SAMPE Presentation
6th November 2018

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The Future of Carbon Fibre in the Automotive Industry

About Sigmatex

- Established in 1986, we have over 30 years experience in the conversion of carbon fibre to advanced textiles
- We are an independant global business with 4 strategically positioned production plants and a large network of customers
- We are a technology driven business with the widest range of textile conversion methods in our industry
- We invest heavily in product innovation to ensure we remain as leaders in the fast evolving composite world
- We serve all major CFRP markets

A Brief History of CFRP in Automotive

McLaren MP4/1

- In 1981 McLaren introduced the worlds first carbon monocoque into a F1 car
- It was a pioneering move by McLaren to reduce weight and improve handling performance during a period of intense competition within Formula 1
- The now infamous crash by driver John Watson at the Monza Grand Prix became the pivotal moment the Automotive world woke up to the benefits of carbon fibre
- Formula 1 became the early adopters of carbon fibre, but the technology quickly transferred to high performance road cars. Again, McLaren were one of the first with the McLaren F1 in 1992, followed by Lamborghini and Ferrari
- Over the last two decades carbon fibre has found its way into almost every Hypercar, Supercar and luxury sports car in production.

The Current State

- CFRP is widely used in the high end of the market – Motorsport, supercar and premium sports cars
- In these segments of the market car performance is the critical factor; weight reduction, lower CoG, driver experience and aesthetics are the main drivers
- Carbon fibre is in commonplace use in components including primary structure (monocoque), roof structures, internal and external body panels, etc.
- The majority share of materials is supplied in pre-preg state, but with some cases HP-RTM is used (typically in relatively high volume programs)
- Until recently, there has been little innovation in this side of the market with customers using what they know and trust.

The Tide is Turning

More recently we've seen the transition of CFRP into more accessible mid-volume vehicles as a result of industry drivers and OEM's seeking to advance their CFRP integration. **Examples include:**

BMW i3
30,000 units/Yr

Toyota Prius Prime
45,000 units/Yr

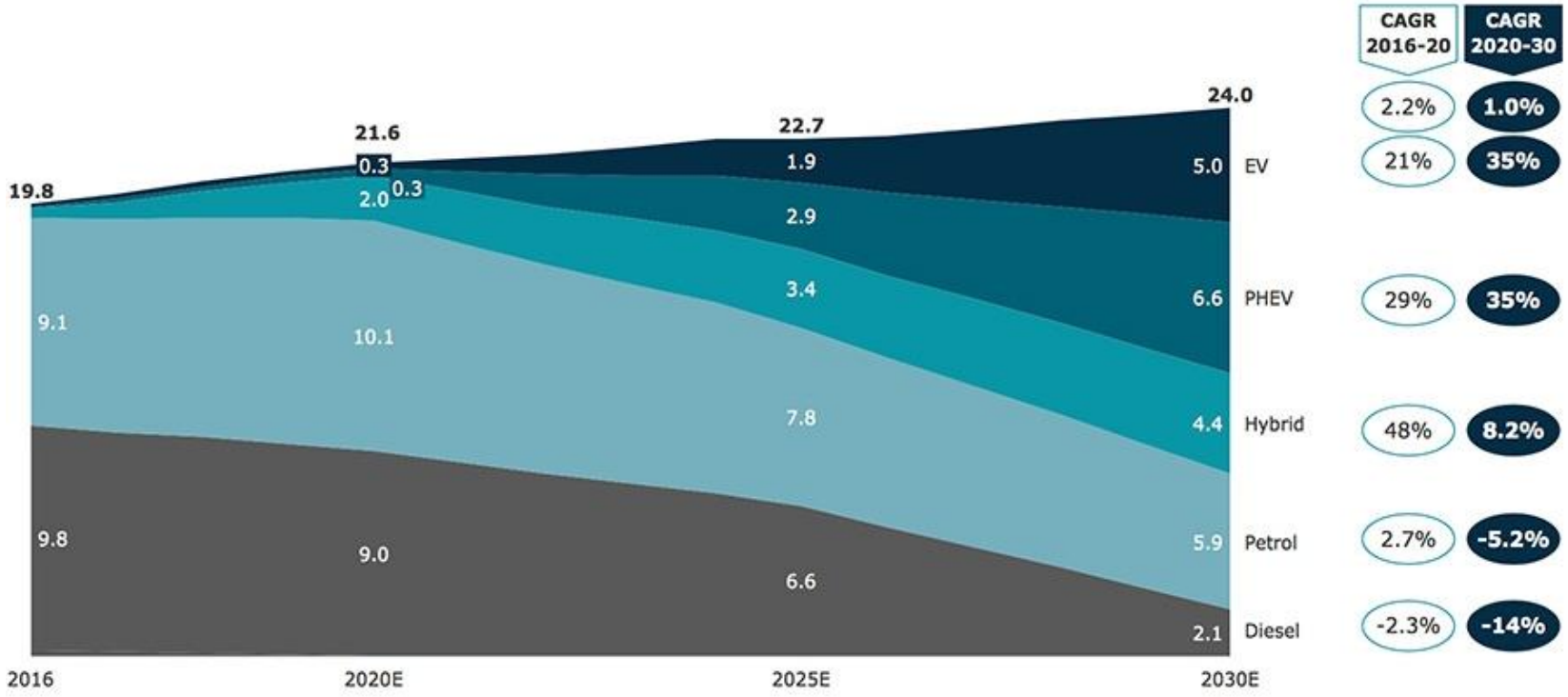
Market Outlook: Growth

- Global passenger vehicles are anticipated to grow at 2.8% CAGR
- Global car production expected to break the 100M by 2020
- China is and will remain the largest market but also the fastest growing market
- Europe and NA will remain relatively flat

Source: Consultancy.UK

Market Outlook: Powertrain

- Major decline in sales of fossil fuel / ICE powertrain – especially diesel engine
- Major growth of 35% CAGR expected for EV / PHEV
- Fastest growth period 2025 - 2030



Source: Consultancy.UK

Key Drivers

The Automotive industry is evolving at a fast rate, this change is driven by:

- **Legislation** – Global governments are increasingly setting tougher (zero) emission targets
- **Environment** – Social responsibility is influencing buyer decisions
- **Running costs** – Fossil fuel prices are increasing the cost of ownership
- **Electric Powertrain** – Range is one of the biggest barriers to EV sales, lower mass equals greater range
- **Safety** – Strength, stiffness and improved energy absorption on impact
- **Design freedom** – Embedded sensors, improved functionality, multi-material integration
- **Driving experience** – Consumers are demanding increased connectivity, autonomous driving

The Challenge

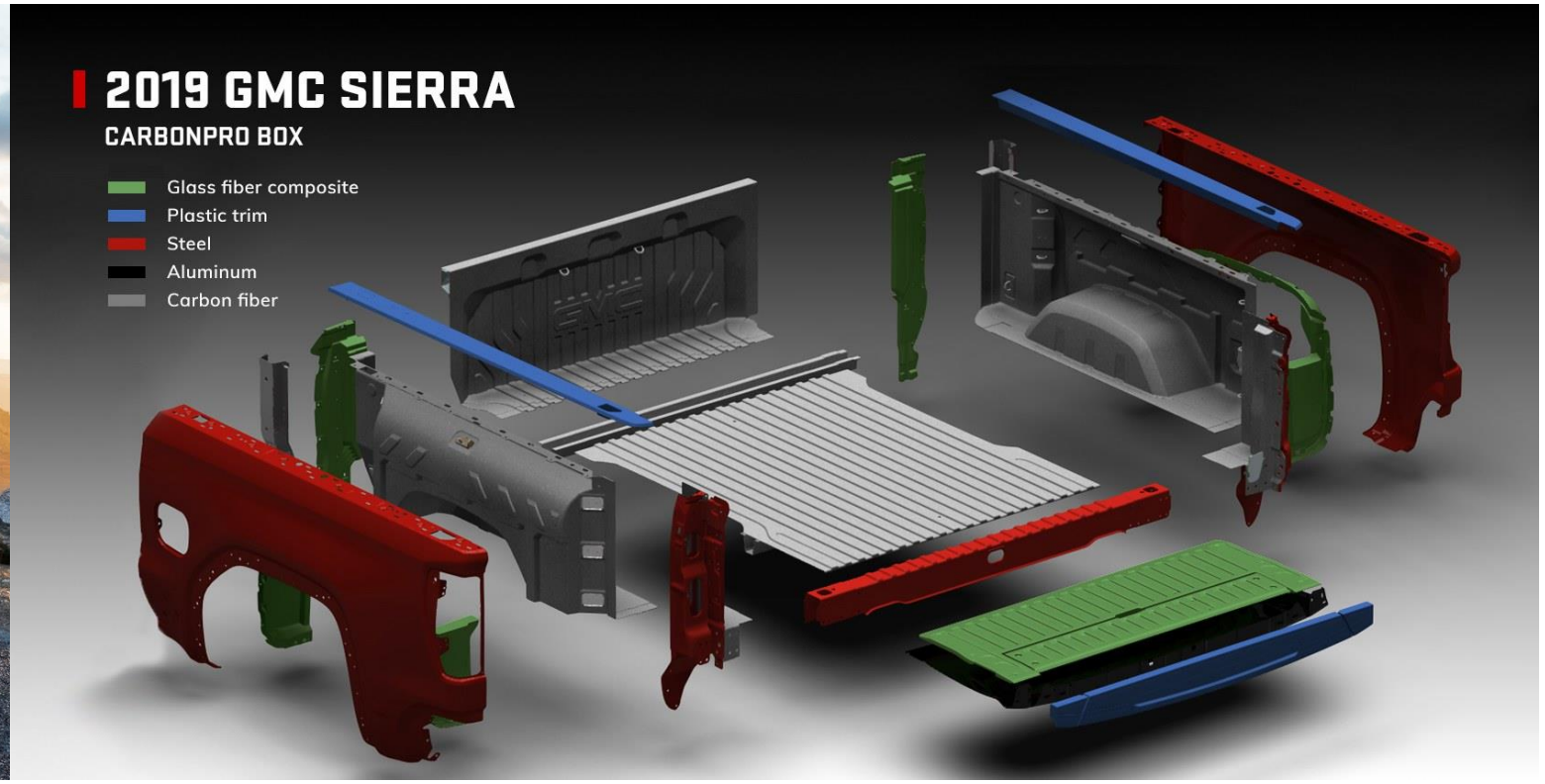
- **Cost** – The single biggest obstacle to CFRP adoption in high volume
- **Capacity** – Scaling up is capital intensive, major investment will be required
- **Cycle times** – Ultra low cycle times for CFRP will be required to meet production rate needs
- **Quality assurance** – Repeatable, low PPM failure levels (6σ)
- **Recyclability** – End of Life recycling / reuse is a regulatory requirement in many countries
- **Integration** – Multi-material solutions will necessitate effective compatibility between metals and plastics
- **Data** – Automotive engineers need good material data to support part design
- **Fibre capacity** – Can we turn on the tap quickly enough?

The Value Chain

- **Multi-material solution** – CFRP will not suit every component, it's about right material in the right place
- **Design for Manufacture** – Educate Automotive Engineers how to design for CFRP Vs Metals
- **Material Innovation** – Cost reduction essential, the price difference must match the value difference
- **Process Innovation** – Major technology advances are required to achieve takt time / conversion cost targets
- **Robust supply chain** – Capable of supplying >200,000 units per part across multiple parts (T1/T2/T3)
- **Assembly line compatibility** – Fits with current methods

CFRP Design


GMC

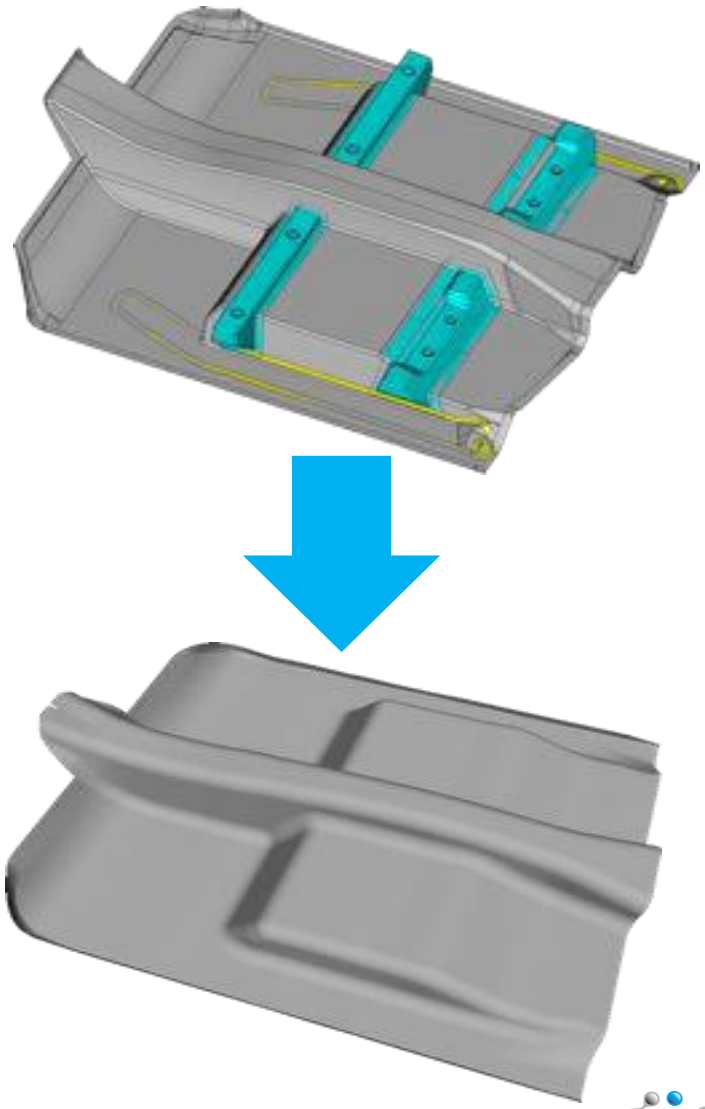

2019 GMC SIERRA
CARBONPRO BOX
Glass fiber composite
Plastic trim
Steel
Aluminum
Carbon fiber

CFRP Design

We must design for composites and not fall into the ‘black metal trap’

That means:

- Reduced numbers of parts / simplified design
- Increased curvature & draft angles
- Design for resin flow / low cycle times
- Consider bonding requirements & part integration
- Minimise waste and design it out where possible
- Select the right processing method for the part
- Collaborate for improved results



Key Technologies: TP Moulding

- Combines CFRTP with injection moulding to create a structure that improves the strength, stiffness and functionality of the component
- Gaining popularity due to ability to produce high volume at a reasonable cost
- Suitable for non-structural and semi-structural parts – Not Chassis, subframes, etc
- End of Life recyclability advantages
- Good weight saving potential

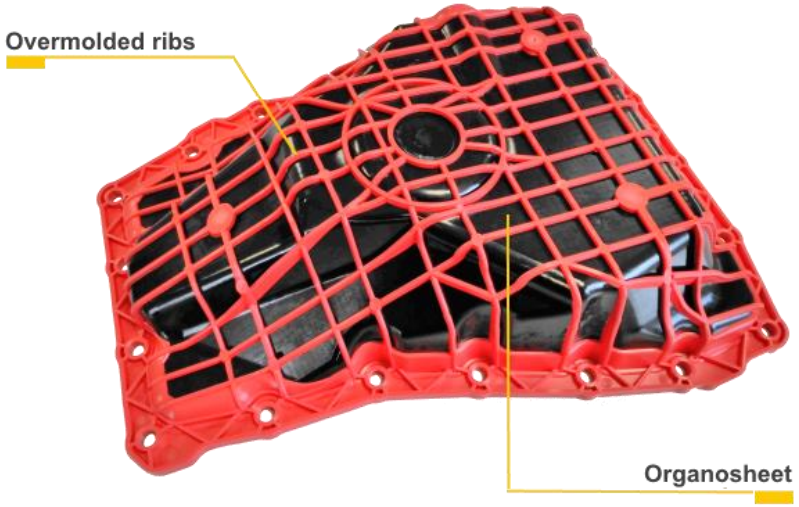


Image: Protoform

Key Technologies: HP-RTM & LCM

- Was once seen as the preferred solution for all automotive applications – but has since been shown to be more suited to major structural parts such as floor pans, battery boxes, support pillars & roof structures
- Cost is still the biggest obstacle to higher use of these methods
- Process is still being adopted for new major programs
- Liquid compression moulding now seen as a stronger option
- Good design and pre-forming processes essential for viability
- Suited to high volume production

Image: Composites World

Key Technologies: Hot Press Moulding

- Most widely used method with large Prepreg supply chain to support
- Good technique for both visual and painted parts
- Suitable for non-structural, semi-structural and structural parts
- Many reinforcement types can be used – UD, Woven, NCF, etc to give desired performance
- Challenges for high volume are cost and cycle time

Image: Composites World

Key Technologies: SMC

- Sheet moulding compound (SMC) has gained a lot of traction recently and looks likely to be a major feature of CFRP production over the next decade.
- Automotive industry likes it due to its fast processing and low cost nature
- Biggest disadvantage is it’s lower mechanical properties – this will limit applications
- Has it’s place for relatively low strength parts
- Toyota Prius is a great example of where this is ideally suited

Image: Toyota

Key Technologies: ATP

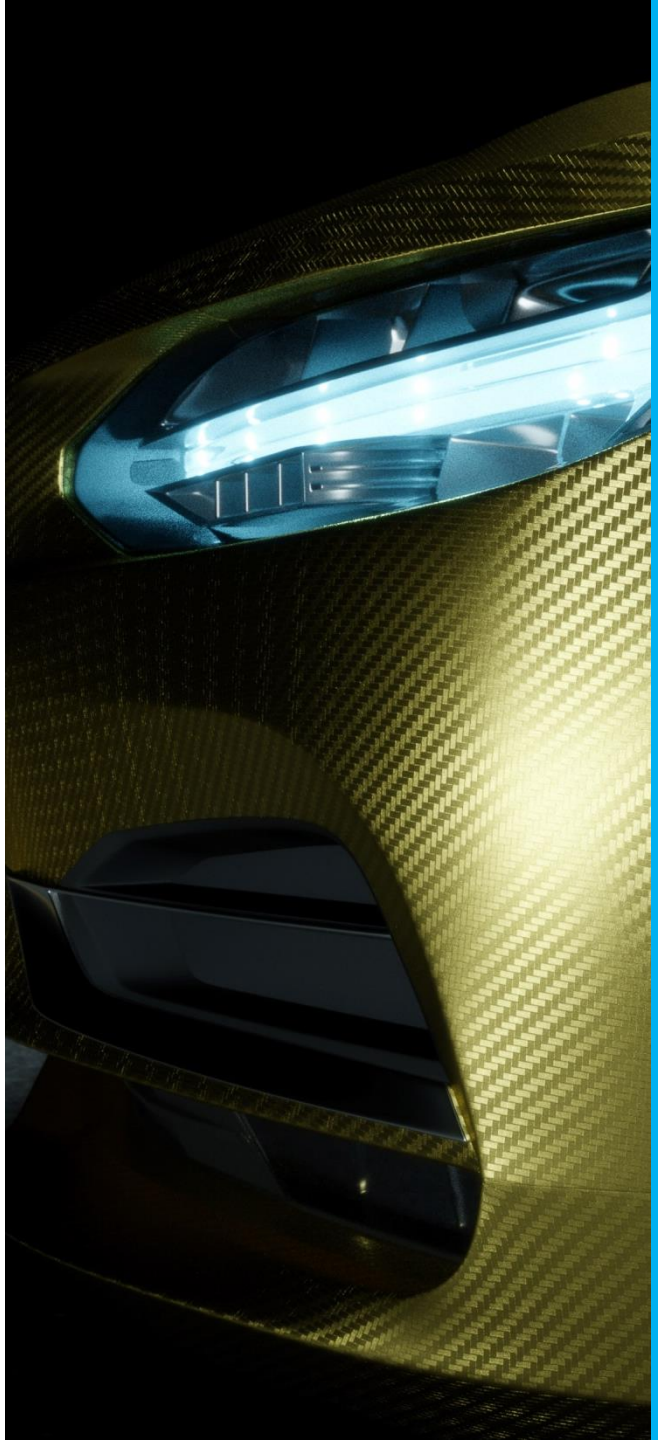
- Tape placement technology is the new kid on the block – but shows lots of promise!

- This process offers many advantages:
  - Precision material placement creating an optimised part
  - Very low waste levels – saving cost
  - No pre-forming – saving cost
  - Flexible resin systems

- The disadvantage – Its slow but this is being addressed

Future Materials

- Low cost carbon fibre for example Oak Ridge’s developments of 300/600K tow count
- Improved fibre sizing chemistry for interfacial bond and resin compatibility
- Improved bonding methods (dissimilar materials)
- Faster cure cycles
- Standardisation of materials
- Developments in textiles, a Sigmatex perspective …



Textiles: Visual Carbon

- Visual carbon is one of the largest segments of the Automotive market for CFRP today
- Consumers and designers alike are growing tired of twill weave, there is a need to rejuvenate interest through more creative designs
- OEMs can create brand identity through customised patterns
- We believe this will become a major trend for VQ carbon parts

Textiles: Ultra low weight UD Tape

- Proprietary fibre spreading technology developed by Sigmatex
- High volume high rate process – very cost effective
- Area weights 40 – 200gsm
- Tape widths 18 – 120mm
- Tapes are stabilised, with optional binder or veil applied
- Automated Tape Laying technology
- Various HS / IM fibres available

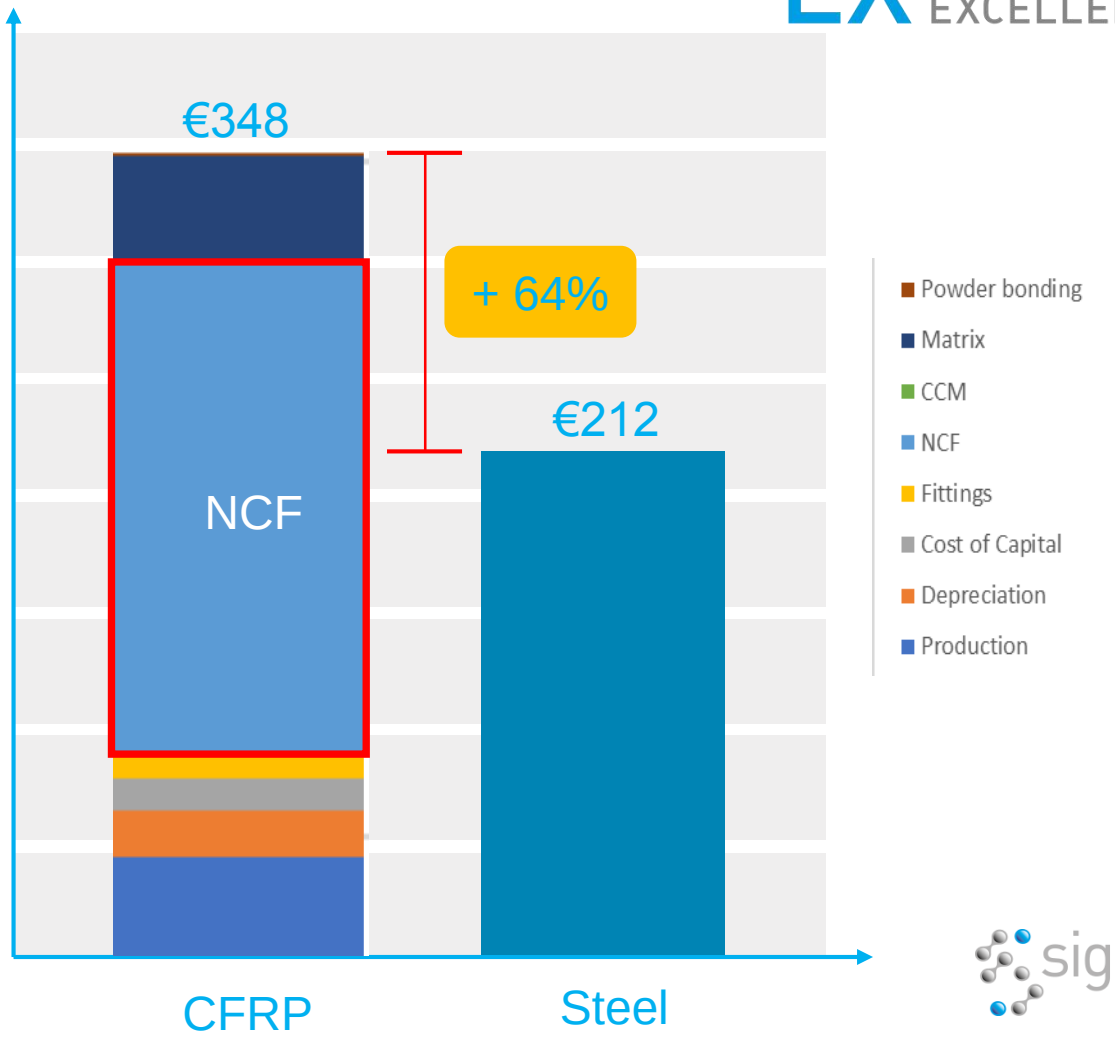
Textiles: Flat Fabric

A Novel weaving process developed by Sigmatex to enable the production of flat fabrics:

- Closed weave with improved cover factor
- Both warp and weft are ‘spread’ and inserted flat (no twist)
- Available in both HS & IM versions
- Area weights from 195 – 280gsm
- Offers improved mechanical performance due to increased fibre alignment and tow spread
- Aesthetically attractive

Current state of CFRP costs

- Detailed cost analysis completed for a floor pan structure (Nissan)
- CFRP was 64% more expensive
- NCF / carbon was 60% of total cost
- We are targeting to close the gap to circa 20%
- Cost / Benefit will stack up



ARCS

ADVANCED PROPULSION CENTRE

ARCS
AFFORDABLE HIGH RATE COMPOSITE STRUCTURES

Affordable highRate Composite Structures (ARCS) is an US$10M collaborative project that will target a step-change in cost and rate production of CFRP components for the Automotive sector.

Main Objectives:

- Develop our high speed NCF technology to deliver low cost carbon fabrics
- Strengthen our knowledge through extensive material characterization (mechanical, drape, permeability, etc.)
- Develop a high rate pre-forming cell and materials handling / automation system
- Demonstrate a joined up supply chain capable to deliver high volume production
- Seek exploitation opportunities across other mobility sectors

NISSAN

DESIGN FOR PERFORMANCE™

GKN Driveline

AMRC
ADVANCED MANUFACTURING RESEARCH CENTRE

Cranfield University

sigmatex
material innovation

Conclusion:

- The Automotive industry NEEDS CFRP as part of a multi-material solution
- Cost is still the biggest barrier to success – We need to continue to work on the economic case for CFRP
- New Technologies and innovation are giving us traction
- The changing market needs around powertrain technology, autonomous vehicles and geographic demand will create opportunity
- Designing for Composites is essential if we are to achieve our targets
- Education is required – especially at OEM level
- We can make this happen!

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Thank You