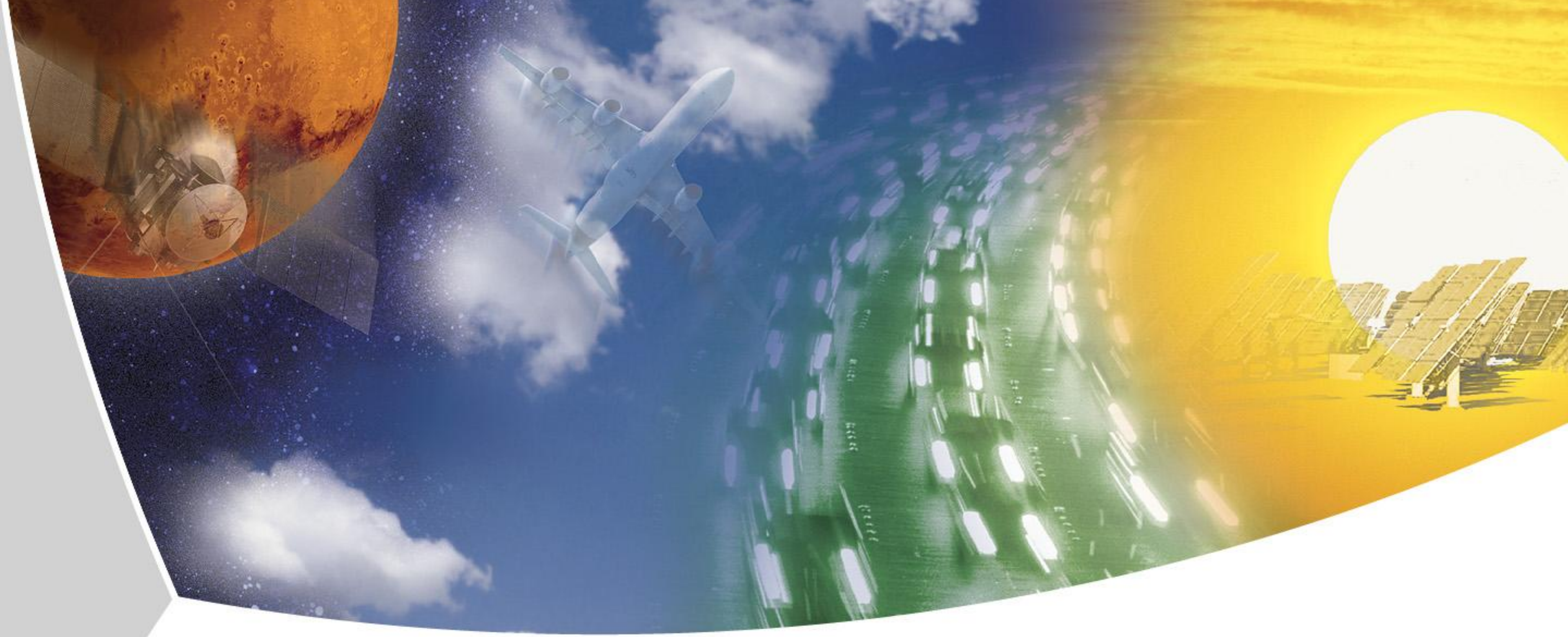


Progress in CELPACT to Month 28

Bob Mines

University of Liverpool, UK

(Coordinator: Alastair Johnson, DLR, Stuttgart)

DLR Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

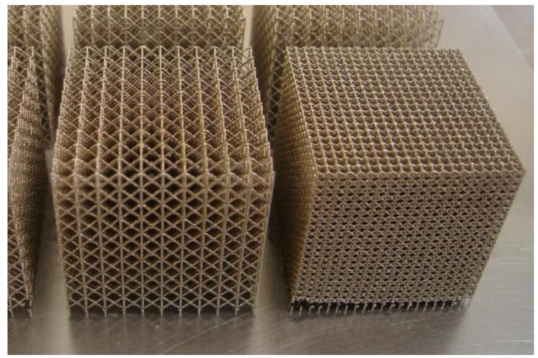
UNIVERSITY OF LIVERPOOL

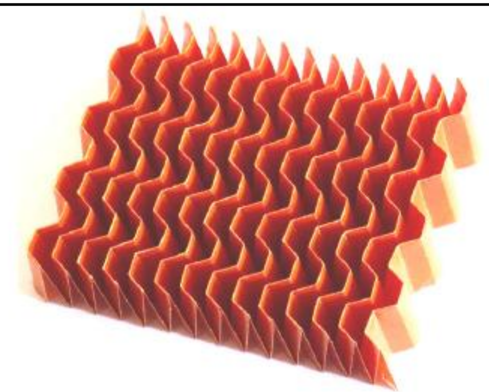
EASN Workshop, Munich

EU CELPACT: Cellular structures for impact performance - FP6 2006 - 2009

CELPACT
Cellular Concept Structure

Partners
1. DLR - Coordinator
2. Uni Liverpool
3. Uni Oxford
4. Uni Patras
5. RWTH Aachen
6. ENS de Cachan
7. Uni Stuttgart
8. Uni Brno
9. ATECA
10. Airbus-D
11. EADS-IW-F
12. EADS-IW-G
13. ALMA





New cellular core materials
- SLM metals
- foldcore composites

New fabrication technologies

Core micromodelling

Design of sandwich structures

Structural impact testing

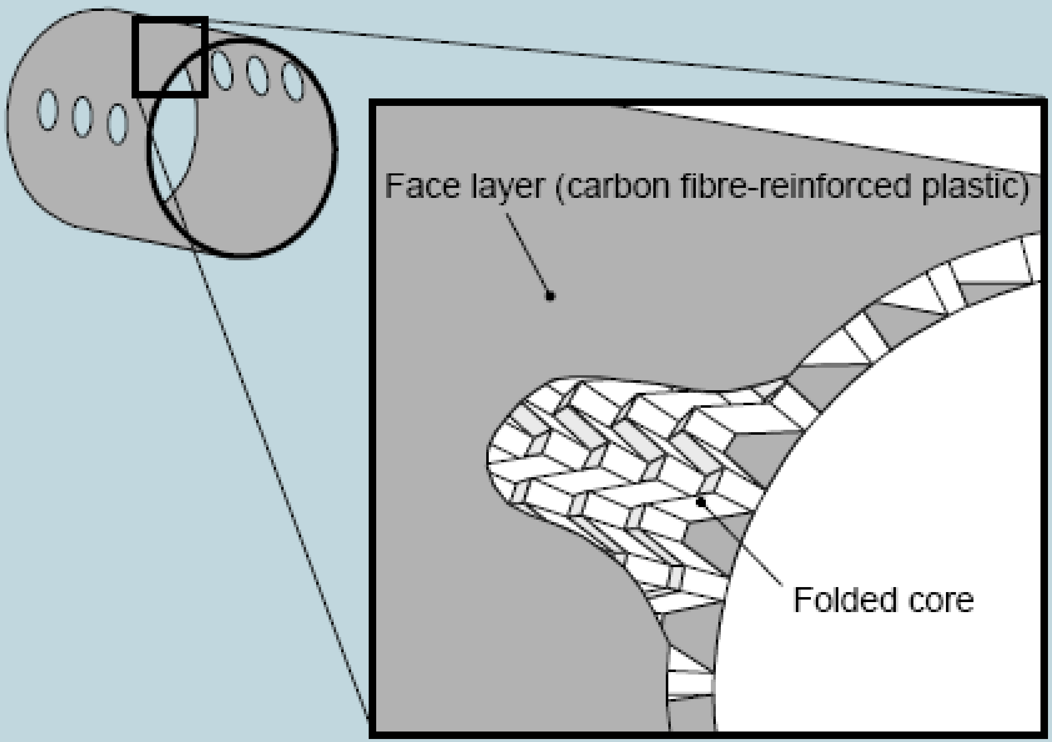
Damage assessment

New aircraft structures

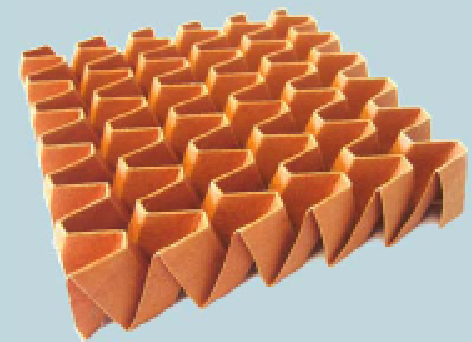
Sandwich concepts for aircraft structures

Sandwich Structures in Aircraft Design

Sandwich Fuselage Concept VeSCo



Foldcore sandwich:



+ Humidity transport through ventilation channels

+ Continuous manufacturing possible (cost-efficient)

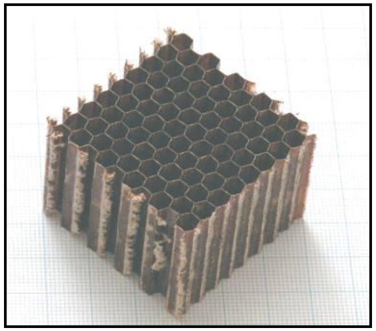
+ Different geometries and materials possible

Sandwich concepts for aircraft structures

Future generation of transport aircraft with “black” CFRP fuselage

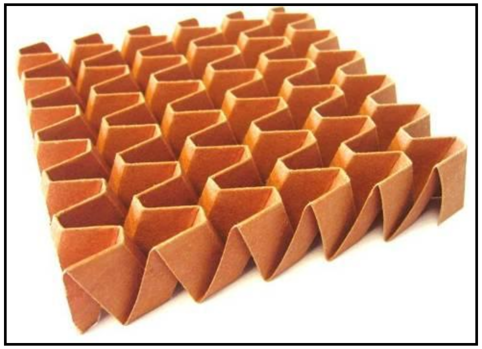
- 30 % weight and cost savings required
- Not possible with conventional shell/stringer design
- Evaluate new concepts with **double-walled fuselage structure**
  - ⇒ carbon fibre/epoxy laminated skins with light weight structural cores

Nomex aramid paper honeycomb core



• Standard core for aircraft structures
• Used mainly in secondary structures, flaps, control surfaces, etc
• Closed cells –no core ventilation – moisture uptake – not suitable for large primary structures

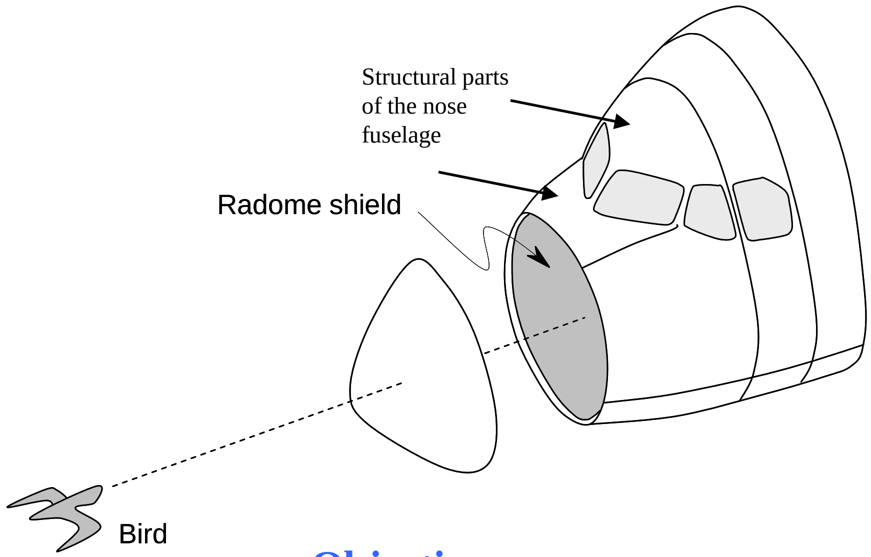
Folded composite core

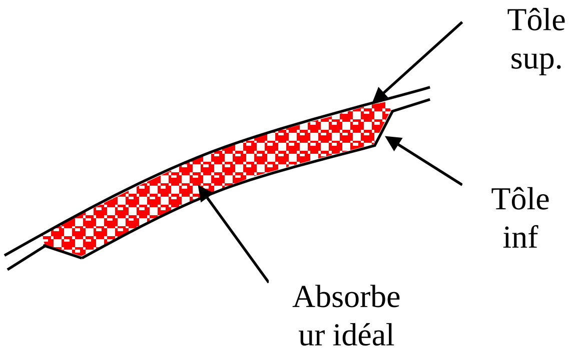


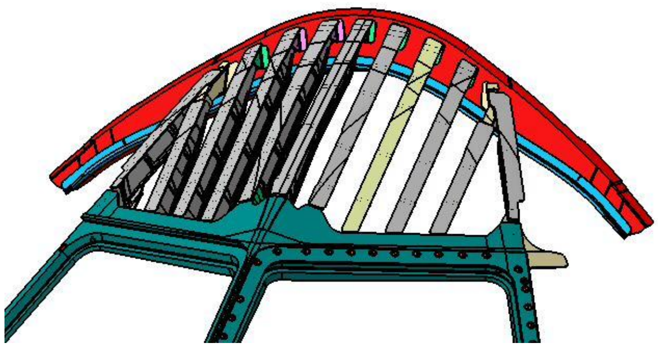
IFB, Stuttgart

• New core concept for aircraft structures
• Based on a structural composite core with folded plate unit cells for primary structures
•Open cells – ventilatable core – suitable for fuselage panels

Bird Strike on Fuselage (EADS F)







Objectives :

The structure of the aircraft nose shall resist without perforation to an impact of a **2kg** bird projected at **180m/s.**

Reference :

Aluminium honeycomb with Kevlar or aluminium skins

The representative size is approx. 1 m^2. with aluminium skins, it weights **13 Kg**.

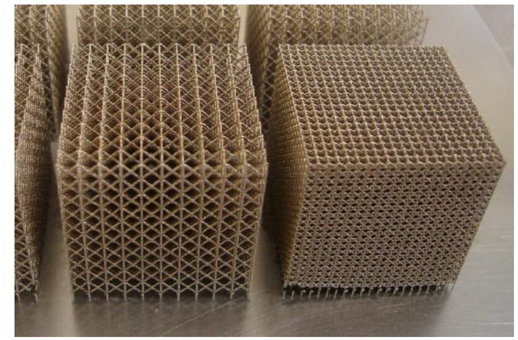
Stakes

Improving performance/weight

Cost reduction

Micro Engineered Cellular Material (MECM) core concept (ULIV)

Powder metallic block - stainless steel, titanium, …
Computer controlled laser welds spots in plane layers
Advances to next layer – produces 3-D network



Study of cell microstructure

			Cell Size (mm)	Density (kgm-3)
bcc	ss	Ti	2	250/144
bcc,z	ss		2	300
f2bcc	ss		4	250
f2cc,z	ss		1.25/2.50	424/983
Alporas			2 to 10	230

Significance of micro strut aspect ratio?

Constant diameter of strut ….200-250 microns

Optimal manufacture conditions: spot size (200/250 microns), power (140W/180W), duration (500 microsecs)

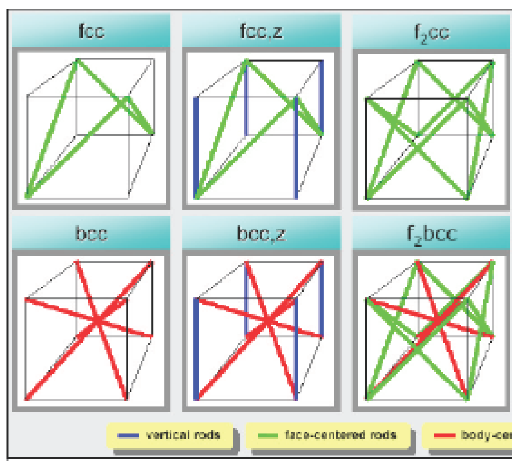
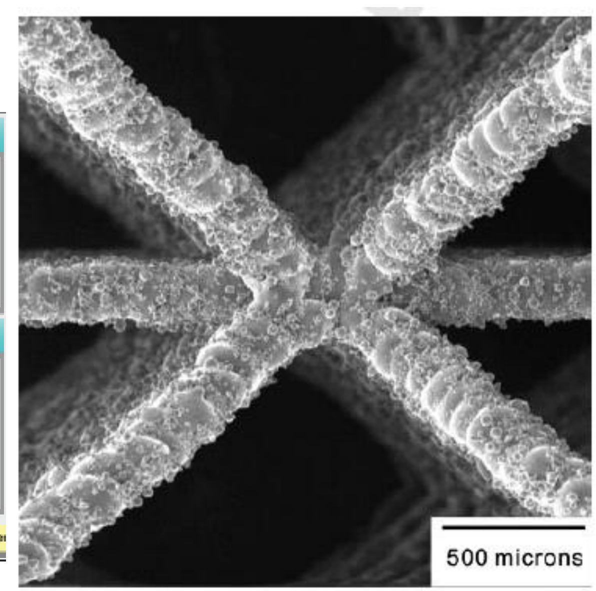
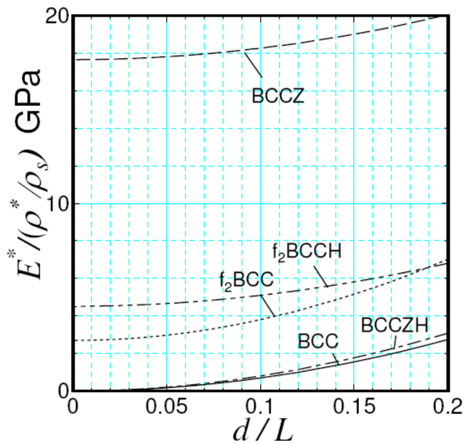


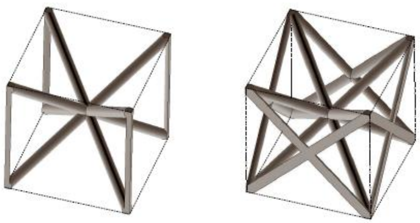
Fig. 3. Definition of cubic cell types



SLM Design Parameters (ULIV)

Parameter	1st Generation	2nd Generation
Material	Stainless Steel	Ti 6 4
Architecture	BCC	(BCC,Z or F2BCC…)
Strut Diam.	200microns	(150<d<250 microns)
Cell Size	2.5mm	(1<L<4mm)
Unit Cell	Cube	(Cuboid)
Comparison	Compression	(Tension,Shear)
Stiff+Strength	Competitive with Al Foam	Competitive with Al Honeycomb

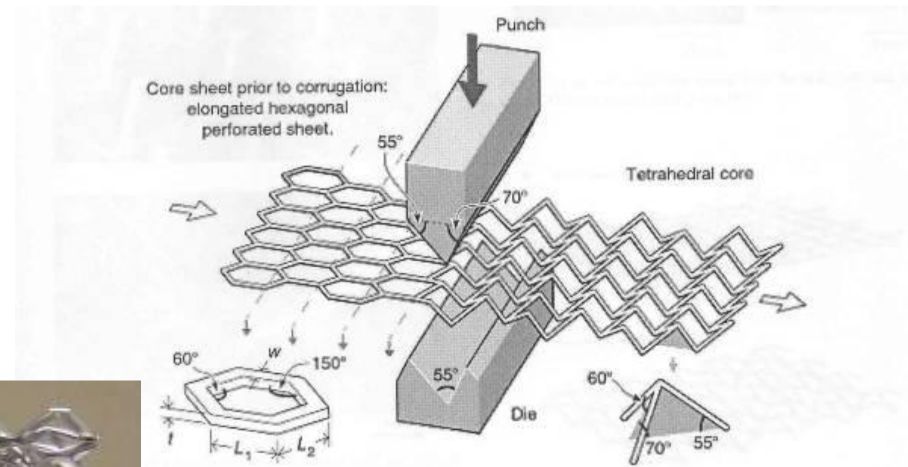


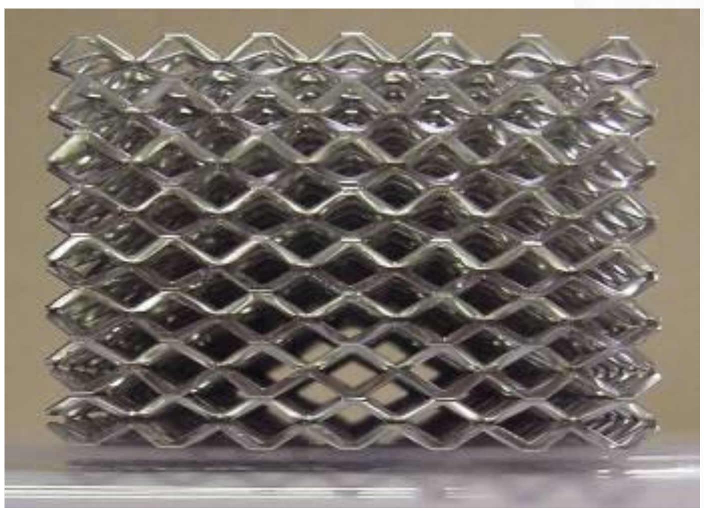


(c) Unit-cell for a $BCCZ$ structure (d) Unit-cell for a f_2BCC structure

Conventional Metal Structures (ATECA)

First Generation

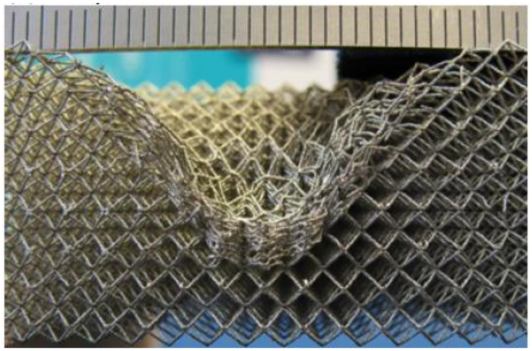


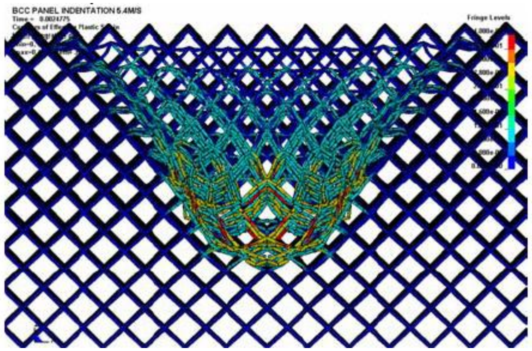


Second Generation

SLM core concept (ULIV)

Measurement of cell properties – LV impact damage

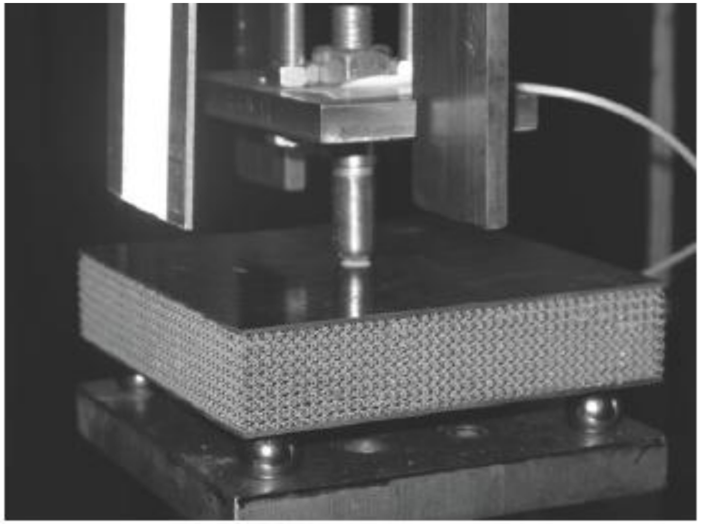


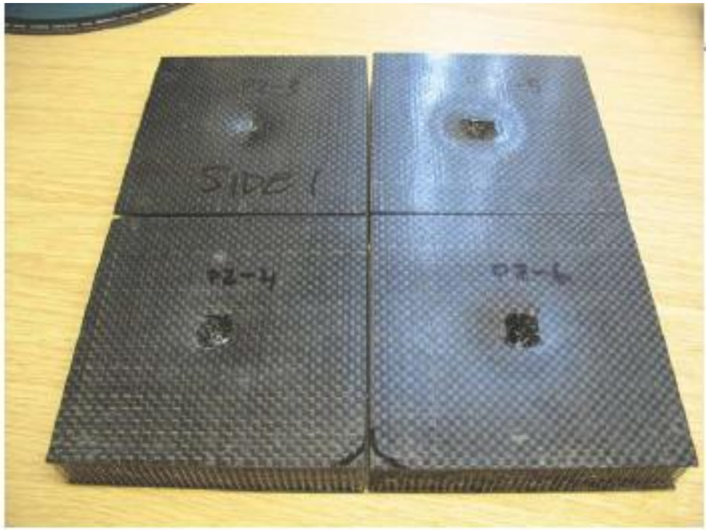


FE models of SLM core impact damage (2.1 J)

-Struts modelled as beams
- Elastic/plastic model
- Microtests on struts

SW panel impact tests with CFRP skins (13.6 J)

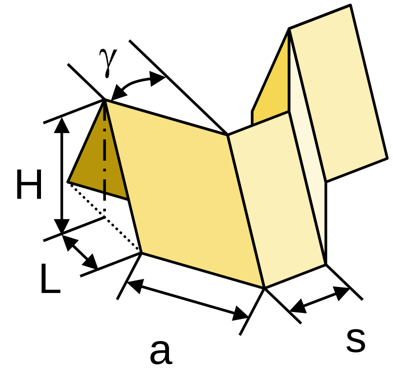


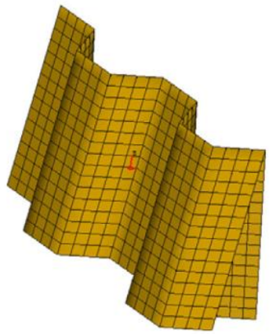


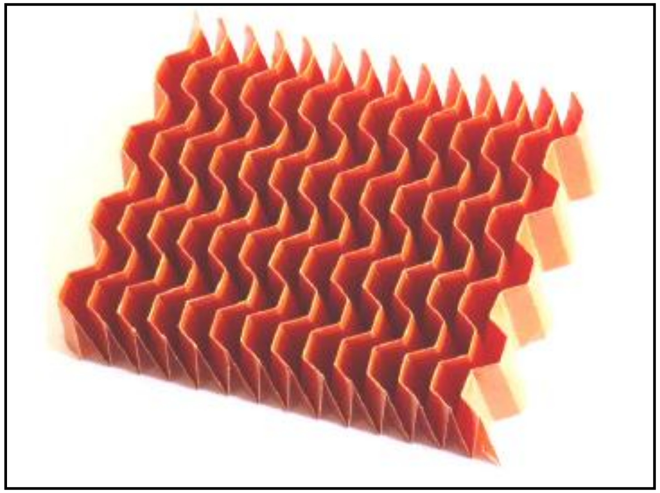
Foldcore structural core concept (USTU,EADS-G)

- Novel composite core structures
- Resin impregnated folded aramid or carbon paper or fabrics
- Wide range of fold geometry possible
- Core densities depend on cell geometry and packing

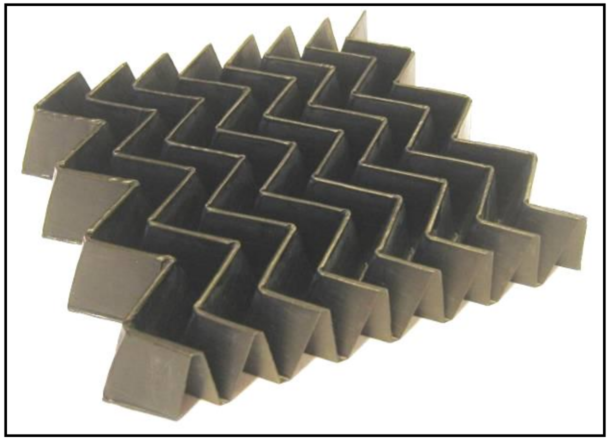
Basic folded element







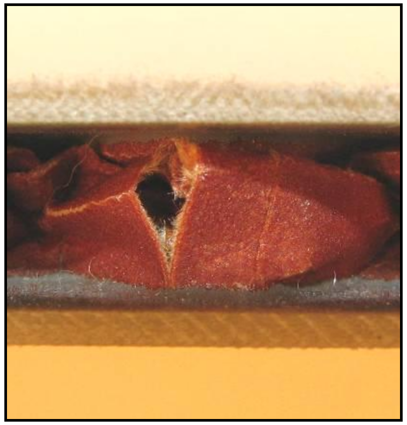
- **Foldcore fabricated by IFB, Uni Stuttgart**
- **Aramid paper – continuous fabrication process**

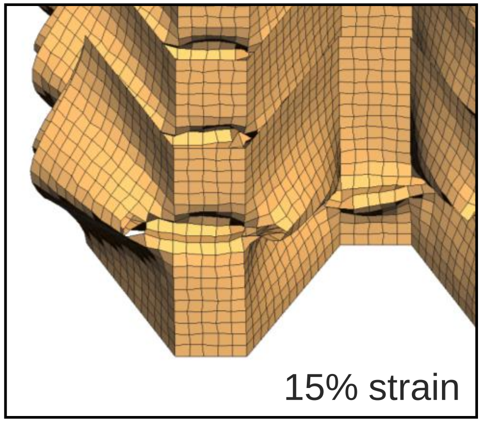


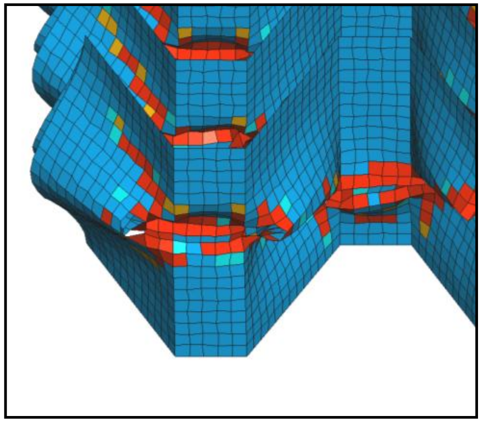
- **Z-crimp core from KGTU, Kazan**
- **Aramid or carbon paper – press formed – discontinuous process**

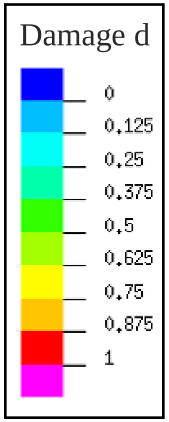
Development of a unit cell FE model for foldcore

Damage and failure model









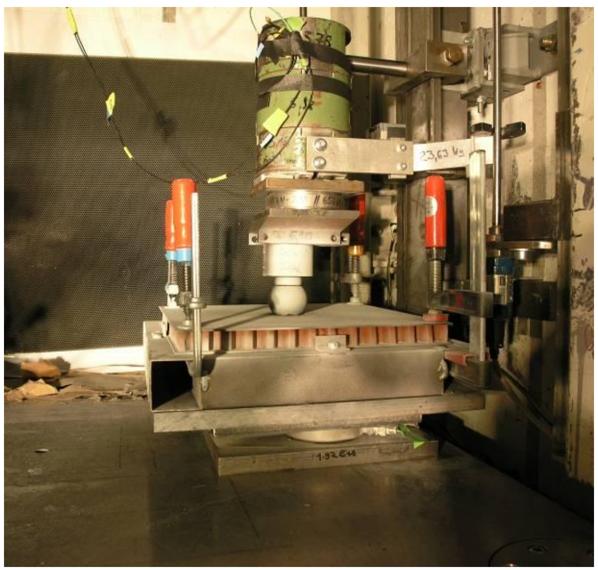
- Damage is very localised during initial collapse and starts to spread during later collapse/densification of the foldcore
- Sharp kinks are forming at the initial buckling zones and the foldcore tears along the edges
- Foldcore stiffness is underestimated during densification

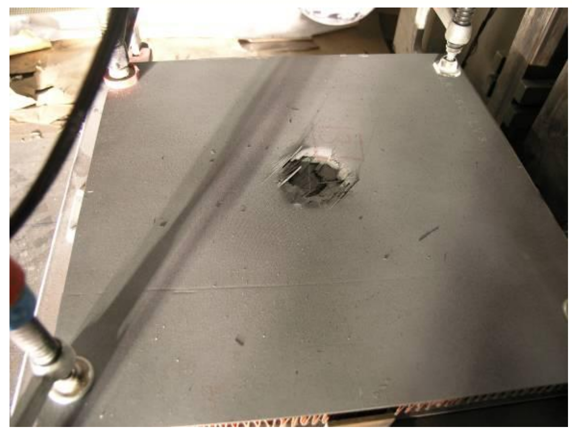
Evaluation of impact performance (DLR)

Drop tower impact

25 kg mass 6.04 m/s 456 J

- Skin penetration
- EA in core
- Bottoms out at inner skin

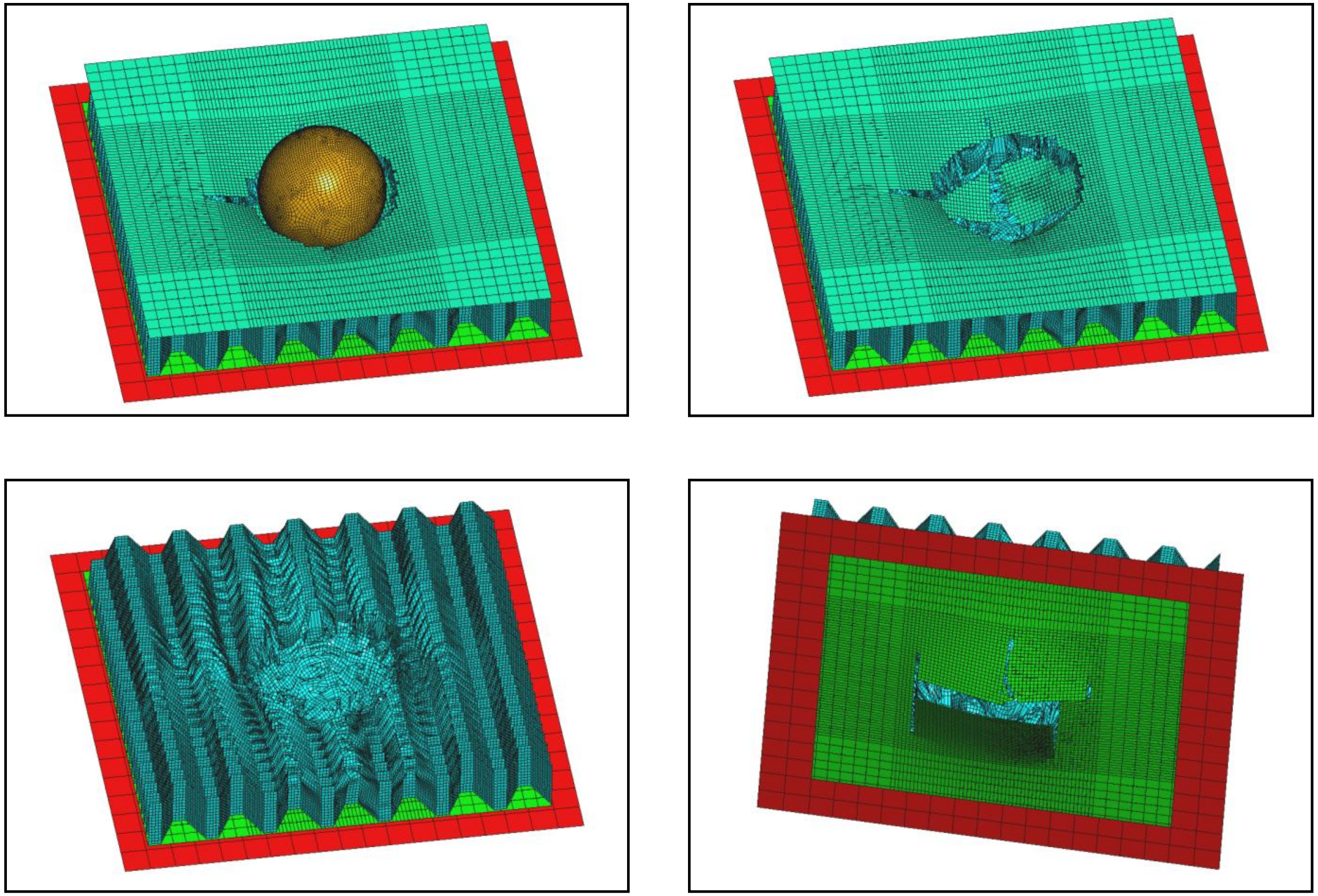




Impact damage models in foldcore panels (DLR)

FE model of LV impact

Deformation in FE model at an impactor displacement of 30 mm



Main Findings

Task 1	Manufacture	CM	SLM and Conventional specimens/panels manufactured
		CHC	Large panels manufactured
Task 2	Simulation	CM/CHC	Micro and Macro models completed
Task 3	Testing	CM/CHC	Cellular properties (stiffness/strength), plus FOI panels completed
Task 4	Validation	CM/CHC	Ongoing
Task 5	Road Map	CM/CHC	Different Technology Readiness Level

Road Map to Application 1

Technology Readiness Levels

Low	1	Basic principles of technology observed and reported
	2	Technology concepts and/or application formulated
	3	Analytical and laboratory studies to validate analytical predictions
Medium	4	Component and/or basic sub-system technology valid in lab. Environment
	5	Component and/or basic sub-system technology valid in relevant Environment
	6	System/sub-system technology model or prototype demo in an operational Environment
High	7	System technology prototype demo in an operational Environment
	8	System technology qualified through test and demonstration
	9	System technology qualified through successful mission operations

Road Map to Application 2 - Aerospace ‘drivers’ for CM

Objective	Contribution to decrease vulnerability of the structures using new cellular materials
Stakes and benefits	To promote cellular materials and increase performances to bird strike, save weight and space in new design.
Applications	Nose parts of the aircraft - nose upper cover, radome shield - belly fairing - leading and trailing edges
Current performance	Metallic honeycomb - light density (37Kg/m3) with metallic skins : assumes the structural load transfer and bird strike
Target performance	Increasing by 10% the dynamic properties for bird strike. To develop a material with the ability to diffuse the load
Obstacles to be overcome	Mastering the relationship between microstructure (unit cell geometry) and static and dynamic properties*

*eg. SLM design parameters

Final Workshops for Celpact

Celpact Final Workshop

At EADS IW G Munich

Friday 11th September 2009

6 paper Session at JEC/SAMPE Paris

23rd to 25th March 2009

Thank you for your attention !