade components and validate repair methods on realistic, large components.



## ***12.1: DPA - Sub component definition***

- **Assessment**
- **During the MTA GAMESA has suggested work to be done here.**
  - This WP was about to be dropped due to lack of time within the original timeframe, however, new input from GAMESA may make this WP still possible.
- **Planning and expected results**
- **The work on Sub component should give additional knowledge on repair in realistic blade parts.**



## ***12.2: Sub component design and production***

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- **Assessment**
- This task will be carried out by GAMESA
- **Planning and expected results**
- We should have a number of components for testing before August 2005, in order to meet the project deadline.



## ***12.3: Static test of components***

- **Assessment**
- **Nothing is done yet**
- **Planning and expected results**
- **Planning for this WP is still tentative, a clear outlook on the expected results cannot yet be given for this WP.**



## 12.4: Evaluation

- **Assessment**
- **Provided the testing is finished in time, this task will be carried out.**
- **Planning and expected results**
- **The new planning should lead to a additional results on realistic repair techniques. In combination with the work done in WP11, a number of design recommendations can be provided**



## ***12.5: Production and test of large flawed component***

- **Assessment**
- This task will be carried out by WMC and GAMESA
  - PMs will be adapted
- **Planning and expected results**
- Planning for this WP is still tentative, a clear outlook on the expected results cannot yet be given for this WP



## WP12: Deliverables and Milestones

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37	12	Report on design and test of thick, curved components	Report	43	CO	To be Done: TG4	0%
38	12	Large components with and without repaired flaws	Report	43	CO	To be Done: TG4	0%

19	12	DPA on curved thick components	27	No	At the MTA
28	12	Finalisation of activities on thickness influence	43	No	
29	12	Finalisation of activities on repair	43	No	