SHAPE MORPHING OF FLEXIBLE SURFACES FOR AEROSPACE APPLICATIONS

Horst Baier, Leri Datashvili

Institute of Lightweight Structures (LLB)

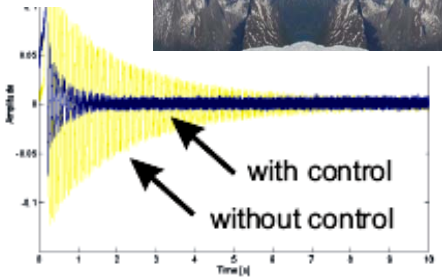
Technische Universität München, Germany

Research areas at LLB / TU München

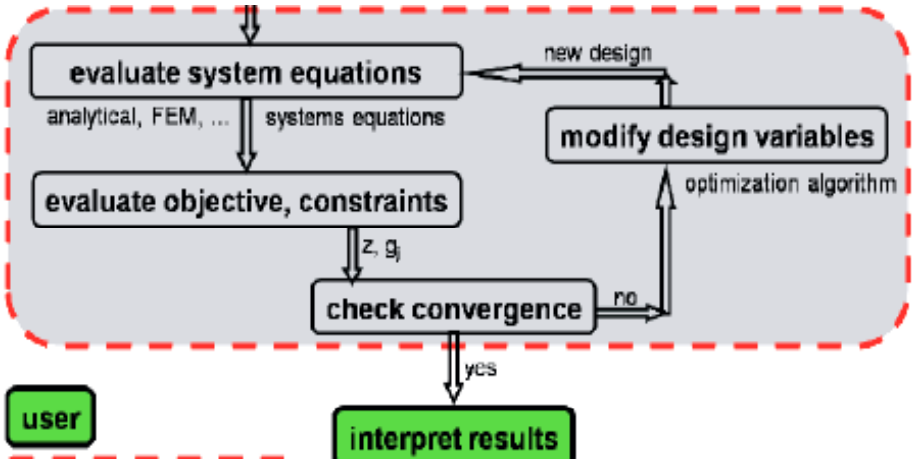
Membrane and reflector structures

Advanced fiber composites / hybrid mat. & structures

Smart Structures



Multidisc. Struct. Optimization



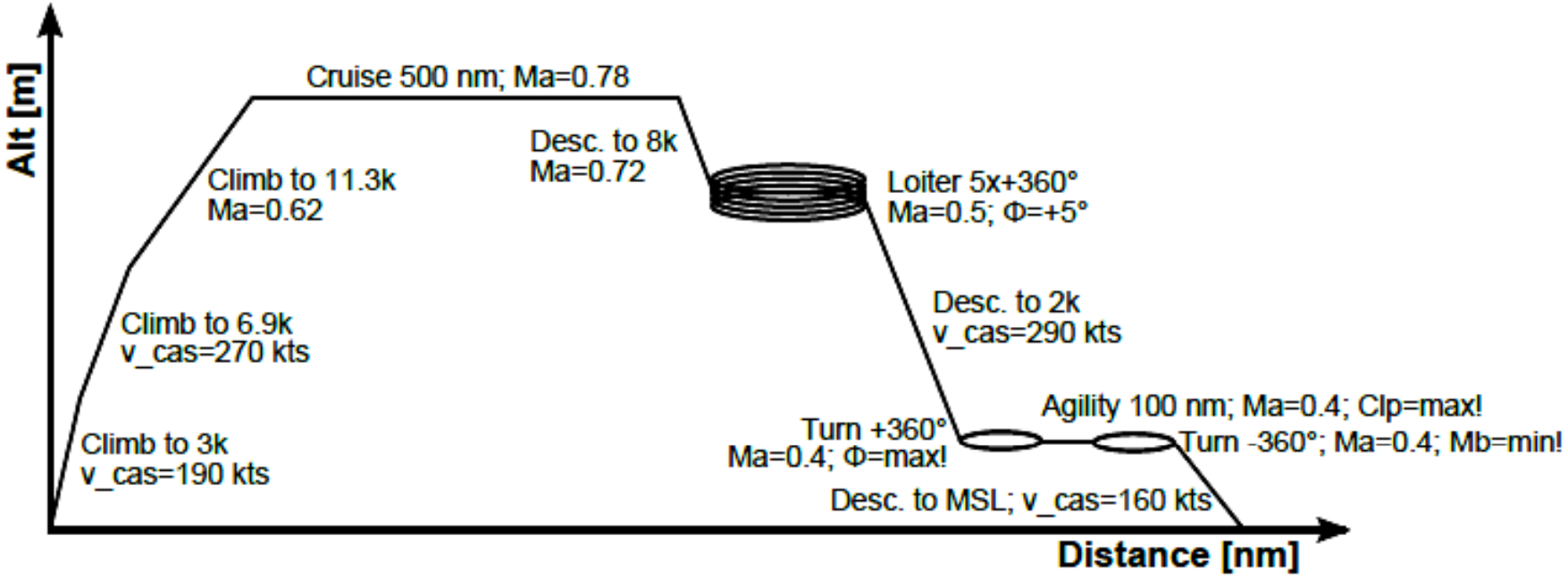
Morphing Aerospace Structures

Massive change in geometry

high loads and stiffness
… and morphing

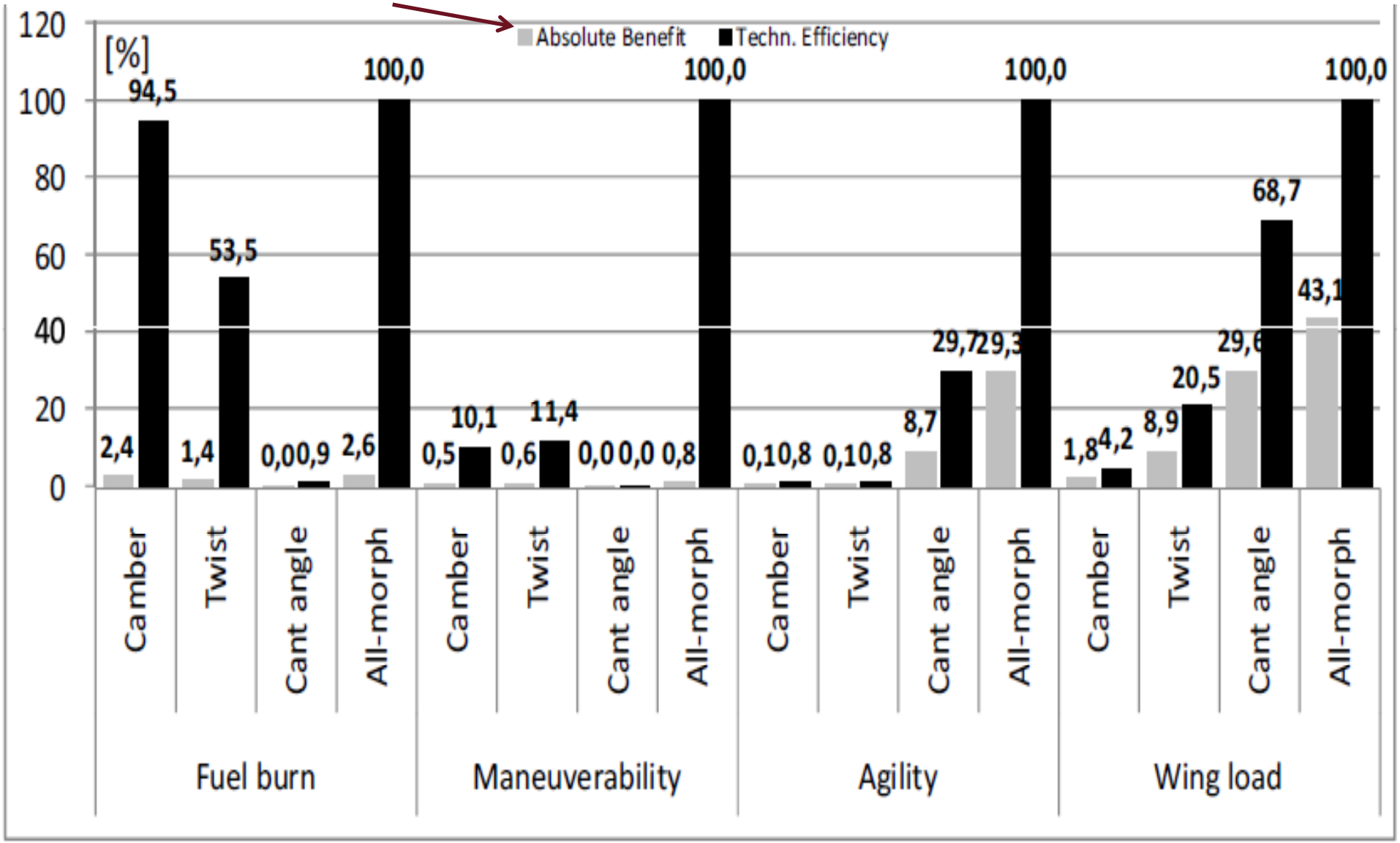
high shape precision
… and morphing

Morphing wing rereference mission for 40 seater



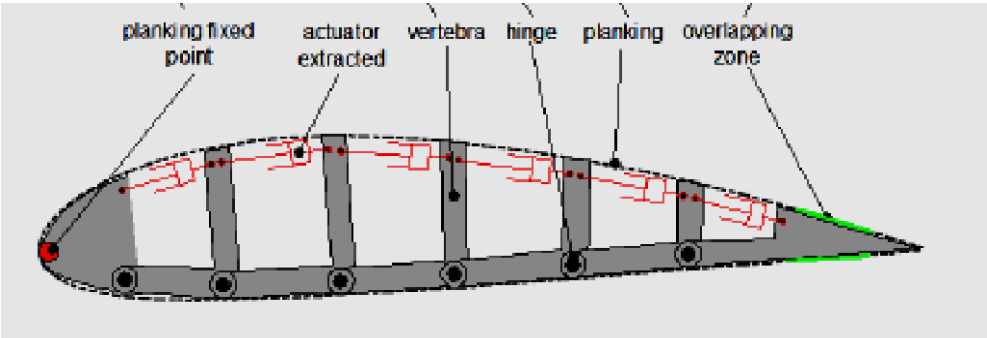
Wing-tip DoF	Lower bound	Upper bound
Twist (ε)	-6°	+6°
Camber (δ_{out})	0%	9%
Cant angle (γ)	-85°	+85°

Morph. param. influence on diff. criteria

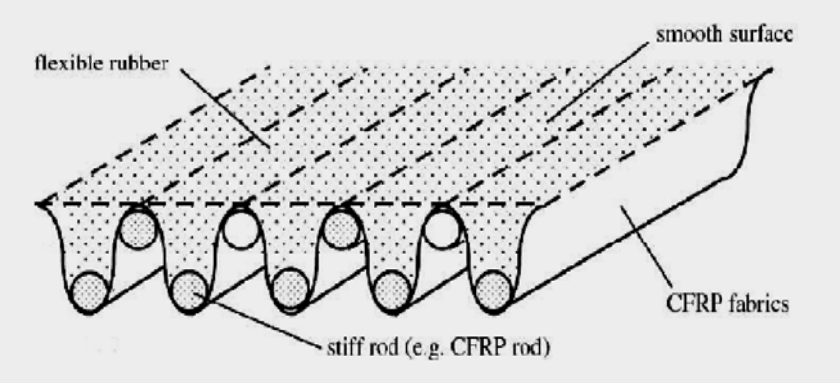


Morphing wing basic principle

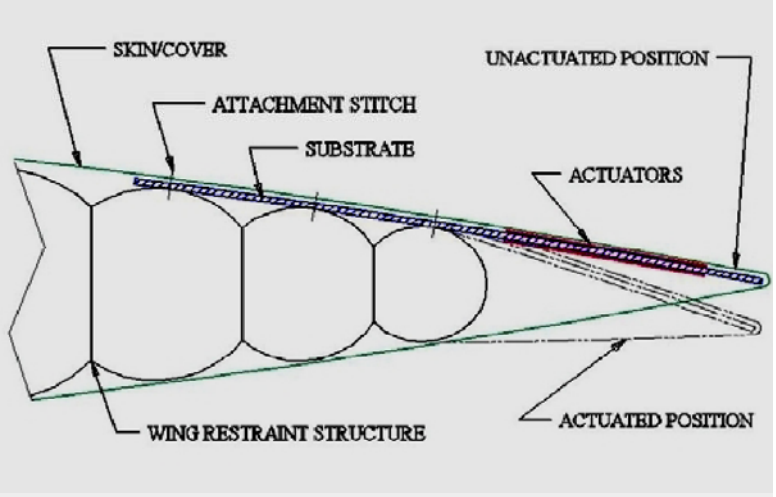
Morphing actuators

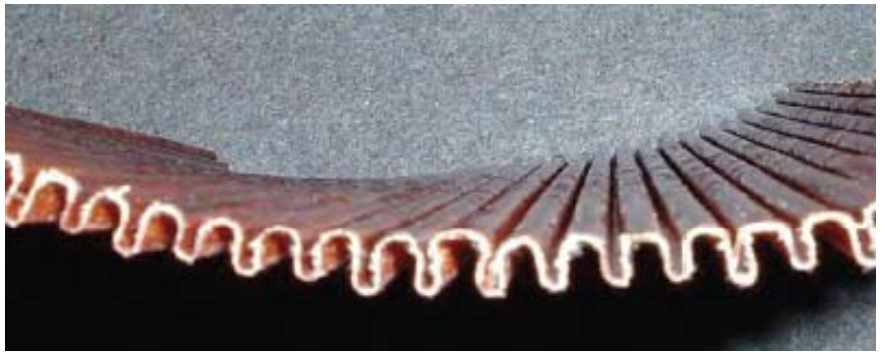


Morphing surfaces



?

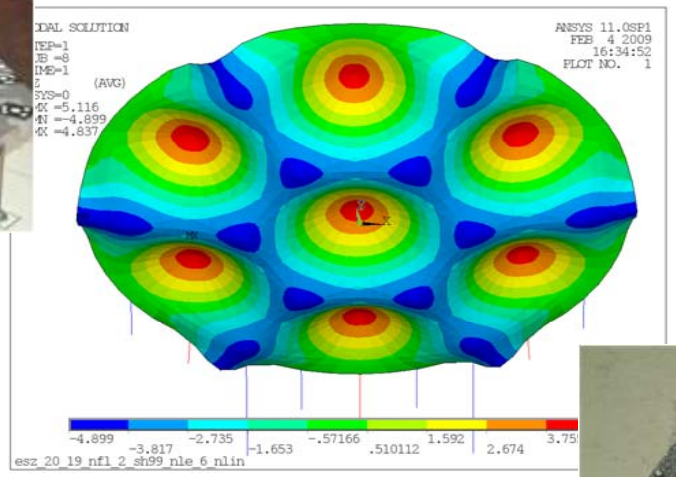


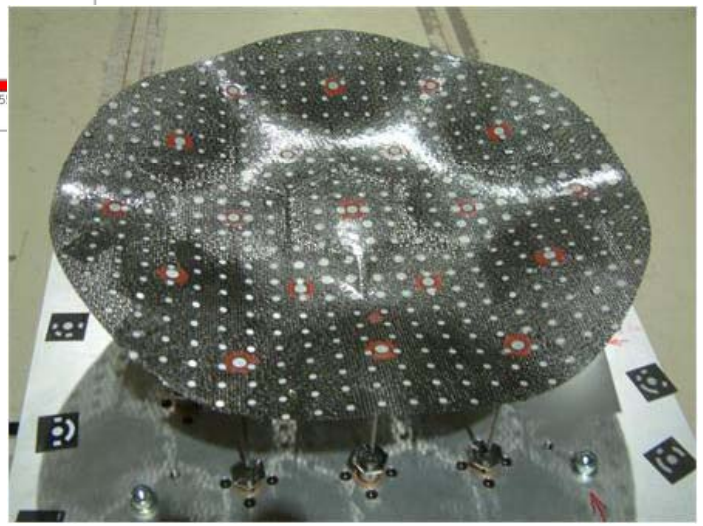


Friswell, Swansea

Massively morphing sat reflectors …

… to achieve non-isotropic RF beam radiation in (space) antennas



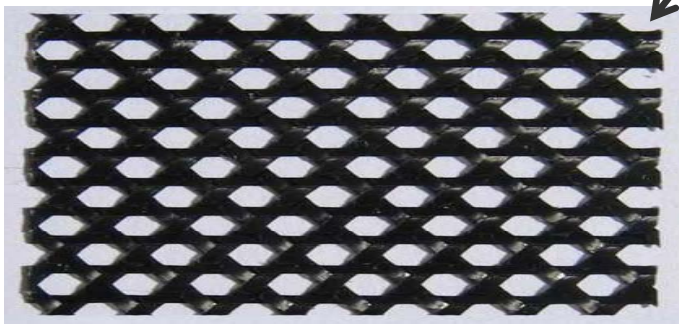


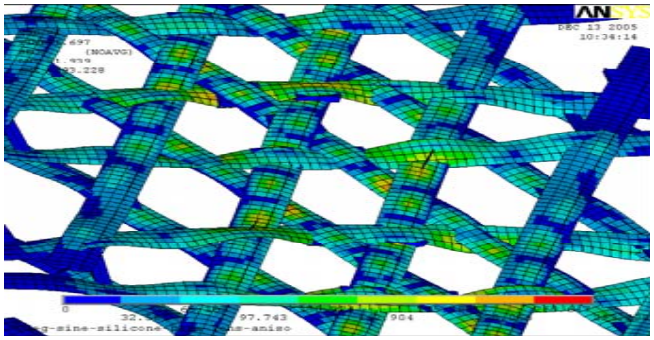
→ **requires actuators and a morphing surface with**

- **low in-plane and shear stiffness**
- **moderate bending stiffness**
- **very low CTE**
- **good thermal and electr. conductivity**

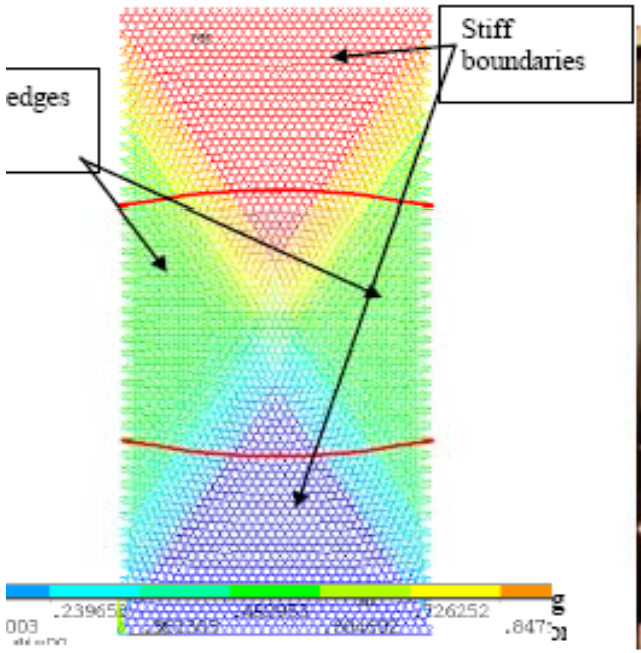
Structural and reflector material

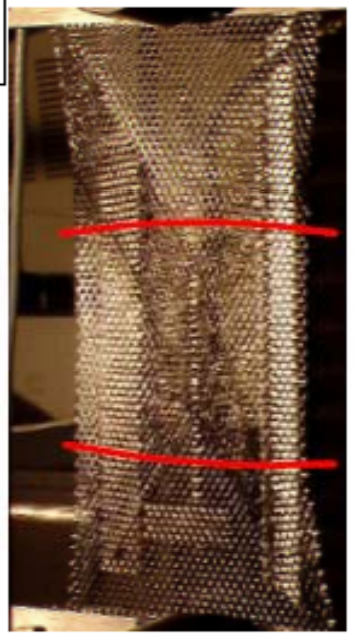
Triax C-fibre shell-membrane material (soft silicone matrix): CFRS





Micro-mech. FE model
(stiffness, CTE, …)

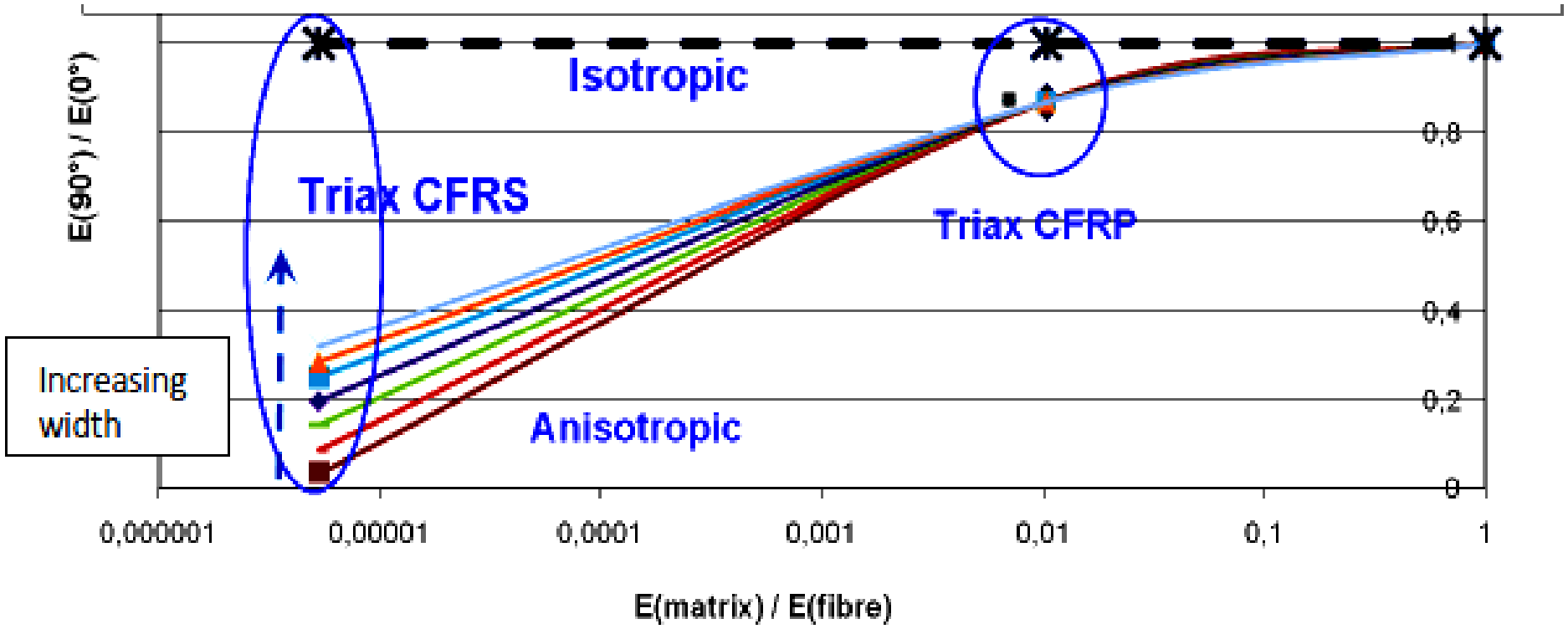




Simul and test results

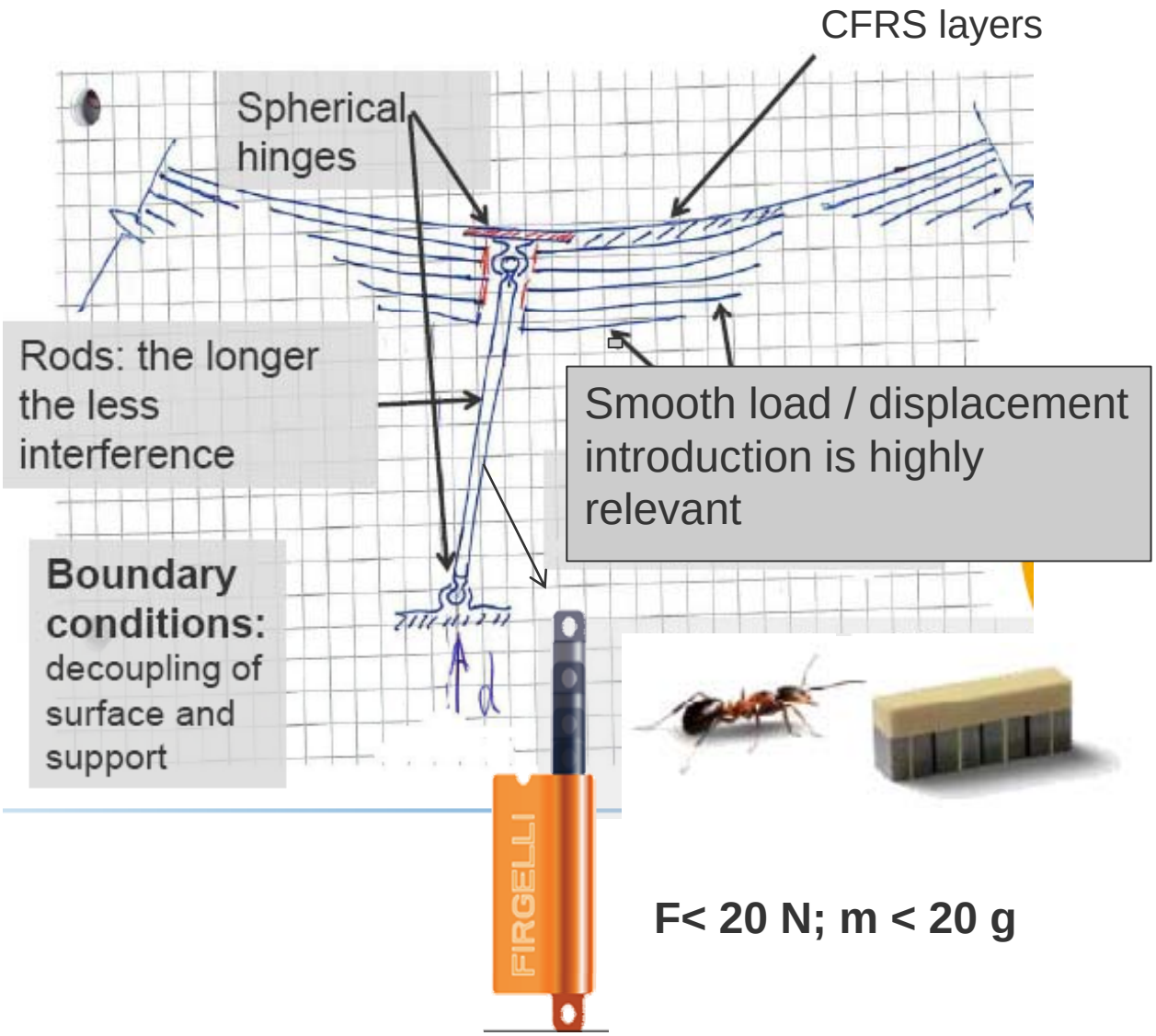
- **excellent thermo-mechanical properties**
- **good RF properties**
- **moderate - good morphing behavior**

Triax CFR-matrices with different Young‘s moduli



→ **Mat. properties and level of anistropy depend on specimen size**

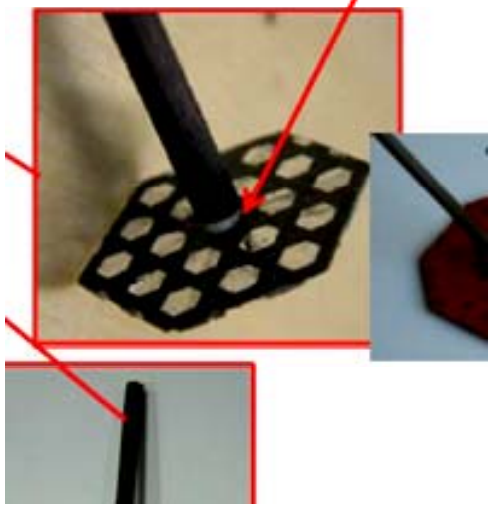
Actuator – structure interface



F< 20 N; m < 20 g

Actuator shaft and i/f

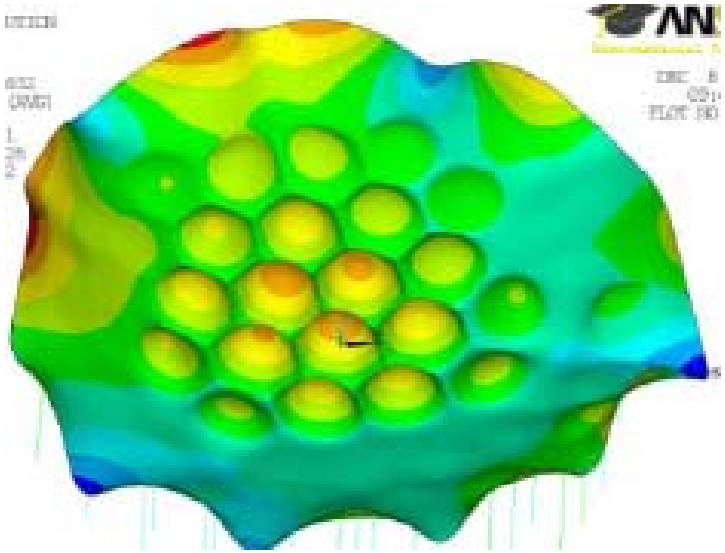
Dry Dyneema fiber tow
- low clearance
- low weight
- low CTE



Some typical results

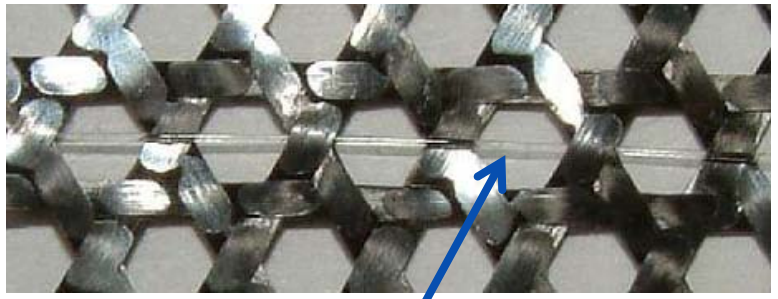
- **Surface rms deviation of actual shape vs. goal (required) shape < 0.15 mm**

- **Surface rms deviation between simulation vs. test results < 0.1 mm**



→shape morphing amplitudes of 10-15 mm and high spatial frequency look feasible

Integrated displ. *field* identification



FOS in CFRS

Measurement of strain at many positions

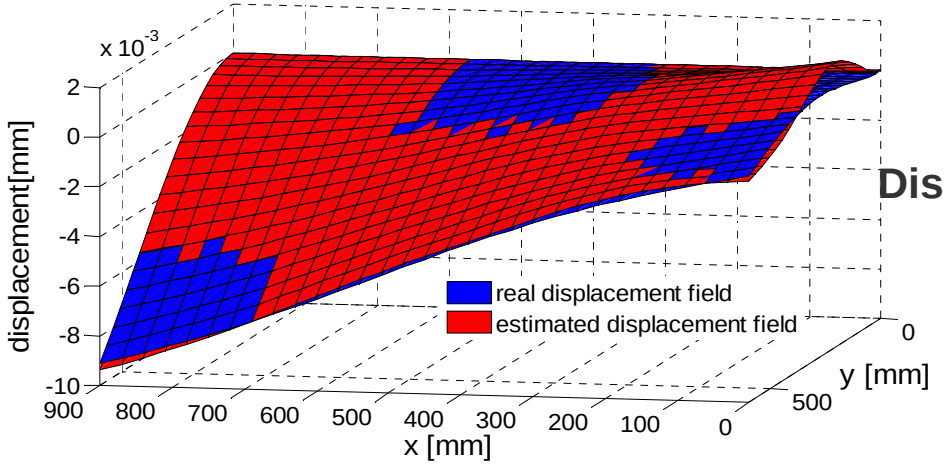
Reconstr. model using.

- **modal data**
- **Krylov vectors**
- **other FEM data**
- **exp. data**

[C]

Displacement *field*

Real and reconstructed displ. field



{U}=[C] {eps}

Morphing requirements

Aero-elasticity	RF-elasticity
• high forces (many tons)	• small forces
• high strokes	• small or high strokes
• moderate resolution	• high resolution (µm range)
• low spatial frequency	• high spatial frequency
• high reliability	• good reliability
• low mass / volume	• low mass / volume
• self locking	• self locking
• moderate temp. range	• extreme temperature range
•low frequency	• quasi-static

Modelling: *Coupling Aeodyn.* ⇄ *Struct.* *Coupling RF.* ←→ *structure*