



Lightweight Vehicle and Powertrain Structures Roadmap 2020

Narrative Report

February 2021 | Version 1.0



Overview: Lightweight Vehicle and Powertrain Structures

Historically, vehicle weight has increased through the addition of more content such as passive and active safety features and more sophisticated comfort and convenience features. Efforts to offset these increases have ensured vehicle weight has remained stable or only slightly reduced across most classes whilst performance and fuel economy continue to improve.

For electrified vehicles, the challenge of reducing vehicle weight is more pronounced. BEV battery packs can contribute up to 300–400kg of additional weight which reduces the vehicle’s range. In both conventional and electrified powertrains, weight reduction enables weight savings in other components such as the brakes and suspension systems.

The roadmap identifies developments in design, materials and manufacturing as the key routes to lowering weight. High-volume vehicles, typically, take on a different development route to premium vehicles, produced in lower volumes, where different approaches to materials specification and manufacturing processes can be adapted as necessary.

High-fidelity multi-physics simulation provides a route to optimising weight whilst embedding manufacturing and bill-of-process at an early design stage. Such concurrent engineering principles and new mobility solutions, for example CAV or zero-crash capable vehicles, provide radically different approaches to weight saving, resulting in more ambitious weight reductions.

Key technologies driving light-weighting opportunities for automotive applications



Foreword and Acknowledgements



Neville Jackson
On behalf of the
UK Automotive Council

The APC would like to acknowledge the extensive support provided by industry and academia in development and publishing this roadmap.

We are grateful to the Automotive Council for entrusting us with the product and technology roadmaps refresh and their continued support.

This work has received significant support from BEIS (Department for Business, Energy and Industrial Strategy).

I am delighted to share the 2020 automotive propulsion technology roadmaps developed closely in collaboration with industry by the Advanced Propulsion Centre. These roadmaps define critical future targets and the most promising pathways to achieve a decarbonised and more sustainable future vehicle parc. They are an essential tool in developing a focused R&D agenda, particularly relevant for collaborative innovation.

The roadmaps build on the foundations of original UK Automotive Council roadmaps and developed further by the APC in 2017. These have been refreshed to reflect the urgency in transitioning to the UK target of net-zero emissions by 2050. The rate of change in propulsion technologies has accelerated rapidly in recent years; electrified vehicle adoption is on the rise, battery prices have come down faster than previously forecast, alternative zero-emission technologies like fuel cells are maturing at significant pace and clean fuels for combustion, including hydrogen, are emerging to replace existing fossil fuels.

However, there are significant challenges to overcome as the rate of change must increase further, requiring more intensive R&D and commercialisation that will deliver affordable products to market that are even more attractive for consumers. The 2020 technology roadmaps have been developed by industry expert surveys and panels, delivering a consensed view of future automotive propulsion targets, technologies and timescales.

Our aim with this report is to support the automotive sector with insights and a common technology focus to accelerate and deliver world-class solutions. The roadmaps are an important source of information in building collaborative R&D opportunities to address future mobility challenges, goods transport and off-highway vehicle research and development.

Alan Banks, Ford Motor Company
On behalf of the UK Automotive
Council Light-weighting Group

The 2020 Auto Council Roadmap updates reflect the growing importance of innovation, alternative fuels and sustainability in the automotive arena. From the previous 2017 roadmaps, it is clear that a lot of work has gone into keeping the technology relevant and timely, with all of the main groups and subgroups updated and accelerated to reflect the rapid nature of the developments. The UK's drive to a ban on petrol and diesel vehicles from 2030 is a real opportunity for the UK to drive all aspects of innovation on a global scale and provide UK PLC with a significant advantage.

The importance of light weighting for new vehicle development is key for the industry as an enabler for advanced and new propulsions. The added mass that these technologies bring will require offsetting – especially from a commercial vehicle perspective where driving license restrictions are dictated by vehicle gross vehicle mass; and payload capacity is a critical to customer criteria.

With intelligent crossovers in all areas of the roadmaps, it is possible for UK academia, research, SME's, Tier 1's and OEM's to come together and offer solutions for the needs of the automotive industry well into the next decade.

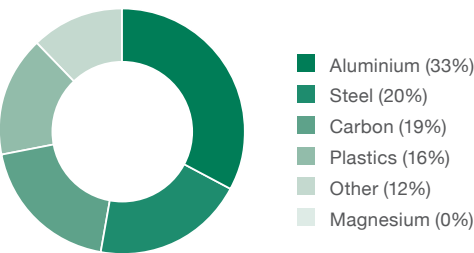
Insights from the 2020 Industry Experts On-line Survey

What are the key materials for mass market light-weighting?

High-strength aluminium and steel remain stable choices for lightweighting, followed by carbon fibre and plastics.

According to the survey, Aluminum and steels make up 53% of materials most likely to deliver weight improvements.

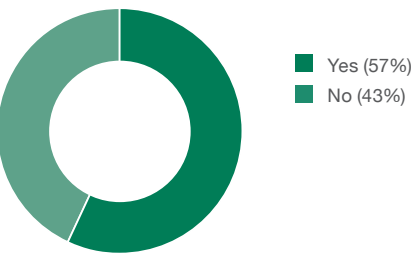
Aluminium is by far the most popular choice, due to its flexible extrusion construction and recyclability credentials.



Is carbon fibre a viable option for high volume vehicle manufacturing?

More than half of the survey responders stated that carbon fibre is a viable option for high-volume manufacturing.

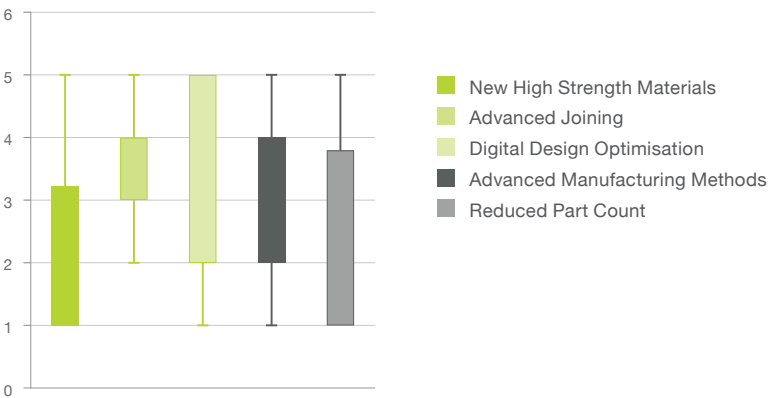
Although recyclability and energy-efficient production challenges need to be overcome, volume production programmes are actively looking to integrate CFRP in their structures.



Where are the biggest weight reduction opportunities?

We asked industry to rank the biggest weight reduction opportunities on a scale of 1 to 5, with 1 being the most likely.

According to our survey responders, high-strength materials and part-count reduction initiatives are likely to provide the greatest weight saving opportunity.





Roadmap 2020

Lightweight Vehicle and Powertrain Structures

Technology Indicators



Technology indicators for light duty vehicles

Technology indicators that industry is likely to achieve in a mass-market competitive environment.

Standard indicators

Incremental changes in technology with a light weighting focus



		2020	2025	2035
Light Duty Vehicle	Conventional vehicle weight reduction (%)	Baseline	5-10%	20-25%
	xEV vehicle weight reduction (%)	Baseline	10-15%	20-30%

High ambition indicators

Fundamental changes in vehicle architecture and new technology adoption



		2020	2025	2035
Light Duty Vehicle	Conventional vehicle weight reduction (%)	Baseline	10-15%	30-35%
	xEV vehicle weight reduction (%)	Baseline	15-20%	30-40%

Notes:

- Conventional vehicles refer to ICE architecture vehicles
- xEV refers all variants of electrified powertrains, but primarily battery electric
- The % weight reductions are from vehicle masses in 2020
- Increasingly stringent decarbonisation targets have accelerated the light weighting forecasts for conventional vehicles
- Battery pack designs, systems integration and advancing electrified drivelines are seeing increased potential for weight reductions in the next 5-10 years



Roadmap 2020

Lightweight Vehicle and Powertrain Structures

Technology Indicators

Technology indicators for light duty vehicles

Technology indicators that industry is likely to achieve in a mass-market competitive environment.

Technology indicators

In 2020, these replace targets in the roadmaps, providing a direction of travel and an approach to measuring best-in-class performance for this technology.

Standard indicators

Incremental changes in technology with a light weighting focus



		2020	2025	2035
Light Duty Vehicle	Conventional vehicle weight reduction (%)	Baseline	5-10%	20-25%
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High ambition indicators

Fundamental changes in vehicle architecture and new technology adoption



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Standard indicators

These performance figures represent achievable weight reductions from incremental improvements in lightweighting using design optimisation, material selection and part-count reductions.

CO₂ targets push OEMs towards higher efficiency (CO₂/km) and lightweighting. Reducing energy demand through weight reduction is a logical means to lower CO₂ in conventional ICE vehicles, offering secondary benefits since elements such as engines and brakes can also be made smaller as vehicle mass reduces.

Limiting vehicle weight has been under increasing pressure for many years due to additional content for safety, NVH, comfort and entertainment. Lightweighting has been applied to compensate for this, resulting in broadly stable weight in most vehicle classes. NB: weight gain is forecast to be around 5% in 2025 and up to 10% by 2035.

Electrification poses additional challenges, since the batteries or added electrified components make them heavier than conventional ICE vehicles. However, opportunities exist in battery carrier weight optimisation, improved energy dense battery chemistries and range management.



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High ambition indicators

Opportunities for enhanced weight optimisation on new platform and new product architectures offer a clean-sheet possibility for design, engineering and manufacturing, and when used concurrently, can deliver higher lightweighting gains.

New vehicle architectures, for example dedicated EV platforms, designs for zero-crash or urban mobility solutions provide a clean-sheet approach enabling the application of holistic lightweight design principles for aggressive weight reductions.

Meeting the need for steep CO₂ reductions will require further weight reductions, many of which cannot be achieved through incremental changes. High ambition indicators have been set to drive innovation in vehicle materials, design and manufacturing, supporting overall CO₂ goals.

There are fresh opportunities for integrating batteries in chassis or body structures that would provide weight-saving. Improving charging and advances in battery chemistry can result in larger EV weight reductions than conventional vehicles.



Roadmap 2020

Lightweight Vehicle and Powertrain Structures

Technology Roadmap

Technology indicators for 2020-2035 can be seen on page 1



This roadmap represents a snapshot-in-time view of the global automotive industry propulsion technology forecast for mass market adoption. Specific application-tailored technologies will vary from region to region.



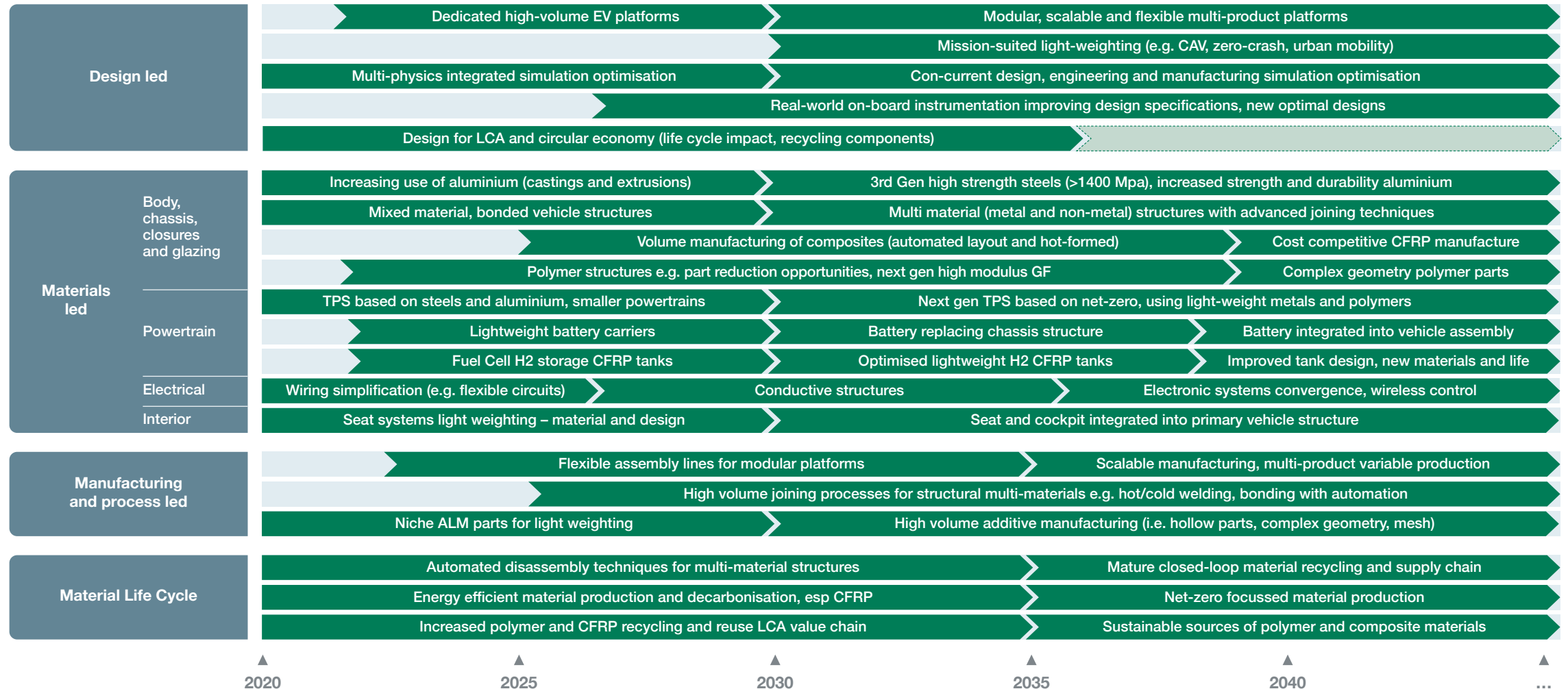
Dark bar:
Technology is in a mass market application. Significant innovation is expected in this time frame



Transition:
Transitions do not mean a phase out from market but a change of R&D emphasis



Dotted line bar:
Market Mature – technology has reached maturity. Likely to remain in mass market until it fades out where it's superseded



Primary Technology Themes



Roadmap 2020

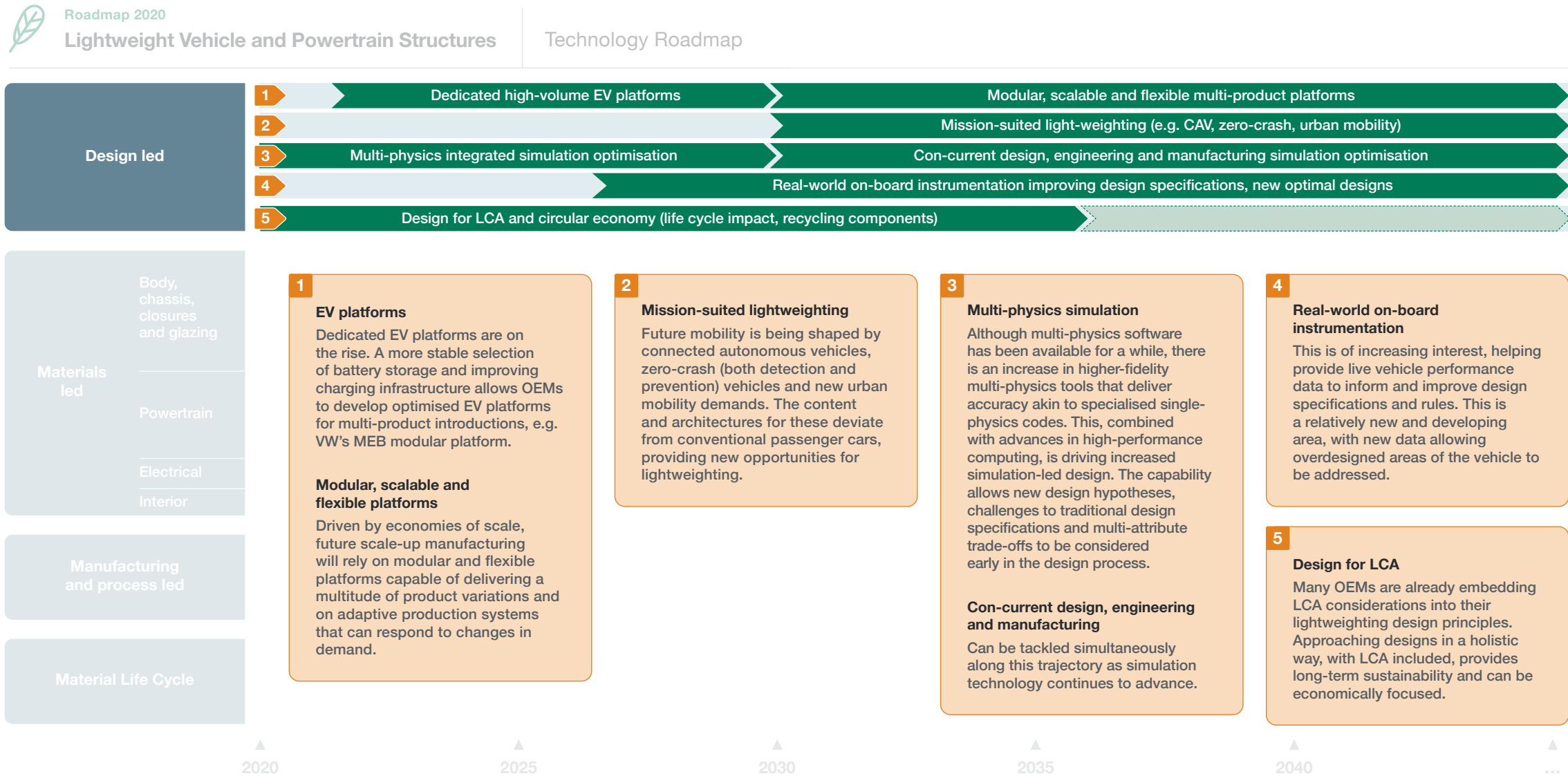
Lightweight Vehicle and Powertrain Structures

Technology Roadmap

Design led	<p>Design led approaches cover vehicle architectures and concepts changing as a result of modular, flexible and scalable designs. New mobility solutions and continued advancements in virtual simulation technologies are driving future designs. An increasing number of manufacturers are using life-cycle assessment upfront to provide environmentally sustainable products whilst maintaining a lightweighting focus.</p>
Materials led <div>Body, chassis, closures and glazing</div> <div>Powertrain</div> <div>Electrical</div> <div>Interior</div>	<p>Materials led:</p> <p>Body, chassis, closures and glazing make up the majority of the traditional weighting approach for mainstream manufactures. High-strength materials, increasing mixed-material structures, new joining methods and increasing adoption of CFRP and polymers for high-volume production are the areas expected to provide the greatest benefits.</p> <p>Powertrain systems for ICE, battery electric and fuel cells have an array of weight reduction opportunities. These range from lightweight materials for driveline components to integrating battery and carriers into vehicle body and chassis structures.</p> <p>Electrical architectures and components can contribute up to 5% of the vehicle weight. Often ignored, these offer significant potential for weight saving.</p> <p>Interior structures provide a range of lightweighting opportunities, including material selection and integrated designs to incorporate into the BIW.</p>
Manufacturing and process led	<p>Manufacturing and process led approaches are at the heart of design concept implementation. Multi-vehicle platform assembly lines, mixed material joining and niche-volume additive manufacturing, have a big impact on seeing lightweighting strategies become a reality.</p>
Material Life Cycle	<p>Material life cycle covers the development of design-for-disassembly, closed loop materials recycling, and sustainable production processes specifically for carbon composites and polymers.</p>

Design led

New platform design and multi-physics simulation are key to unlocking significant benefits in lightweighting.



Materials led

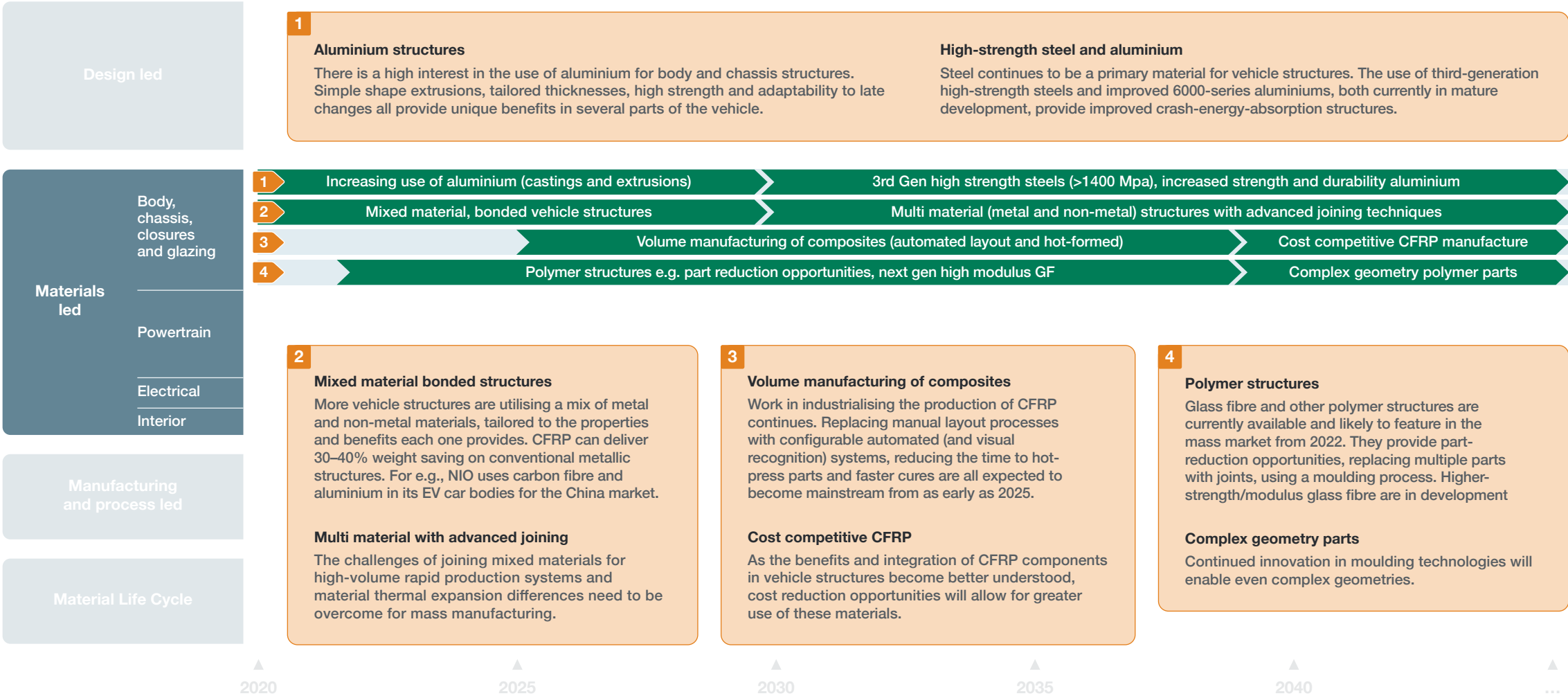
Materials fit-for-purpose, next-generation high-strength steel and aluminium and multi-material bonded structures offer the largest gains in body, chassis and closures.



Roadmap 2020

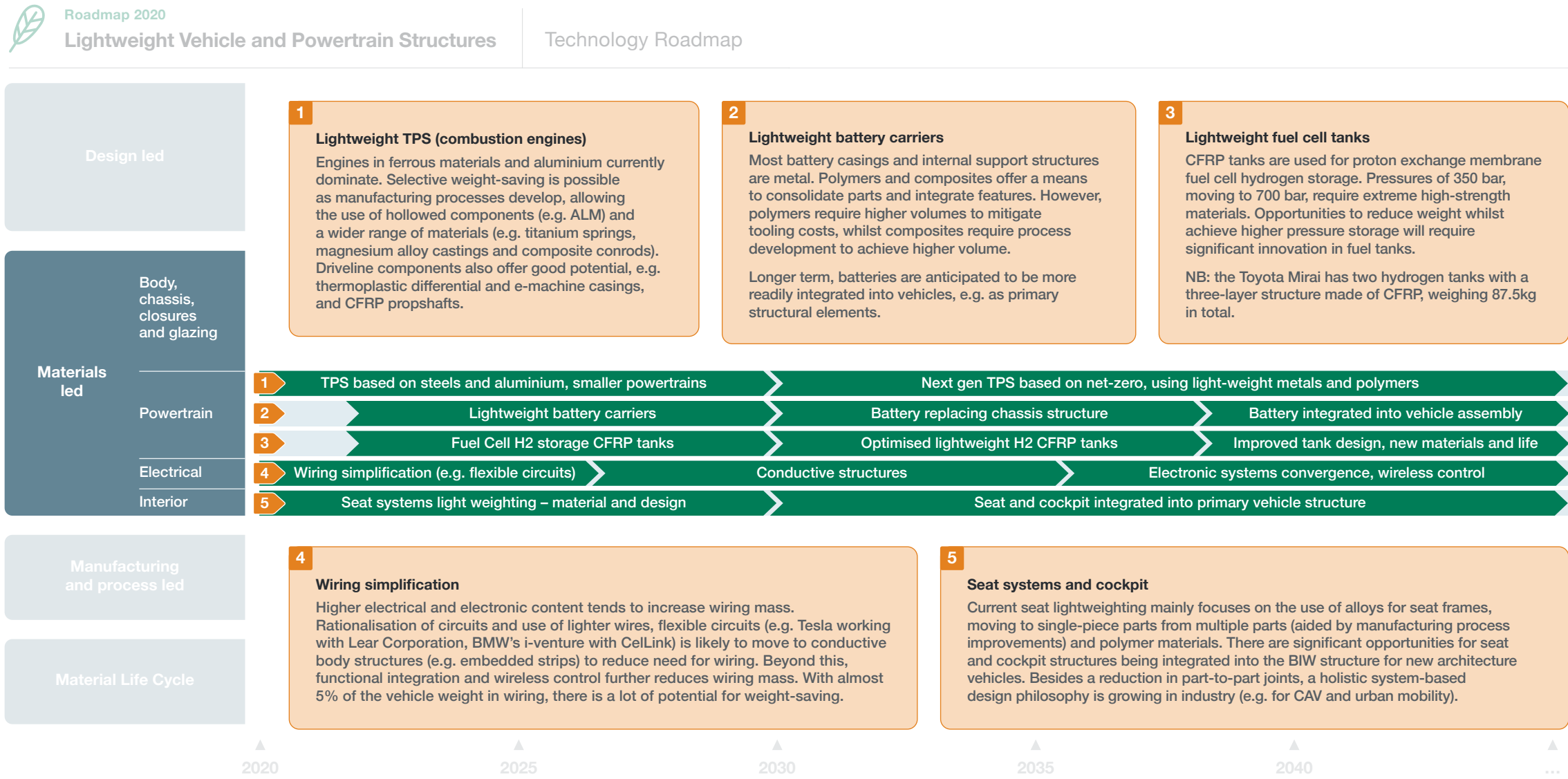
Lightweight Vehicle and Powertrain Structures

Technology Roadmap



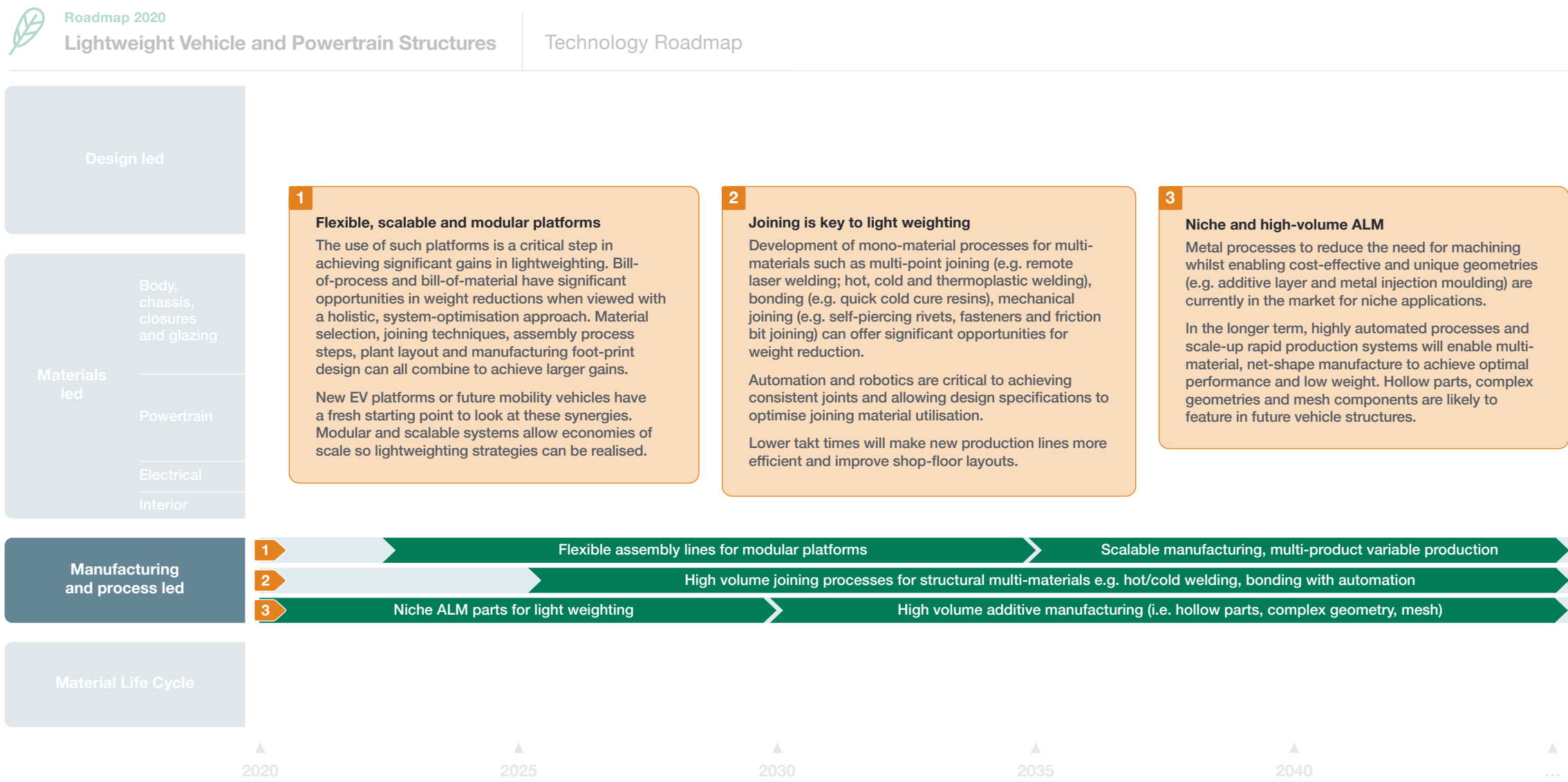
Materials led

There are opportunities in powertrain lightweighting, electrical systems and vehicle interiors still waiting to be realised.



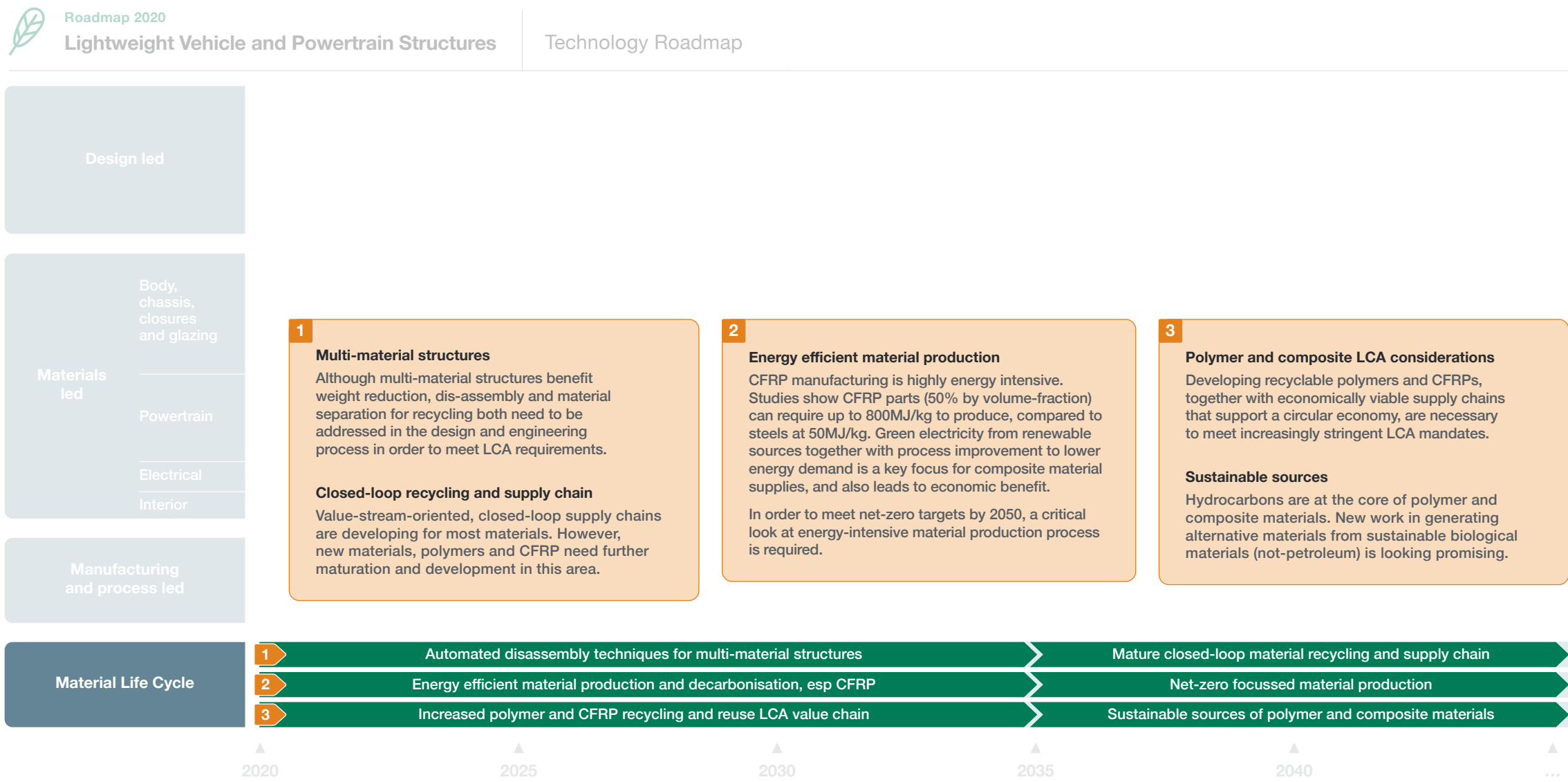
Manufacturing and process led

Concurrent design with manufacturing and bill-of-process development has the potential to develop holistic solutions that are unobtainable in a conventional sequenced development process.



Material life cycle

CFRP and polymers offer significant weight-saving opportunities but require further LCA development and a reduction in energy utilisation for their production and recycling.



Glossary

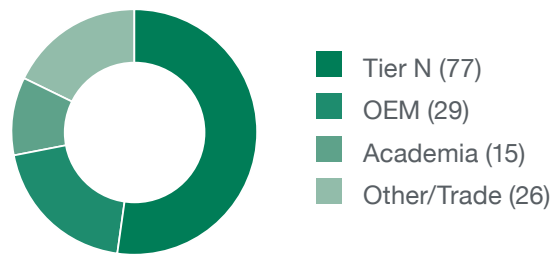
Abbreviation	Explanation
ALM	Originally used for rapid prototyping, additive layer manufacturing creates three dimensional parts by assembling numerous two-dimensional layers. There are numerous forms of additive layer manufacturing that range from 3D printing to electron beam melting.
BIW	Body-in-white. The structural shell of a vehicle.
CAVs	Connected and autonomous vehicles is an umbrella term to capture the varying levels of autonomy and technologies relating to self-driving vehicles.
CFRP	Carbon fibre reinforced polymer composites
LCA	Life-cycle assessment. Assessing environmental impacts over all stages of the life-cycle of a product (for instance from raw material extraction, through processing, to manufacture, use and ultimately recycling/disposal).
MIM	Metal injection moulding merges two established technologies, plastic injection moulding and powdered metallurgy. The process uses finely-powdered metal, which is mixed with binder material to create a feedstock, that is then shaped and solidified using injection moulding.
Multi-physics simulation	Computer simulation of multiple interacting physical phenomena (such as electrical current in a circuit, magnetic fields in an e-machine, physical feedback to a driver and chemical reactions from a battery).
NIO	Chinese electric vehicle manufacturer.
NVH	Noise, vibration and harshness
TPS	A thermal propulsion system is a device that integrates an engine or fuel cell with thermal and/or electrical systems to manage power delivery to the wheels and recover waste energy to improved performance and efficiency. The key feature of a TPS is that the primary energy is stored chemically (rather than electrochemically like in a battery).
MEB	VW's MEB modular platform or modular electric drive matrix - a joint electric-vehicle platform which underpins volume production of multiple models within the brand.

This is an industry consensus roadmap facilitated by the APC

Summary of engagements during the 2020 roadmap refresh

Spread of companies that participated in the refresh

109 industry organisations participated in Workshops and Interviews
38 additional industry organisations participated via the Online Survey
Total engagements 147 Industry Organisations



A global view with international participation

- | | |
|-------------|---------------|
| Austria | Singapore |
| Belgium | Sweden |
| England | Switzerland |
| Germany | United States |
| Netherlands | Wales |
| Scotland | Japan |

