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Lokale Verstärkung von thermoplastischen Bauteilen mit endlosfaserverstärkten UD-Tapes

Sascha Bockelkamp

Content

- Introduction of Celanese
- Introduction Celstran® Composites Materials
  - Celstran® CFR-TP Tapes
  - Celstran® LFRT
- Established Manufacturing Processes for UD-Tapes
- Market and Application Examples
  - Concept Examples of Applications and Demostrator Studies

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Introduction of Celanese

Celanese is a global technology and specialty materials company

- We produce chemicals and advanced materials used in consumer products and industrial applications
- Our products enjoy leading global positions
- Globally positioned with regional subsidiaries or dealers network
- Excellent technical services
- Based in Dallas, Texas
- Approx. 7,400 employees worldwide

Celanese is a global technology and specialty materials company

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2014 Net Sales: **$6.8B**
Employees: **7,500**
Manufacturing Locations: **27**

Advanced Engineered Materials
$1.5 billion net sales

- **Specialty thermoplastics** used in automotive, electrical, electronics, more

Acetyl Intermediates
$3.5 billion net sales

- **Acetic acid, vinyl acetate monomer,** and additional intermediate chemistries

Consumer Specialties
$1.2 billion net sales

- **Cellulose derivatives** like acetate tow for filters
- **Food ingredients** including sweeteners, preservatives

Industrial Specialties
$1.2 billion net sales

- **Emulsion polymers** for paint, adhesives, nonwovens, carpets
- **EVA polymers** for flexible packaging, medical solutions

Global network – strong global presence

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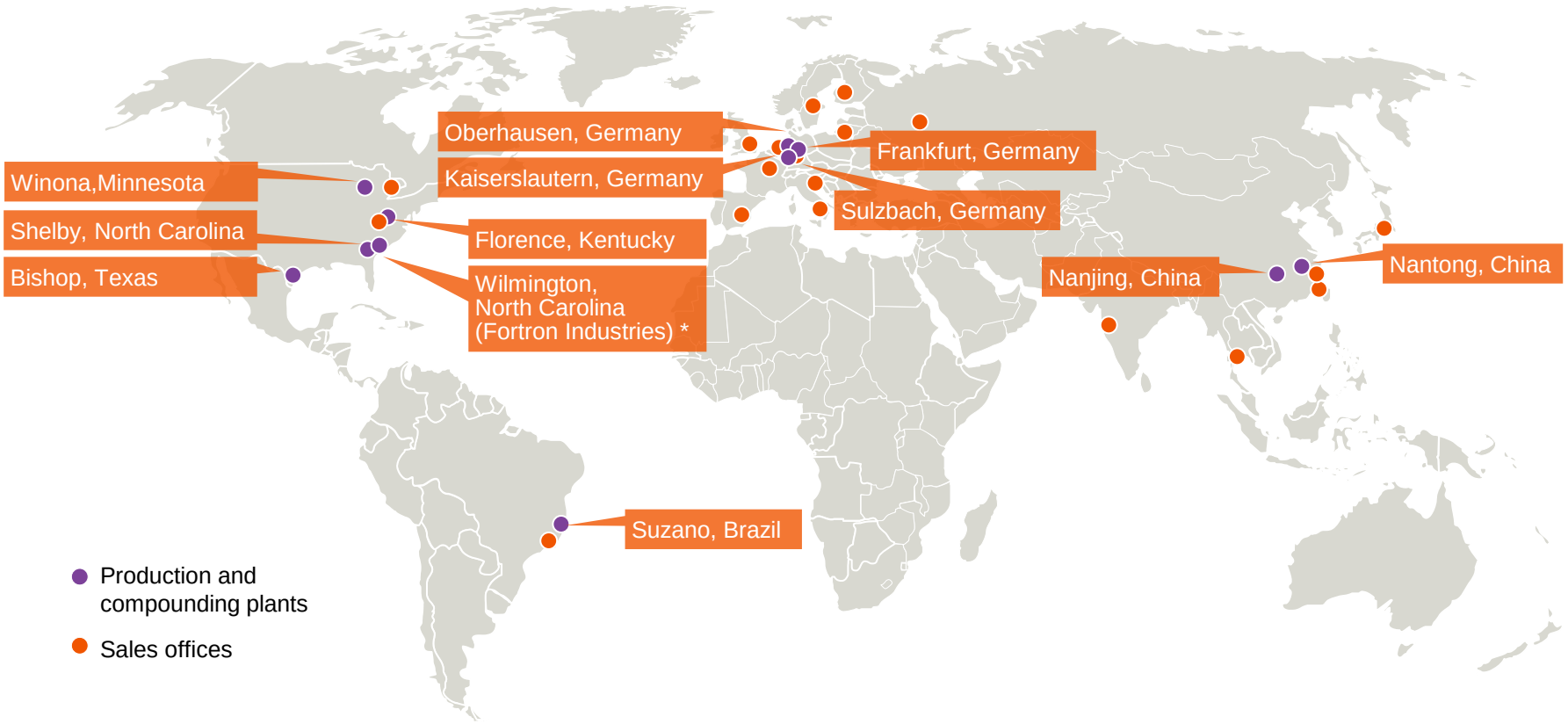

* Fortron Industries is a non-consolidated affiliate of Celanese(50%)

Consistent products and services – worldwide

Celanese maintains leading position in engineered materials

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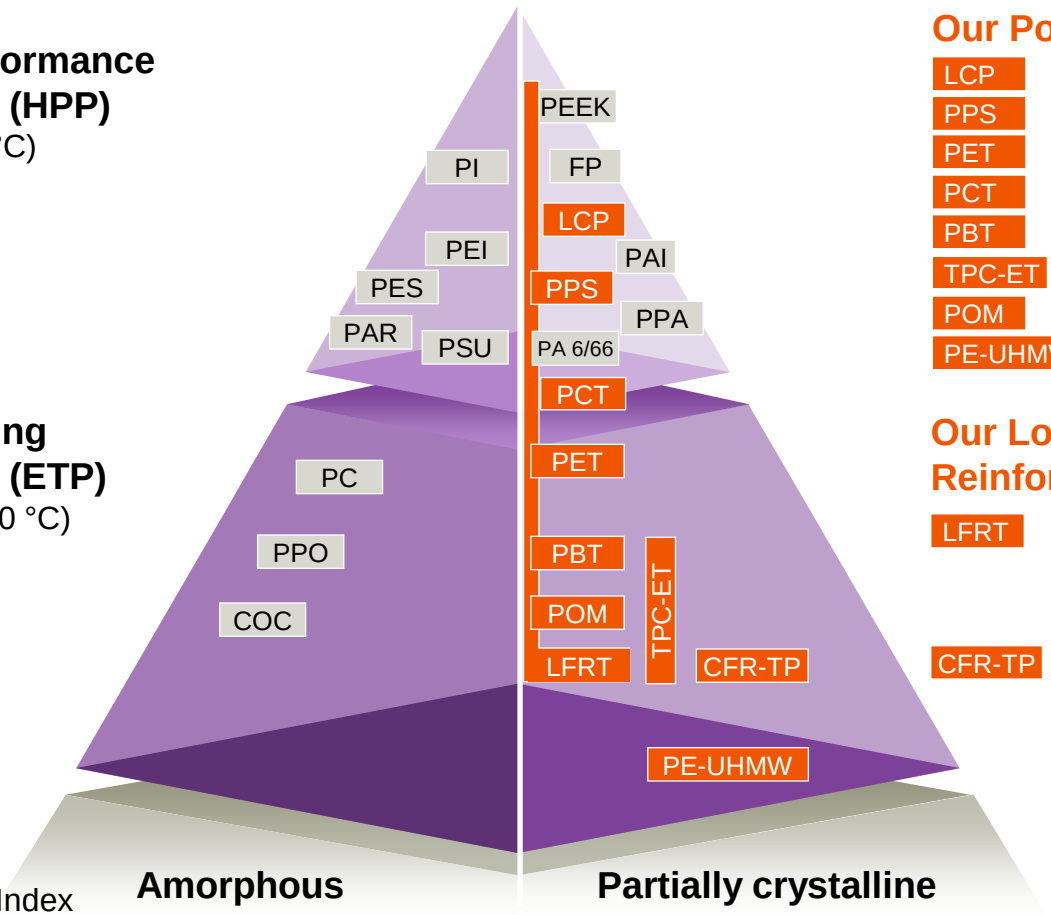
Service temperature

High-Performance Polymers (HPP)
(TI[1] > 150 °C)

Engineering Polymers (ETP)
(TI[1] 90 – 150 °C)

Basic Polymers



TI[1] = Temperature Index

Our Polymers

LCP	Vectra®, Zenite®
PPS	Fortron®
PET	Impet®
PCT	Thermx®
PBT	Celanex®, Vandar®,
TPC-ET	Riteflex®
POM	Hostaform®
PE-UHMW	GUR®

Our Long Fiber Reinforced Plastics

LFRT	Celstran® with Matrix Polymers: PP, PA, PPS, PBT, POM and others on request
CFR-TP	Celstran® Tapes

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Introduction Celstran® Composites Materials

Celstran® LFRT & Celstran® CFR-TP

Composites landscape

Where we are

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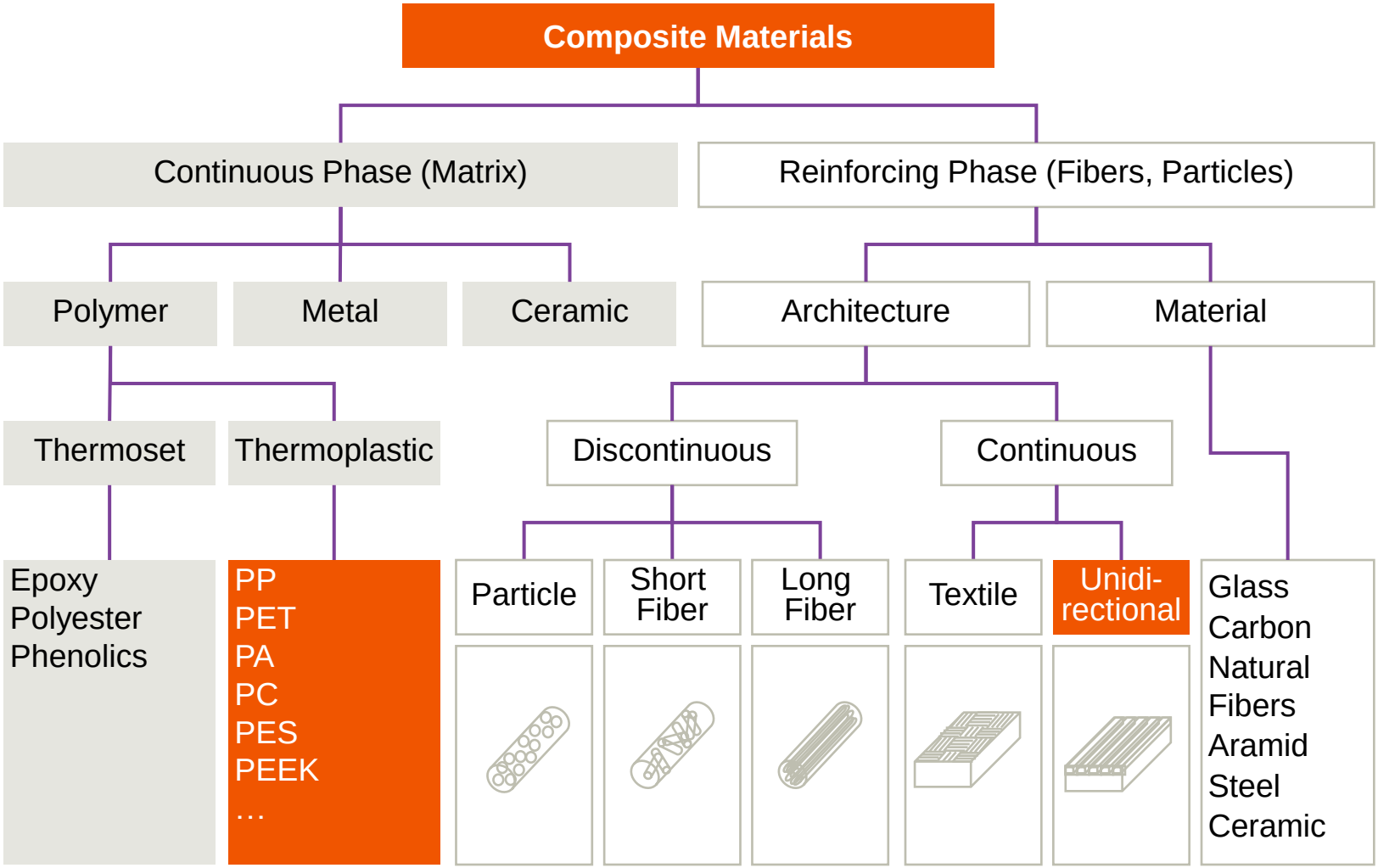

Thermoplastic fiber reinforced polymers

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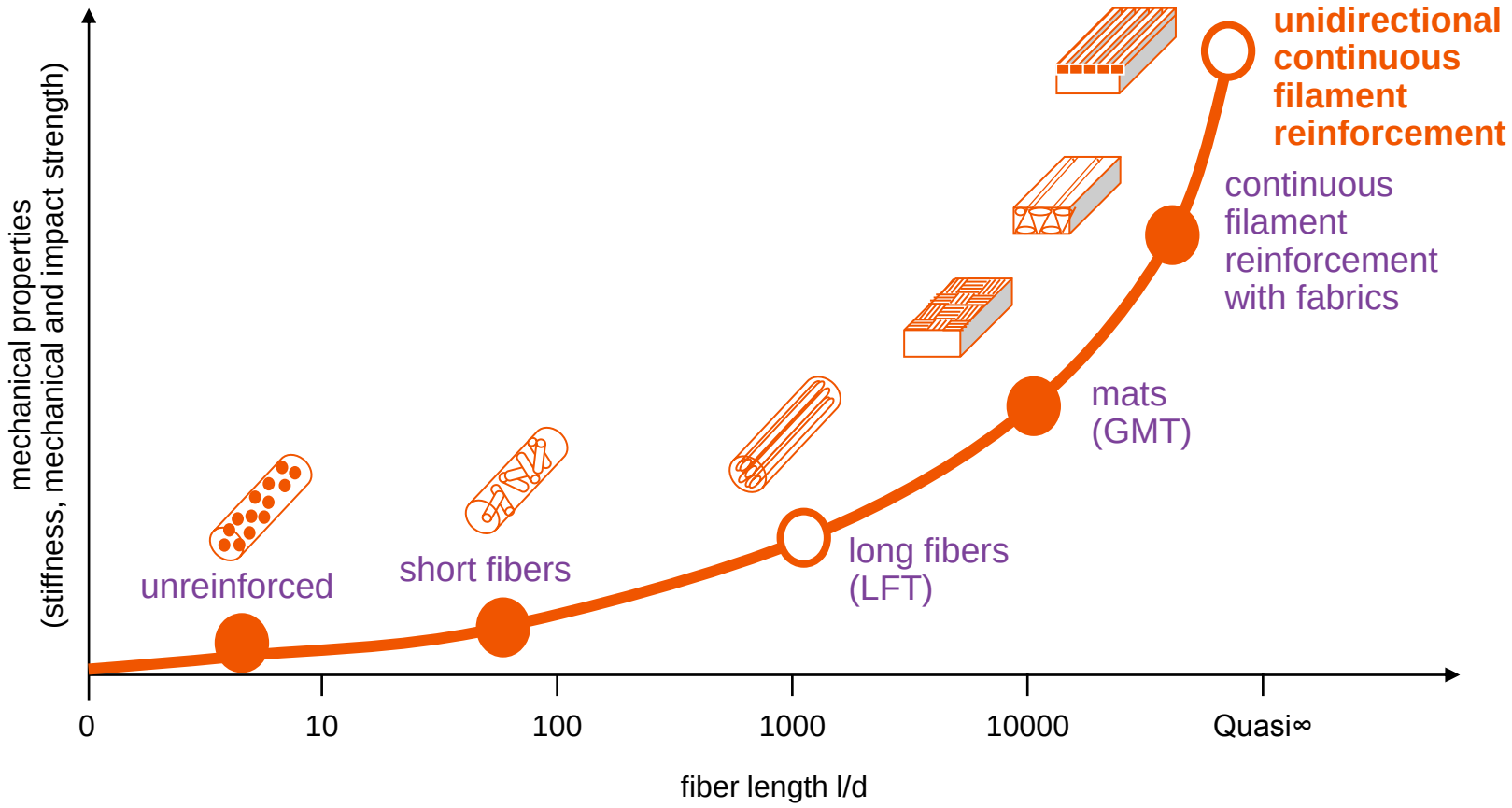

Successful Engineering and Production

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Material modeling
("Structural Analysis")

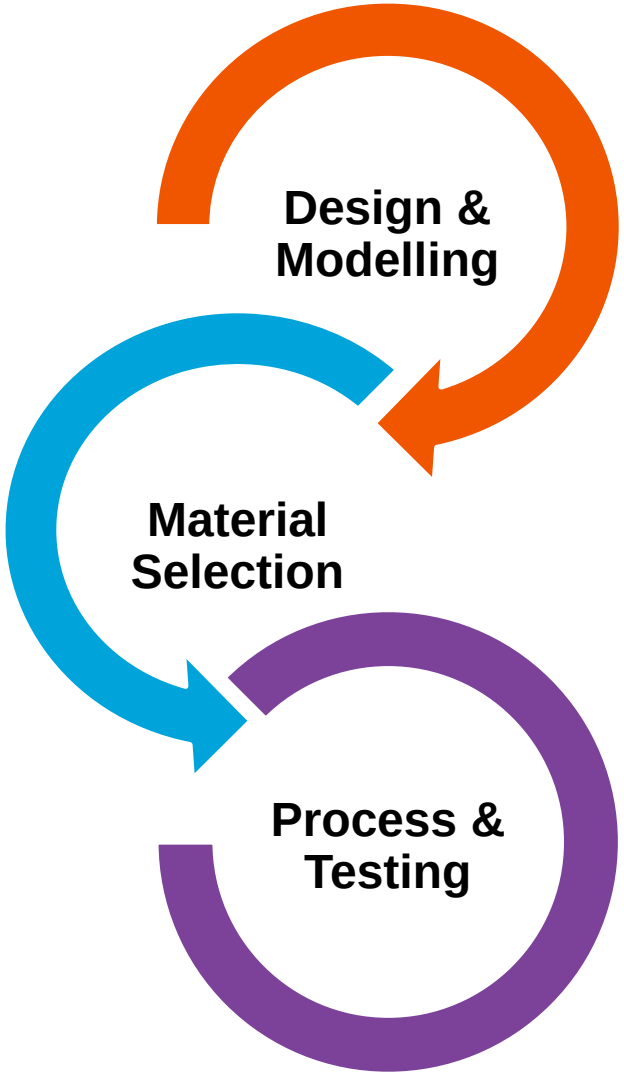
Fiber orientation
("Forming and Moldflow Analysis")

Material database & tailored products
("Celstran® LFT & Celstran® CFR-TP Tapes

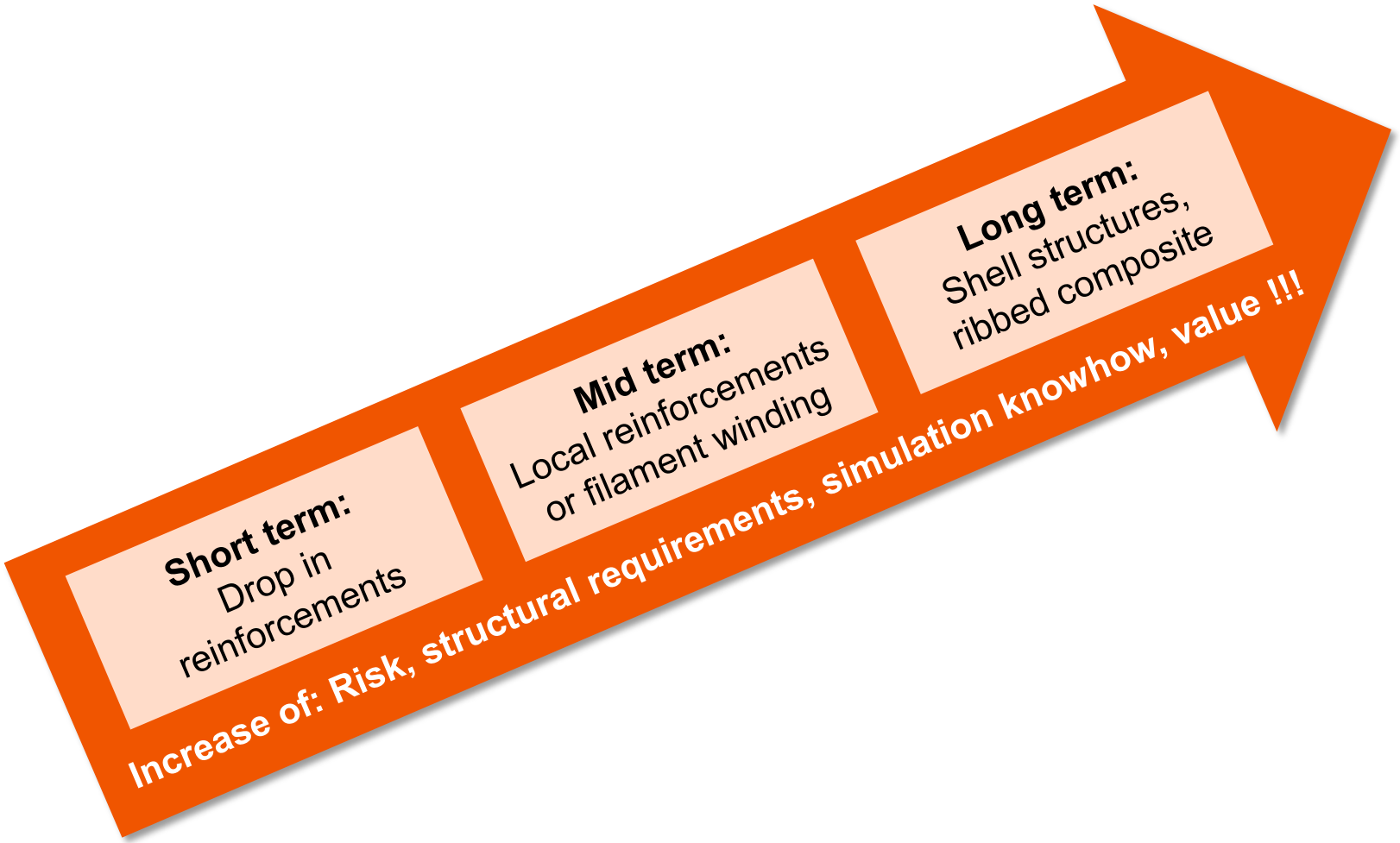
Design guideline
for Celstran® LFT & Celstran® CFR-TP Tapes
("Material Limitations")

Celstran® LFT & Celstran® CFR-TP Tapes
("Process Optimized Products")

Process guideline
for Celstran® LFT & Celstran® CFR-TP Tapes
("Process Limitations")



Development Timeline of Composites Applications in the Automotive Sector



Material, Processing & Application vs. Costs & Investment

Celstran® CFR-TP Composites
Broad Portfolio

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		Polymer Matrix														
		ABS	**TPU**	**HDPE**	**POM**	**PP**	**PVDF**	**PA12**	**PA6**	**PES**	**PBT**	**PET**	**PA66**	**PPS**	**PPA**	**PEEK**
	mp (^{0}C)	110	117	127	166	173	173	177	220	225	249	254	255	282	300	343
Reinforcing Fiber (Type - Weight %)	**E-Glass**	GF-60	GF-60	GF-70	GF-60	GF-60	GF-50	GF-60	GF-60	GF-60	GF-60	GF-60	GF-60	GF-60	GF-60	GF-60
						GF-70								GF-70	GF-70	
						GF-72										
	S-Glass							SGF-67								
	HT Carbon Fiber	CF-60	CF-60	CF-65	CF-50	CF-60	CF-50	CF-60	CF-60	CF-60	CF-60	CF-60	CF-60	CF-50	CF-60	CF-55
														CF-60		
														CF-67		

Standard Material

R&D Grade, Special type

Available on request

* Materials available in Black or Natural; Special colors available on request
** Other reinforcing fibers (e.g. Aramid, IM-7, heavy tow) available on request

Recognized by the Industry for the Ability to Customize Unique Combinations of Fiber, TP Resin Matrix and Additives

Why Celstran® CFR-TP Composites?

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- CFR-TPs can extend the range of physical properties attainable with reinforced thermoplastic materials
- Take advantage of the full strength of the reinforcing fibers
- Extends the range of CFR-TPs commercially available to include most significant resins, fibers and additives
- Improved range of useful, economical fabrication methods
  - Winding, compression molding, automated tape placement, localized reinforcement of injection and blow molding
- Combines easy processing of TPs with performance of composite materials
- Recyclability and shelf stability lend to better material yields
- For a wide range of applications and market segments

Our Strong Combination of Celstran® Products is your Structural Advantages

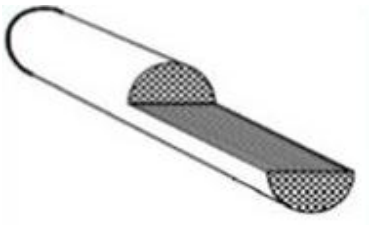
Celstran® LFRT (LFT)

Benefits

- Part geometry (ribbing,…)
- Implementation of Functions
- Interface
- Surface

Material

- Fully impregnated long fiber pellet in a fiber length of:
  - ½ ” (≈ 11–12 mm)
  - 1” (≈ 25 mm)
  - Custom



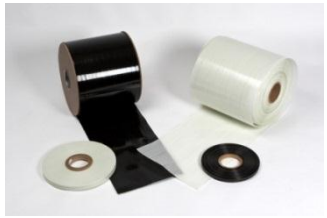
Celstran® CFR-TP (Tape)

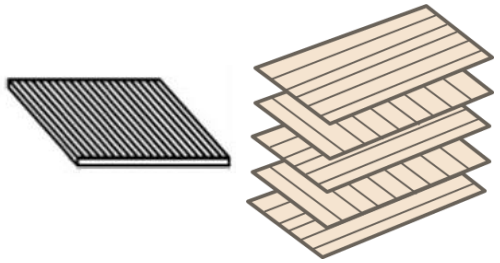
Benefits

- Stiffness, Strength, Impact Resistance
- Structural performance
- Local reinforcement

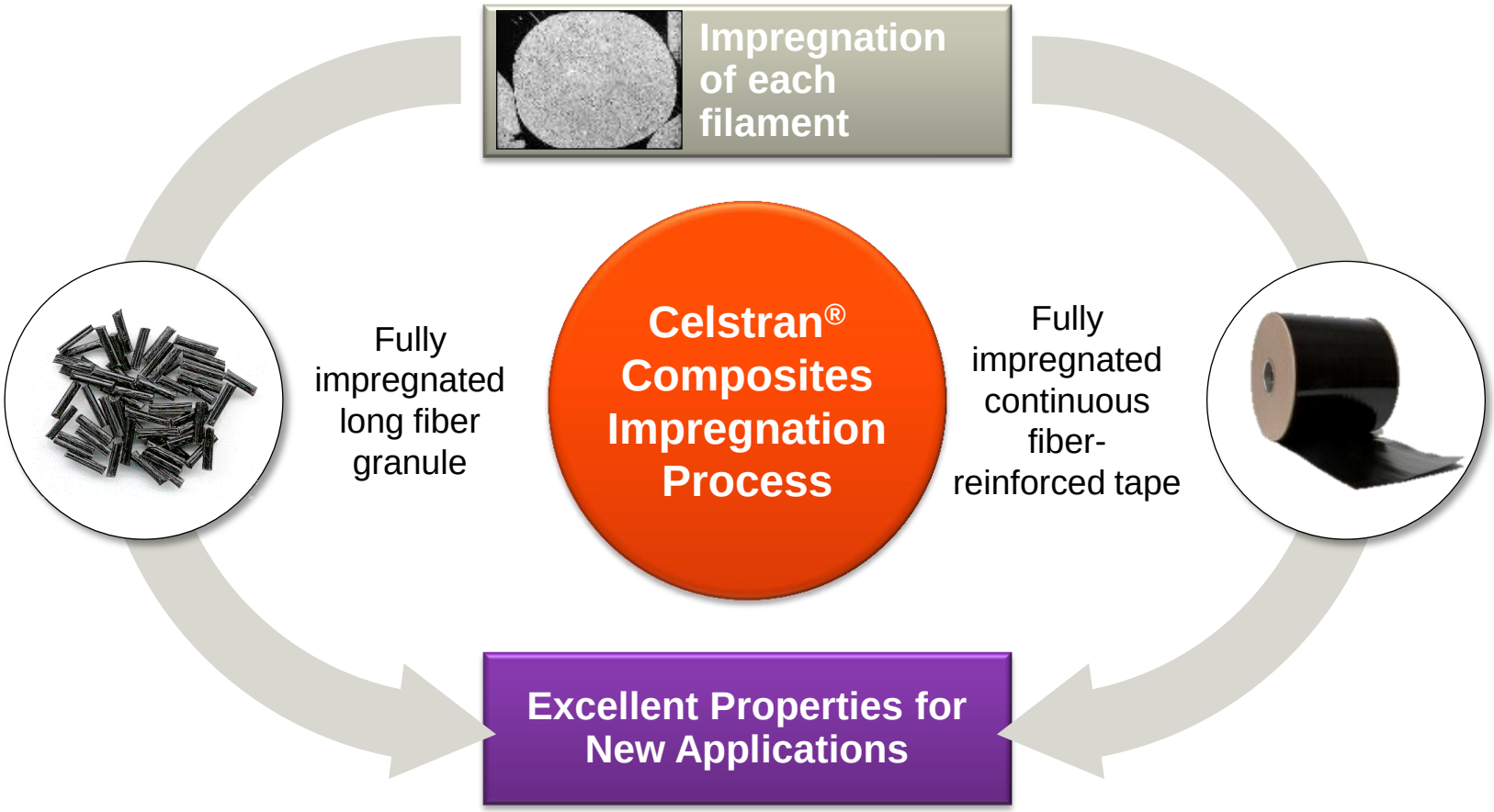
Material

- Fully impregnated continuous fiber reinforced tape:
  - Tape (Full width rolls between 254-330mm, slit widths of 6, …, 100mm or custom
  - Tape (customized Tape inlay, single ply)
  - Tape Laminates (pre-consolidated, 0/90 or QI)





Transfer From Pellet Knowledge Into CFR-TPs



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Established Molding Processes

Celstran® LFRT & Celstran® CFR-TP Tapes

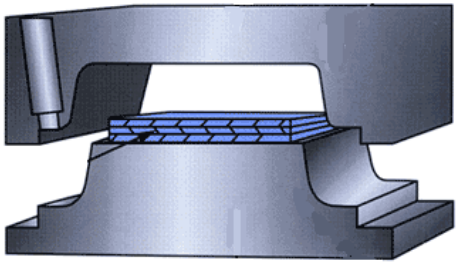
Celstran® CFR-TP and LFRT
Processes

Celstran® CFR-TP:

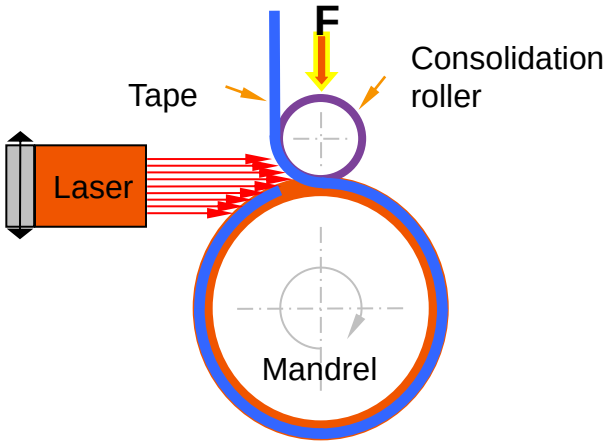
- **Automated Tape-Laying**
  - Winding
  - Laying (e.g. Fiberforge (Dieffenbacher))
- **Press Consolidation**
  - Doppelband Pressing
  - Heat Pressing
  - Interval Pressing
  - (Thermoforming)

Celstran® LFRT and CFR-TP:

- **Partial reinforcement**
  - Injection molding
  - Compression molding
  - Extrusion



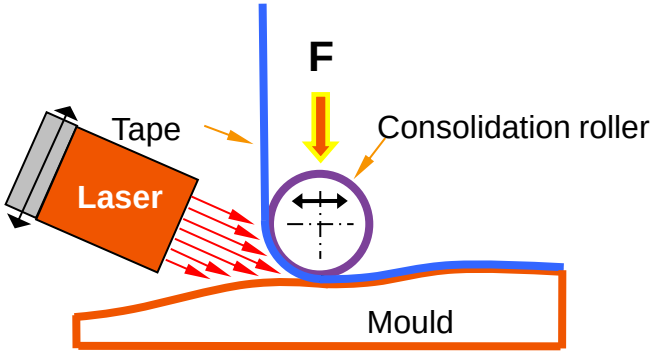
Filament Winding



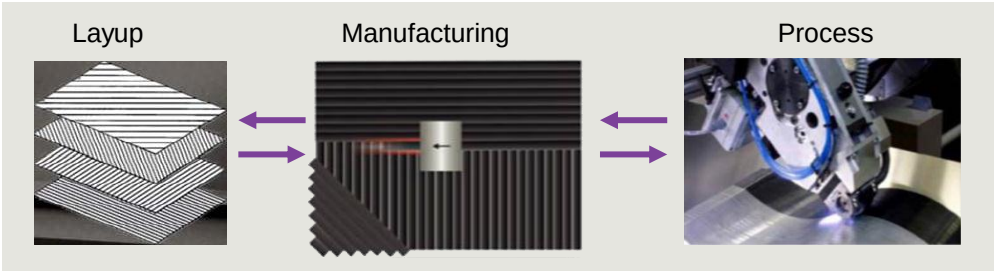
- Used for production of high performance tubular, e.g. oil and gas, city gas transportation, sport, aerospace and defense industry.
- Very fast and economic
- Various heating systems: super heated nitrogen, hot air, IR, laser.

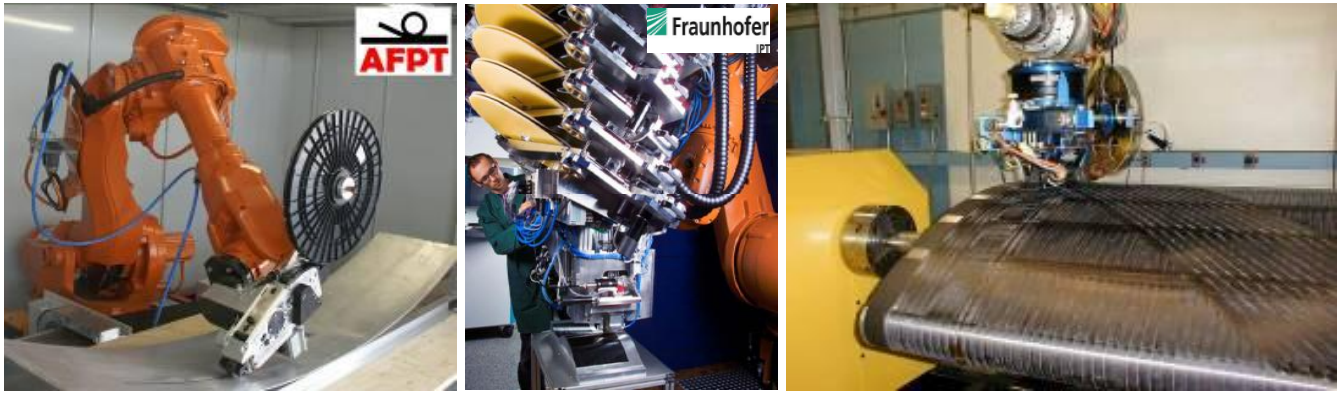
Source: AFPT, Fraunhofer IPT

Tape Placement / Laying



- Very good structural properties possible through lay-up in complex patterns
- Produced in sections or in continuous length.



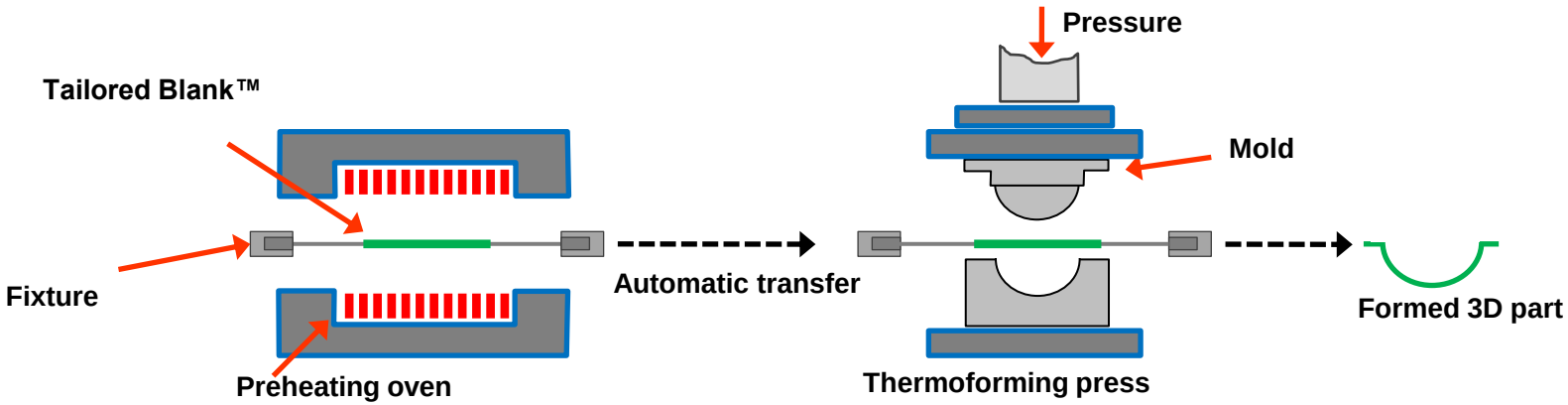


Consolidation roller with laser integration for production of 3D-Applications

Source: AFPT, Fraunhofer IPT

Celstran® CFR-TP Thermoforming/-stamping
Shell Structures

- Focus on Structural and semi-structural parts to maximize light weight design
- Celstran® Tape



Source: Fiberforge

Maximize Composites Benefits for High End Applications

CFR-TP
Application by market segment!

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Aircraft

Energy

Sport/
Leisure

Celstran® Composites - Expanding markets Growing demand

Piping

Building/
Construction

Transportation

Celstran® CFR-TP for Oil & Gas Pipes
Airborne Onshore / Offshore

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Reinforced Thermoplastic Pipe

- Significant reduction in life cycle cost
  - Excellent resistance to corrosion, aging and permeation
- Spoolability allows for installation speeds of up to 500 or more meters per hour
- Pipe system can be tailored to avoid permeation issues
- Designed to handle pressure fluctuations over its lifetime
- Burst pressure up to 520 bar with 5mm wall thickness

Breadth of Portfolio Allows Tailored Materials and Pipes to Meet Geographic and Application Requirements

Celstran® CFR-TP for Water Transfer Pipes
Composite Fluid Transfer LLC

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Reinforced Thermoplastic Pipe

- 11” ID, 30 ft sectioned water transfer pipe.
- Lightweight
  - Two persons can carry, eliminates need for heavy equipment

- 250 psi working / 500 psi burst pressure
- Quick coupling
  - butt fusion and electro fusion joints

- Flexibility enables 90 degree bend in 60 ft pipe span.
- Reduces number of fittings
- Low pressure drop

JEC COMPOSITES WINNER OF 2013 INNOVATION AWARD

COMPOSITE Fluid Transfer LLC

Broad Product Portfolio to Expand to High-temperature Applications

From UD tape to structural components - Example of a composite inlays -

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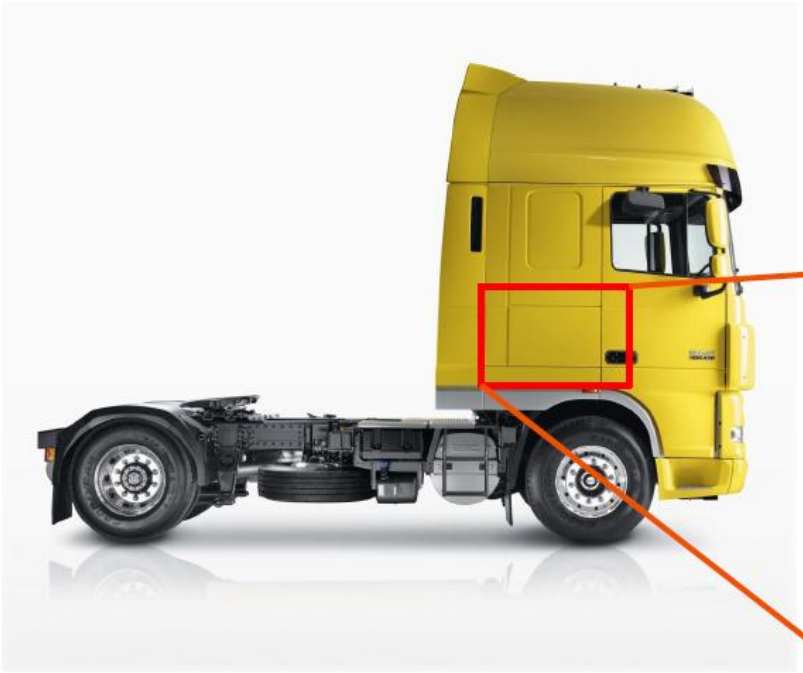
Structural Reinforcement of a Truck Storage Compartment



Source: www.daf.com / 17.04.2012

Source: EDAG

Simulation Optimization Cycle

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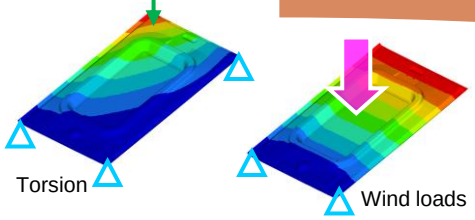
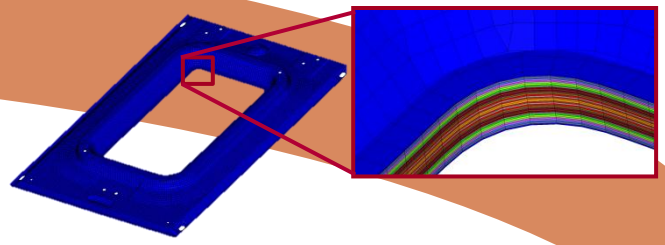
Reference simulation



Basic simulation for optimization



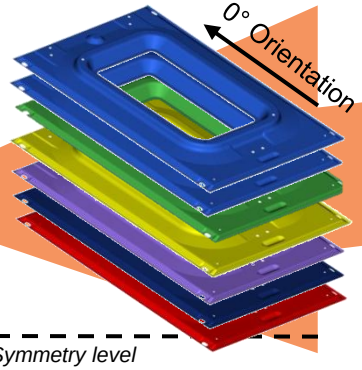
Size optimization

Shuffle optimization

Iteration 0	Iteration 1	Iteration 2
11101	12101	12101
12101	13101	13101
12102	11101	11101
13101	14101	14101
14101	12102	12102
11201	14201	14201
12201	13201	13201
13201	11201	11201
14201	12201	12201
14202	14202	14202

handover for production

Orientation [°]	ply thickness [mm]
0	0,27
0	0,27
45	0,27
-45	0,27
10	0,27
-10	0,27
90	0,27



Source: EDAG

From UD tape to structural components - Example of a composite inlays -

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Production in 4 steps

a) Tape laying using RELAY-Process:
- Ply laying and fixation utilizing ultrasonic welding heads

b) Preconsolidation step:
- Manufacturing of a 2D-tailored tape laminate using hot press process

c) „One-Shot“ Manufacturing process:
- Thermoformed component in 3-D geometry

d) Final component:
- Trimming of the component using water jet cutting or stamping process

Source: Fraunhofer ICT

Ford Transit Courier B460 Door Panel

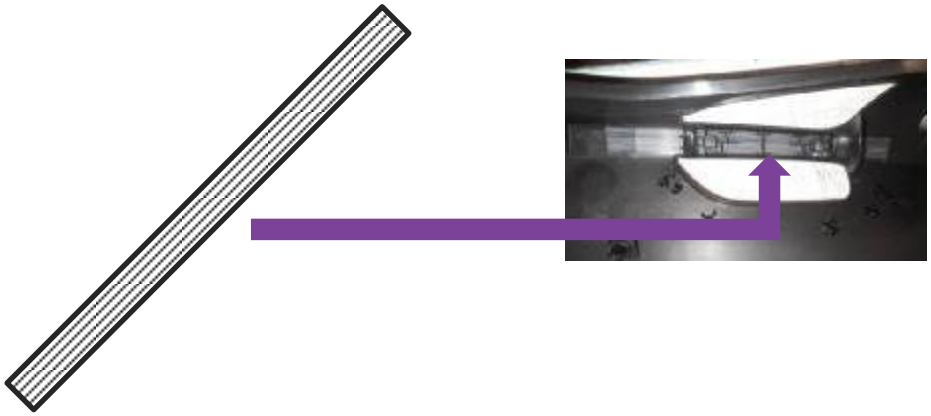
Tape PP-GF 70-13-305-0.25

Why Celstran UD-Tape:

- Crack of door handle in Crash Test
- No tool change necessary
- Very little weight increase (Alternative: Increase of wall thickness of complete part would be necessary)

Injection Molding
Drop in Reinforcement

- Focus on hanging on parts and Semi-Structural parts
- Injection molding
- Quick fixation to local reinforce parts
- over molding of “one” single UD-Tape ply
- Celstran® CFR-TP PP/GF70

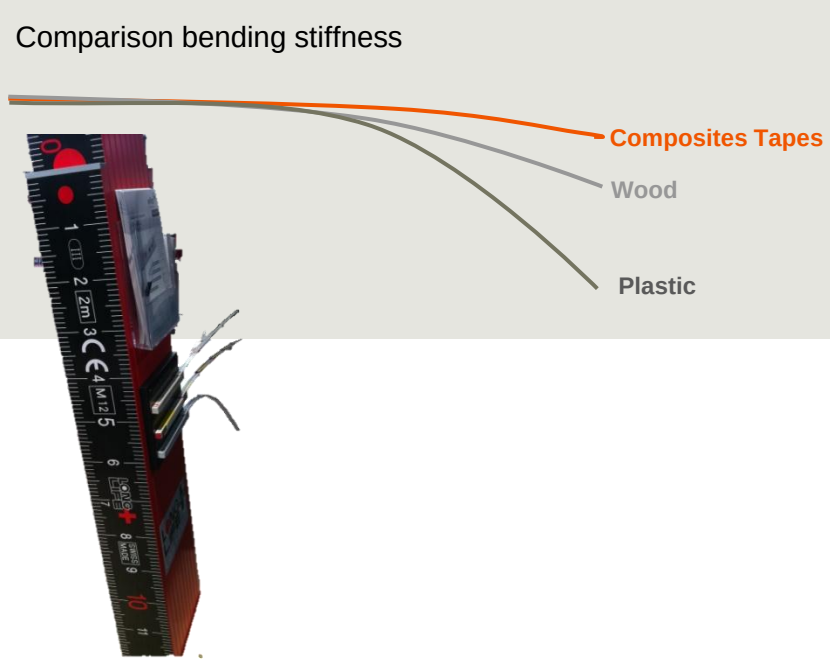


Celstran® PP/GF30+Tape

“Quick Problem Solver”

Ruler with increased bending stiffness

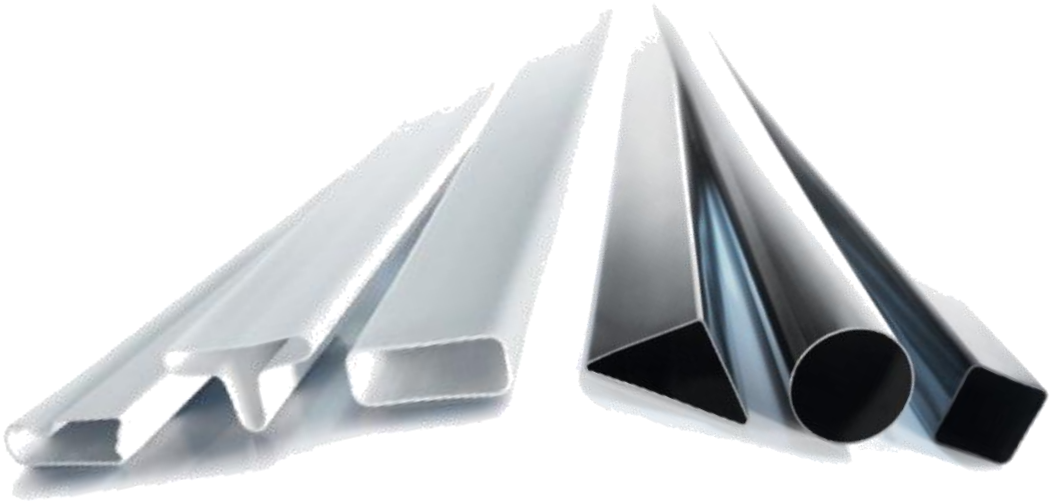
- No kinking with vertical measurements
- No excessive sagging with horizontal measurements



- Lengthwise oriented surface layers, hard and abrasion resistant, absorbs flexural forces

Structural Profiles

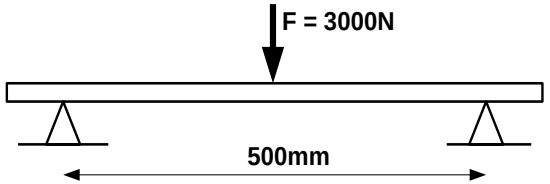
- Hollow profile structures (multiple degrees of fiber orientations)
- Pultruded UD profiles
- Extruded local reinforced profiles



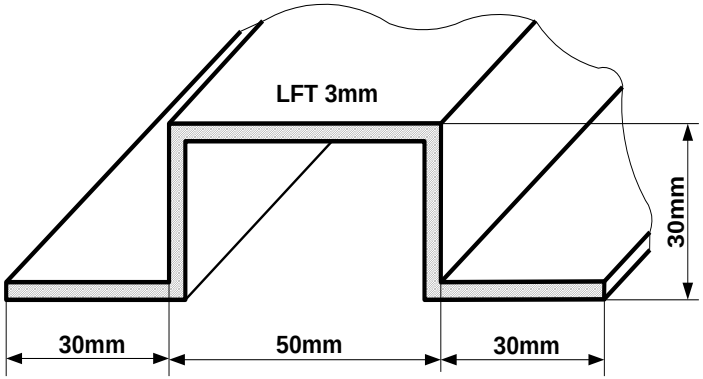
Source: Stükerjürgen

Structural Components for Automotive Applications

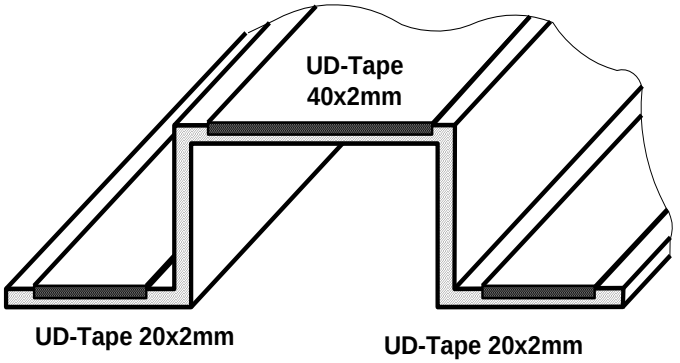
Bending Stiffness
U-Profil with Tape Reinforcement



LFT U-Profil with 3mm thickness



LFT&UD-Tape U-Profil



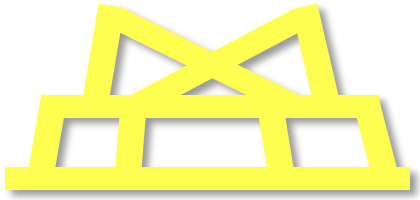
3x Improvement!

Bending: 22mm
Bending stiffness: 345 MNmm^2
Weight per meter: 550g/m

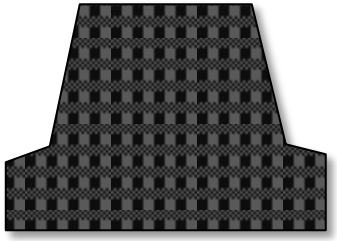
Bending: 7mm
Bending stiffness: 1100 MNmm^2
Weight per meter: 660g/m

Case study - Underbody Shield

D-LFT strand

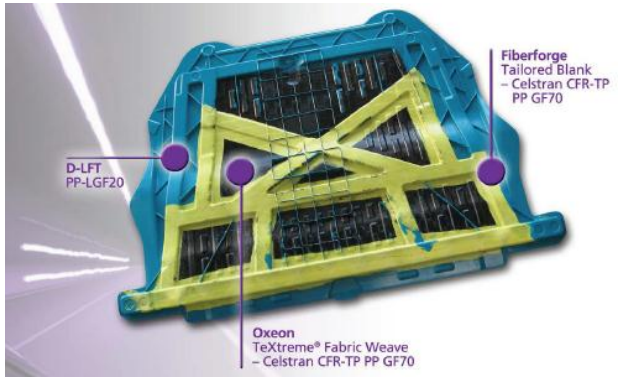


Tailored tape laminat



TeXtreme insert for surface coverage (Tape fabric)

Source: Dieffenbacher

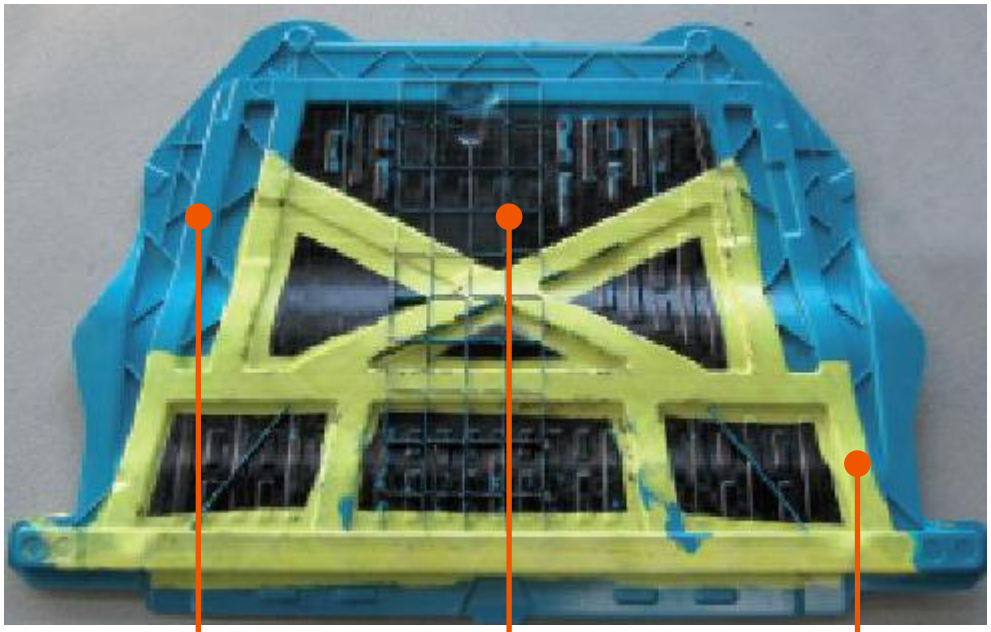


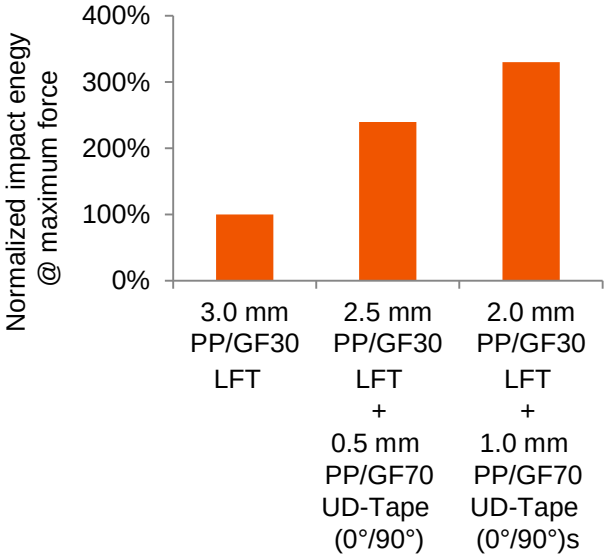
Tailored underbody shield

Source: Fraunhofer ICT

Local Reinforcement of UD Tapes

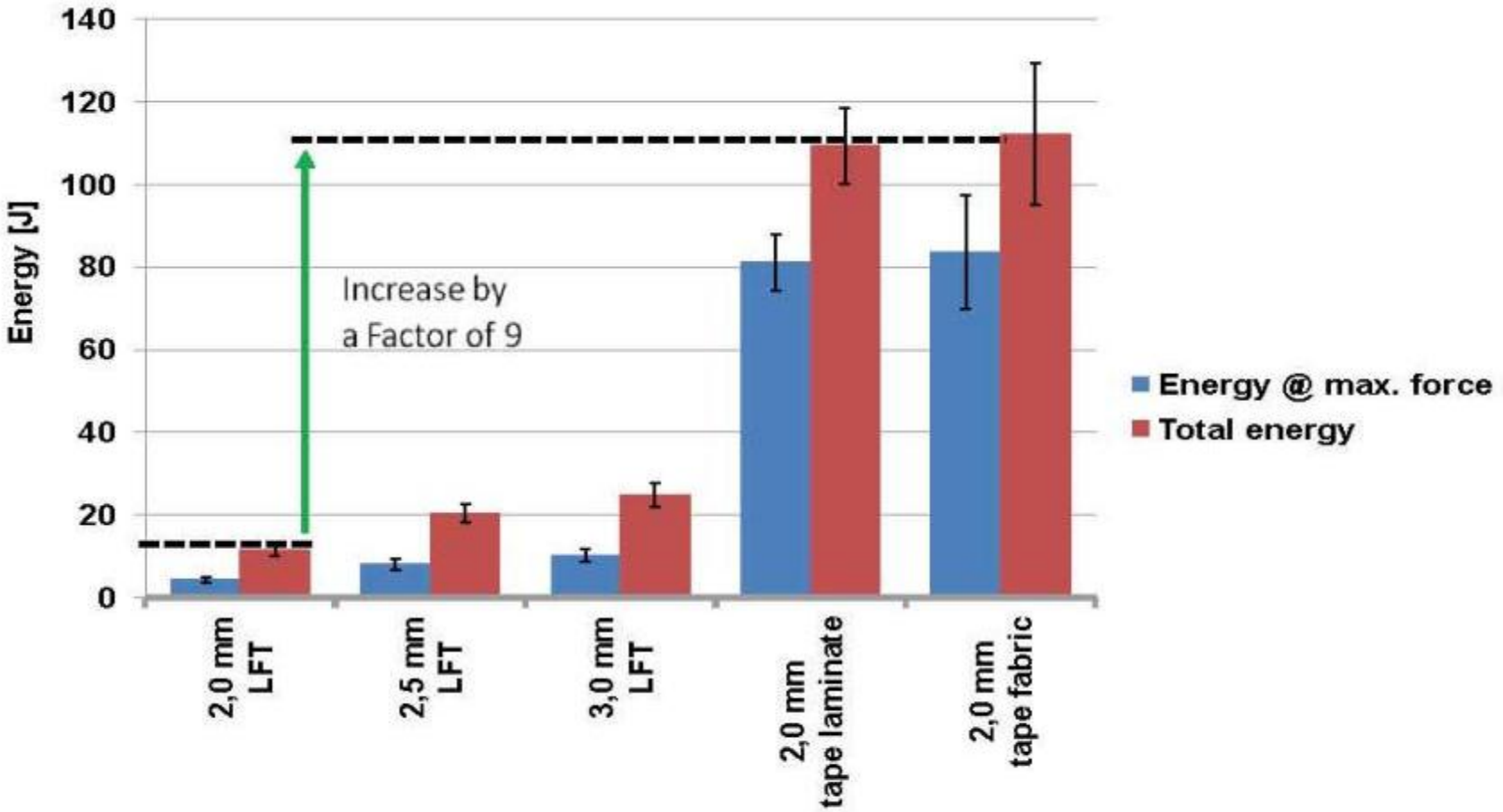
Under Body Cover/Shield





PP-LGF20	oXeon TeXtreme	FIBERFORGE
Made from Celstran® PP-GF40 + neat PP	Made from Celstran® CFR-TP PP-GF7O	Tailored Blank made from Celstran® CFR-TP PP-GF7O

Result Impact Energy
Pure D-LFT vs. Pure Fabrics & Laminates



Graph Cannot be Used to Pull Absolute Values for Samples of Different Thicknesses

Potentials in automotive for CFRT + LGT-G

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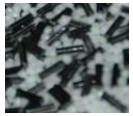
LFT PP with C-Fiber

Instrument Panel

Battery Tray

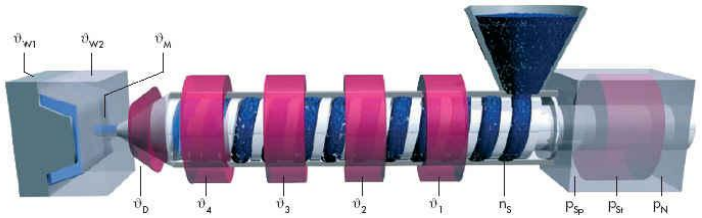
Heckscheiben-Leiste

Bumper



Door Module

Tailgate



Housing

Frontend

Seat Back

Noise Control

Underbody Shield

Spare Wheel Recess

Tapes in combination with injection molding

Chem. / Physical. Foaming

Celanese

The chemistry inside innovation™

Thank you very much for your attention

4. März 2015

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